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Chapter 1 General Information

1.1 Adoption

This City of Omaha Wastewater Collection Systems Design Manual (Manual) presented herein has been adopted by the City of Omaha City Council on __________, by City Council Resolution No. ______ and represents the minimum design criteria for public wastewater collection systems within the corporate limits of the City of Omaha, Nebraska, and its 3-mile-wide extra territorial zoning jurisdiction. This Manual supersedes the previous Design Criteria for Sanitary Sewers – Public Works Department, City of Omaha – Omaha, Nebraska, document that was approved by City Council Resolution No. 3475 November 15, 1960.

1.2 Intent

Wastewater collection systems are essential to the public health and welfare in all areas of concentrated population and development. This Manual provides the minimum design criteria for the design of wastewater collection systems. The goals of the Manual are:

1. To assist the Designer in the preparation of reports, plans, specifications, and other data for public wastewater collection systems.
2. To establish a basis for the design and review of plans and specifications for public wastewater collection systems.
3. To establish the minimum design criteria for public wastewater collection systems to minimize long-term maintenance needs.

In general, the design and construction of the public wastewater collection system shall be in conformance with all federal, state, county, and city laws, ordinances, rules, and regulations governing the design and construction of wastewater collection systems. In case of conflict, the most stringent requirements shall apply.

Compliance with this Manual does not relieve a Designer from the responsibility to apply accepted industry standards and sound professional judgment when designing wastewater collection systems. All Manual users are responsible to review and verify the applicability of the material presented herein as it pertains to the specific project under design.

1.3 Relationship between this Manual and Other Documents

This Manual provides the minimum design criteria that Designers are to follow and apply in conjunction with the City of Omaha Standard Specifications (Standard Specifications) and City of Omaha Standard Plates (Standard Plates) in the preparation of plans and specifications for public wastewater collection systems construction.

The following list and links has been assembled to aid the Designer in the design process. Each document addresses overlapping though different aspects of wastewater collection systems design and construction. Designers will need to reference each document to determine the appropriate application to the project. The links provided were active at the time of publication of this Manual. The Designer should make sure they are using the most current versions of the documents.

- City of Omaha Standard Specifications and Standard Plates for Public Works Construction; City of Omaha Standard Bid Item List; City of Omaha Materials and Testing Manual for Public Works Construction; Public Works Information Request
Additional design references may include, but are not limited to, the *Recommended Standards for Wastewater Facilities* (Ten State Standards), the manuals of engineering practices from the United States Environmental Protection Agency, the Water Environment Federation (WEF), the American Society of Civil Engineers (ASCE), and other recognized professional organizations.

### 1.4 City of Omaha Departmental Functions

The City of Omaha Public Works Department (Public Works) is responsible for the planning, design, construction, operation, maintenance, and acceptance of the public wastewater collection system. The City of Omaha (City [as the governmental unit]) maintains only the public wastewater collection system, and is not responsible for maintenance of private connections to the public system located within the public right-of-way or easements, in accordance with City of Omaha Municipal Code, Chapter 31-2.

The City of Omaha Planning Department Permits and Inspections Division is responsible for the design review and acceptance of private sewers (building sewer/service lateral) and the permitting of connections to any public wastewater collection system. Designers of private sewers are to reference the Plumbing Code and City of Omaha Municipal Code, Chapter 49 for the design of any private sewer within Omaha’s jurisdiction. Connections to the public wastewater collection system from a private sewer are addressed in this Manual in Chapter 2 and Section 4.5.

Clarification of public and private sewers is shown in Figure 1.1.
1.5 Sanitary and Improvement District

A Sanitary and Improvement District (S&ID) is created when a developer buys land for development outside of city limits. The S&ID can install streets, sewers, and other infrastructure through their authority to issue bonds, to levy taxes and special assessments, and to fix rates for services. Sanitary sewers constructed within the zoning jurisdiction of the City are required to meet the City’s design and construction requirements. The S&ID is responsible for the construction inspection of its own project and to provide documentation that the sewers were constructed in accordance with City requirements, including but not limited to, record drawings, CCTV¹ inspection, and testing reports.

1.6 City of Omaha Collection System Background

The City’s public sewer system consists of three types of collection systems, one for collecting wastewater (sanitary), a second for stormwater (storm), and a third for combined wastewater and stormwater (combined).

The City’s sewer system is divided naturally by terrain into the Missouri River Watershed and the Papillion Creek Watershed. Most of the City’s development prior to 1940 is located in the Missouri River Sewer System, including the combined sewer system. The Papillion Creek Sewer System contains mostly separated collection systems for wastewater and stormwater, except in the Cole Creek, Saddle Creek, and Papillion Creek sub-basins.

The City operates and maintains more than 2,200 miles of sewer collection pipelines, and more than 70 pumping stations in a service area that is approximately 320 square miles in Douglas and Sarpy Counties. The City provides service for a population of approximately 600,000 residents, including those in the Cities of Bennington, Bellevue, Boystown, Gretna, La Vista, Papillion, and Ralston, Nebraska.

The City wastewater collection systems convey sewage to the treatment of wastewater at two major treatment facilities: the Missouri River Water Resource Recovery Facility (MRWRRF), located south of the Veterans Memorial (Highway 275) Bridge along the Missouri River, and the

¹ Closed-circuit television (CCTV)
Papillion Creek Water Resource Recovery Facility (PCWRRF), located south of Omaha near Bellevue.

Figure 1.2 is a conceptual layout of the City’s sewer system components and the terminology used within this Manual. The “Area Sewered by Combination Sewers” portion of Figure 1.2 is included to clarify the terminology used within the City’s geographic information system (GIS) data.

Figure 1.2. Conceptual Wastewater Collection System
1.7 Glossary

All terms in this glossary relate to planning and designing sewer facilities. If a conflict between the definitions in this Manual and another document is identified, ask City staff to clarify the issue before proceeding.

ASCE – American Society of Civil Engineers
ASTM – American Society of Testing and Materials
AWWA – American Water Works Association
CCFRPM – Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe
CIP – Cast Iron Pipe
Cleanout – A pipe constructed vertically from a sanitary lateral or a terminus sewer using a wye or elbow fitting and extending to the ground surface to provide a point of entry for sewer cleaning or inspection equipment.
City Sewer – “Any sewer maintained by the City [of Omaha]” (City of Omaha Municipal Code, Chapter 49 – Plumbing).
Building Sewer (sanitary) – “That part of the horizontal piping of a building’s sanitary drainage system, conveying the drainage of one building site, beginning at the connection to the building drain (four feet outside the outer face of a building wall) to its connection with a public or private main sewer or private sewage disposal system” (City of Omaha Municipal Code, Chapter 49 – Plumbing). Also known as a service lateral.
Collector Sewer – A sewer designed to collect flow from sanitary sewer laterals.
Combined Sewer – A sewer intended to receive both wastewater and stormwater.
CSO – Combined Sewer Overflow
CSO Outfall Sewer – A sewer designed to discharge a mixture of wastewater and stormwater to a waterbody when the flow capacity of a combined sewer system is exceeded during a rain event.
Designer – The Designer is the Professional Engineer licensed in the State of Nebraska responsible for, or the coordinating professional for, the design of the proposed wastewater collection system improvements.
DIP – Ductile Iron Pipe
Diversion Structure (Chamber) – A structure that contains controls for diverting or drawing off all or part of a flow to another pipe, a point of disposal, or to a storage facility.
Dry Weather Diversion Sewer – A pipe used to carry a defined amount of dry-weather flow from a Diversion Structure (Chamber) to an interceptor sewer.
Force Main – A pipe used to convey sewage under pressure to a desired elevation or location.
HDPE – High Density Polyethylene Pipe; also referred to as PE pipe.
Hydraulic Gradient or HGL – The calculated slope between the potential head difference measured at different points along a pipe or conduit.
Interceptor Sewer – Serves an area greater than 1,000 acres or more than 10,000 people; or has two or more upstream Sanitary and Improvement District outfall connections.
Manhole – A structure that provides access to underground utilities for maintenance and inspection purposes.

Main – “The principal artery of a continuous system to which branches may be connected” (City of Omaha Municipal Code, Chapter 49 – Plumbing). The main could be a collector, trunk, relief, or interceptor sewer.

Master Plan – City of Omaha Papillion Creek Sanitary Interceptor Master Plan (PCSIMP).

Outfall Sewer – A sewer that receives flow from a water resource recovery facility and carries it to a point of final discharge (also known as an effluent line, and differs from S&ID Outfall Sewer, defined below).

Pigging Station – A location where a cleaning device known as a pig is inserted into a force main to perform various maintenance operations without stopping the flow of the product line.

Private sewer – “A sewer main, which receives the discharge from one or more commonly owned building sewers and conveys it to a public sewer or private sewage disposal system” (City of Omaha Municipal Code, Chapter 49 – Plumbing).

Public sewer – “A sewer in public right-of-way or on public easements” (that is owned and maintained by the City of Omaha) (City of Omaha Municipal Code, Chapter 49 – Plumbing).

Pumping Station/Lift Station – A structure that contains pumps, piping, valves, and other mechanical and electrical equipment for pumping wastewater or other liquid under pressure.

PVC – Polyvinyl Chloride Pipe

Lined RCP – Lined Reinforced Concrete Pipe

Relief Sewer – A sewer designed and constructed to convey flows in excess of the capacity of an existing sewer.

Sanitary Combined – A sanitary sewer or manhole that discharges into a combined sewer downstream.

Sanitary Sewer – A sewer that carries only liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with minor quantities of stormwater, surface water, and groundwater that are not admitted intentionally.

Service Lateral – A sewer that discharges into a collector or other sewer and has no other common sewer tributary to it. Also known as a building sewer (sanitary) in plumbing. Typically 6-inch inside diameter.

Storm Combined – A storm sewer that discharges into a combined sewer downstream.

S&ID – Sanitary and Improvement District

S&ID Outfall Sewer – The sanitary sewer pipe from a Sanitary and Improvement District that connects to the public sewer.

Tributary Area – The tributary area of a sewer includes all areas contributing flows to the system.

Trunk Sewer – A major sewer collecting flows from several collector sewers and serves a large service area. Typically 10-inch or greater inside diameter.

VCP – Vitrified Clay Pipe

Wastewater – The spent or used water of a community or industry, which contains dissolved and suspended matter.
WRRF – Water Resource Recovery Facility
WEF – Water Environment Federation
Chapter 2  Project Planning

2.1  Introduction

Each sanitary sewer collection system project varies in complexity. The Designer is responsible for conducting the appropriate investigations and preliminary design prior to contacting the City for confirmation of their design assumptions. The following are the minimum project planning requirements for wastewater collection system design.

2.2  Existing Available Information

The Designer shall use the following websites early in the project planning phase:

- **Public Works Information Request**
  
  As applicable in the project planning phase, the Designer shall request the existing sewer record drawings and available collection system data from the City. Designers shall make requests through the Public Works website: [www.dogis.org/information_request](http://www.dogis.org/information_request).

- **GIS Data**
  
  Douglas County and Sarpy County GIS Data is available through their respective websites, [www.dogis.org](http://www.dogis.org) and [maps.sarpy.com](http://maps.sarpy.com), for project planning. The Designer shall complete topographic surveys for sewer design and construction, as discussed in Section 2.3.

2.3  Site Survey

Designers must complete a topographic survey for sewer design and construction at the site of the proposed sewer construction. It is not acceptable to establish elevations and locations for sewers from aerial survey topographic maps, GIS, or indirect sources.

Designers must complete all surveys in Nebraska State Plane (feet) coordinates North American Datum of 1983 (NAD 83), modified to ground. The Nebraska State Plane grid to ground scale factor used by the City is 1.0003828. Vertical datum shall be North American Vertical Datum of 1988 (NAVD 88). Designers shall complete surveys according to Public Works Design Division requirements.

2.4  Existing Sewer Connection Investigation

The Designer shall confirm the condition, elevations, and capacity (see Section 2.8) of the existing sanitary sewer or manhole to which the proposed pipe(s) would connect.

- **Connecting to an Existing Manhole**
  
  When connecting to an existing manhole, the investigation shall include a manhole inspection with photographic documentation. Appendix A includes the manhole inspection form to be used.

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2 Note regarding vertical datum on sewer record drawings: many older elevations shown in quarter section maps used the Omaha Datum, which roughly translates to National Geodetic Vertical Datum (NGVD 29) by adding 962.04. Most as-built plans prior to the year 2000 used NGVD 29, and most as-built plans after the year 2000 use North American Vertical Datum of 1988 (NAVD 88). Designers should be aware that variations may exist between the datums.
• Connecting to an Existing Pipe

When connecting to an existing pipe, the City may require CCTV inspection of the existing pipe pre-construction in addition to post-construction if recent documentation is not available or if there is some other indication of risk.

2.5 Existing Brick Sewers and Brick Manholes

If the existing sewer connection investigation (Section 2.4) reveals the existing sewer is brick construction, the City requires CCTV inspection of the sewer pre- and post-construction. The Designer shall exercise extreme caution when working around existing brick sewers and manholes, because they have a history of unravelling and collapsing when disturbed during construction.

2.6 Connections to Combined, Outfall, and Interceptor Sewers

Approval from the City is required for any proposed connection to a combined sewer or an outfall sewer. All new connections to interceptor sewers shall only occur at a manhole. The City will not allow a direct connection/tap to an interceptor sewer pipe.

2.7 Existing Sewer Connection Method

Manufactured fittings, field fabricated fittings, and coring and tapping are all acceptable methods for existing sewer system connections. The size and material type of the existing pipe or manhole and the proposed pipe should be used by the Designer to determine the appropriate connection method that maintains the reliability of the sewer system. All taps to existing pipes shall be installed in a manner that does not result in pipe protrusion beyond the interior face of the existing pipe. The Standard Plates contain details for existing sewer system connections.

2.8 Capacity of Existing Sewers

The Designer is responsible for determining adequate capacity in the existing sanitary sewer to which the new sanitary sewer is connecting. The Designer shall determine the appropriate downstream length from the connection point to include in the analysis.

For new construction in the Papillion Creek Watershed, the Designer should be familiar with the PCSIMP (Section 1.3), because it may be applicable to their project. The PCSIMP discusses the existing interceptor restriction areas and the corresponding capacity improvements and sewer extensions included in capital improvement planning for the City.

For infill development, redevelopment, or in the combined sewer system area, additional capacity analysis in the form of flow monitoring may be needed by the Designer.

2.8.1 Flow Monitoring

The City has existing flow meters at a few locations throughout Omaha. Depending on the location of the project, the City may be able to provide the Designer with the existing sewer flow, velocity, and depth data upon request.

If flow monitoring is required for the project, the Designer shall follow the City protocols, which are available by contacting the Sewer Maintenance Department at 402-444-5332.
2.8.2 Existing Sewer Model

The City has an existing model of the sanitary sewer system. Depending on the location of the project, the City may be able to provide the Designer with the modeled existing sewer flow data upon request.

2.9 Utility Investigations

Utility investigations are necessary for the proper design of any sewer project. The Designer is responsible for contacting the utility companies to obtain information on their infrastructure within the project limits; adequately investigating the depth and location of other utilities; and meeting with the utilities to resolve any conflicts.

2.10 Geotechnical Investigations

The Designer shall complete geotechnical investigations for all projects to determine the existing soil conditions and the fluctuation of groundwater elevations to facilitate wastewater collection system design and construction. This information provides a baseline to anticipate the conditions to be encountered during construction of the project, to design the pipe trench section for rigid and flexible pipe, to determine installation methods to minimize risks, to accurately estimate project costs, and to minimize construction cost escalations.

The Designer shall have a geotechnical report prepared by a geotechnical engineer and include a discussion of the general soil and groundwater conditions underlying the proposed project site. For each project, the Designer and geotechnical engineer shall determine the number of soil borings to adequately define the variability of the soils in the project area. Geotechnical investigations should include at a minimum, the following:

- Description of the project area topography, landform, and geological formation.
- A site plan showing the location of the soil borings or test pits. All soil borings and test pits shall be assigned latitude and longitude coordinates and elevations, referenced to NAD83. Soil borings shall be located within 25 feet either side of the proposed sewer alignment, where possible. Soil borings shall be performed at all proposed pumping station sites.
- Soil profiles from the soil borings or test pits shall extend a minimum of 5 feet deeper than the planned depth of construction. The water table, if applicable, shall be shown on the soil profiles. The soil blow counts shall be shown on the profiles. Prepare soil descriptions in accordance with the current Unified Soil Classification System (USCS).
- Description of anticipated seasonal water table range. Discussion of the effect the water table may have on any proposed construction including recommendations for shoring, dewatering, and trench foundation stabilization.
- Recommended design of the trench section for rigid and flexible pipe, including suitability of the existing site soils for backfill above the pipe.
- Recommended design of the pumping station foundation, as applicable.

Trenchless design projects will require a detailed geotechnical investigation, the scope of which is not included in this Manual.
2.11 Right-of-Way and Easements

All public sanitary sewer collection systems shall be located within dedicated public right-of-way to the maximum extent practical. Public sanitary sewers and appurtenances may be located in easements granted to the City only where locating the sewer in public right-of-way is not practical. Easement widths shall be sufficiently wide to allow for future maintenance of the sewer and appurtenant structures. In locations where long easements traverse inaccessible areas, the Designer must provide access easements at regular intervals to allow maintenance vehicles to access the sewer. The Designer shall ensure access easements on either side of the stream for aerial crossings or an inverted siphon. Generally, easements shall conform to the requirements provided in Table 2-1.

Table 2-1. Easement Widths

<table>
<thead>
<tr>
<th>Pipe Size (I.D.)</th>
<th>Less than 10 feet</th>
<th>10-15 feet</th>
<th>15-20 feet</th>
<th>Greater than 20 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 inches and smaller</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>16 inches to 30 inches</td>
<td>30</td>
<td>40</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>31 inches to 54 inches</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Greater than 54 inches</td>
<td>Discuss with City of Omaha Public Works Department</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.12 Environmental Investigations

Environmental investigations and subsequent permitting needs should be considered during the design. A list of various permits that may be applicable to the project are included in Appendix B. At a minimum, the Designer’s environmental investigation should consider the following:

- Historical use of the property
  
  The Douglas County GIS Data is available at its website, [www.dogis.org](http://www.dogis.org), and includes a Historic Preservation geodatabase that provides locations of local landmark sites, national register sites, local heritage districts, and national register historic districts.

- Floodplain Classification
  
  The Federal Emergency Management Agency (FEMA) Flood Map Service Center is available at its website: [https://msc.fema.gov/portal/](https://msc.fema.gov/portal/).

- Lead Registry
  
  The Omaha lead registry database is available online with an interactive map at its website: [www.omahalead.org](http://www.omahalead.org).

- Wetlands
  
  The United States Fish and Wildlife Service (USFWS) National Wetlands Inventory Map is available at its website: [https://www.fws.gov/wetlands/Data/Mapper.html](https://www.fws.gov/wetlands/Data/Mapper.html).

- Waterways
  
  The United States Geologic Survey (USGS) National Hydrography Dataset (NHD) is available at its website: [https://viewer.nationalmap.gov/advanced-viewer](https://viewer.nationalmap.gov/advanced-viewer).
• **Wells**

  The Nebraska Department of Natural Resources (DNR) groundwater well database is available online with an interactive map at its website: [https://dnr.nebraska.gov/groundwater](https://dnr.nebraska.gov/groundwater).

• **Threatened and Endangered Species**

  The Nebraska Game and Parks Commission (NGPC) provides an online tool to submit proposed projects for environmental review; the Conservation and Environmental Review Tool (CERT) will assist in determining the project’s effect on threatened and endangered species and their habitat. CERT is available at NGPC’s website: [https://cert.outdoornebraska.gov](https://cert.outdoornebraska.gov).

• **Hazardous Materials Review**

  NDEQ maintains an interactive mapping tool that provides locations of facilities and entities the NDEQ has, or had, an interest in (for example, leaking underground storage tanks [LUST], brownfields sites, and superfund sites). The interactive map is available at NDEQ’s website: [http://deqims2.deq.state.ne.us/deqflex/DEQ.html](http://deqims2.deq.state.ne.us/deqflex/DEQ.html).

The Designer should be aware of the Migratory Bird Treaty Act (MBTA). The MBTA protects the majority of avian species, except non-migratory game birds such as pheasants, grouse, quail, or any species introduced into the United States such as pigeons, starlings, and house sparrows. The MBTA protects migratory birds from activities that would affect the bird, its nest, or its egg. In an effort to reduce the likelihood of effects on migratory birds, tree removal activity should occur between October and April. Should any proposed construction activity require removal of trees from the project area during the nesting season (April 1 through September 30), the area may require a survey to determine whether migratory birds and their nests would be disturbed.

### 2.13 City GIS Coordination

City GIS staff will provide to the Designer identification numbers for all proposed pipes and structures. The identification numbers will be assigned at approximately the 90 percent design level (or earlier upon request of the Designer). The identification numbers should be displayed on the plans in the structure and pipes tables as well as in the profile view in the following format:

- **Structures**: City GIS No. XXXXXXXX (seven or eight characters)
- **Pipes**: City GIS No. XXXXXXXX (seven or eight characters)

If changes occur to the design after identification numbers have been assigned, the Designer should contact City GIS staff at 402-444-5332 to request additional identification numbers.

### 2.14 Sanitary Sewer Design Report

The Designer shall submit to Public Works a sanitary sewer design report at approximately the 30 percent and 90 percent design level for any projects that make improvements to the public sanitary sewer system. This requirement includes private property improvements that include a connection to the City public sanitary sewer system.

The 30 percent report shall include at a minimum:

- A narrative description of the project including the name, City project number (if applicable), location, purpose, and type and size of development (residential, nonresidential, or industrial).
• A vicinity map showing the location of the project with major streets labeled.
• A site map showing the tributary area for each manhole used in the sanitary sewer design calculations.
• Sanitary sewer design calculations for the new sewers. See Appendix C for the recommended gravity sewer design calculation form, or use a similar form.
• The effect of the project’s expected peak flow on the sewer system downstream, from the point of connection to the first significant outfall point, as determined by the Designer.
• If future development upstream of the project is anticipated, the estimated peak flow from upstream development is to be calculated and routed through the project to assess the effects of such flows on the entire system.
• An appendix including the existing manhole survey investigation results in Portable Document Format (PDF).
• An appendix including flow monitoring analysis results in PDF, if applicable.

The 90 percent report shall be considered a technical submission for public record and shall be sealed by a Professional Engineer registered in the State of Nebraska in accordance with the Nebraska Engineering and Architecture Regulation Act Handbook.

The 90 percent report shall be an update to the 30 percent report and shall include at a minimum:

• An update to any calculations included in the 30 percent report.
• A discussion of the geotechnical investigation results and the resulting pipeline strength design calculations and trench design.

2.15 Sanitary Sewer Construction Documents

The guidance document for plan submittals has been included in Appendix D to assist the Designer in the preparation of plans for submittal to the City.

2.16 As-Built Construction Documents

The guidance document for as-built plan submittals has been included in Appendix E to assist the Designer in the preparation of as-built plans for submittal to the City.
Chapter 3  Quantity of Wastewater

3.1  Design Criteria

Designers shall design all sanitary sewers to carry the flow from all existing and future development occurring within its tributary area for the project service life of the pipe. The service life for sewer components shall be as shown in Table 3-1.

Table 3-1. Sewer Component Service Life

<table>
<thead>
<tr>
<th>Sewer System</th>
<th>Project Service Life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity sewer pipes</td>
<td>50–100</td>
</tr>
<tr>
<td>Force mains</td>
<td>50</td>
</tr>
<tr>
<td>Manholes</td>
<td>50</td>
</tr>
<tr>
<td>Pumping stations</td>
<td>50</td>
</tr>
<tr>
<td>Pumping stations mechanical equipment</td>
<td>25</td>
</tr>
</tbody>
</table>

3.2  Projection of Flows

The Designer is encouraged to use its own judgment for the projection of flows in conjunction with the following guidelines. See Appendix C for a sample gravity sanitary sewer calculation sheet. The projection of flows for new sewers shall be calculated for every sewer reach (manhole to manhole) using the following information:

3.2.1  Tributary Area

The tributary area of a sewer includes all areas that would contribute flows to the system. The Designer shall review record drawings and GIS data to define the tributary area boundary for every sewer reach.

3.2.2  Land Use

Current land use zoning information is available online at the Douglas County GIS website: www.dogis.org. Future land use and zoning information is available through MAPA. The Designer shall use the land use that results in higher equivalent population.

3.2.3  Equivalent Population

The equivalent population is the sum of the residential and nonresidential population. Population density shall be based on the values listed in Table 3-2, if the specific data is unknown.

**Residential Population** – includes the population from any house, apartment, mobile home, hotel, school dormitory, prison, nursing home, or other dwelling unit where people live.

**Nonresidential population** – includes the population from employees in office, commercial, and institutional areas.

\[
\text{Equivalent Population} = \text{Residential Population} + \text{Nonresidential Population}
\]
Table 3-2. Population Density

<table>
<thead>
<tr>
<th>Land Use Type</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (House, Apartment, Mobile Home)</td>
<td>2.47 people per dwelling unit</td>
</tr>
<tr>
<td>Residential (Other)</td>
<td>44 people per acre of floor space(^1)</td>
</tr>
<tr>
<td>Nonresidential</td>
<td>150 employees per acre of floor space(^1)</td>
</tr>
</tbody>
</table>

\(^1\) Use only if specific data is unknown.

3.2.4 Unit Flow Rate

The unit flow rate is the sewer flow in gallons per capita per day (gpcpd). The unit flow rate shall be based on the values shown in Table 3-3.

Table 3-3. Unit Flow Rate

<table>
<thead>
<tr>
<th>Land Use Type</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>83 gpcpd</td>
</tr>
<tr>
<td>Nonresidential</td>
<td>30 gpcpd</td>
</tr>
</tbody>
</table>

gpcpd = gallons per capita per day.

3.2.5 Industrial Flow

Industrial flow is industrial wastewater discharged (gpcpd) from a facility that uses water in the manufacture of products. For manufacturing industries, especially large factories, wastewater generation should be developed on a case-by-case basis. The Designer should inquire if a water audit has been performed for the facility to assist in wastewater forecasting. Industrial wastewater classification and discharge requirements are discussed in City of Omaha Municipal Code, Chapter 31.

3.2.6 Average Dry Weather Flow

Average Dry Weather Flow (ADWF) is the average daily sewer flow in gallons per day (gpd) or million gallons per day (mgd).

\[
ADWF = (\text{Residential Population} \times \text{Residential Unit Flow Rate}) + \\
(\text{Nonresidential Population} \times \text{Nonresidential Unit Flow Rate}) + \text{Industrial Flow}
\]

3.2.7 Infiltration and Inflow

Infiltration and Inflow (I/I) is the infiltration of groundwater entering the sewer through joints, walls, and cracks and the inflow of rainfall from illicit connections such as roof connections or manhole covers (gpd or mgd). The I/I flow rate shall be based on the value shown in Table 3-4 if the specific data is unknown.

\[
I/I = (\text{Residential Population} + \text{Nonresidential Population}) \times (I/I \text{ Flow Rate})
\]

Table 3-4. I/I Flow Rate

<table>
<thead>
<tr>
<th>Contribution</th>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration and Inflow (I/I)</td>
<td>17 gpcpd</td>
</tr>
</tbody>
</table>

gpcpd = gallons per capita per day.
3.2.8 Average Wet Weather Flow
The Average Wet Weather Flow (AWWF) is the sum of the ADWF and the I/I (gpd or mgd).

\[ AWWF = ADWF + I/I \]

3.2.9 Peaking Factor
The Peaking Factor (PF) is the ratio of the peak wet weather flow (PWWF) to the AWWF. The PF is dependent on the equivalent population (unitless).

\[ PF = 4.5 - 0.5x \log_{10}(Population) \]

3.2.10 Peak Wet Weather Flow
The PWWF is the largest hourly flow during the end of the service life of the pipe (gpd or mgd). The PWWF for new sewers shall be calculated for each sewer reach (manhole to manhole). The PWWF will be used for capacity design of the pipe.

\[ PWWF = PF \times AWWF \]
Chapter 4  Design of Gravity Sewers

4.1 Sewer Design Computation Sheet

Appendix C shows a typical gravity sewer design computation form. All Designers should use this computation form or a similar format for the design of gravity sewers acceptable to the City. In lieu of the computation form, computer derived computational methods are acceptable alongside a descriptive narrative of the inputs, equations, and computational results for City review.

4.2 Hydraulics

For the hydraulic design of sanitary sewers, one-dimensional, incompressible, steady, uniform flow is acceptable to assume. Use Manning’s equation to determine hydraulic capacity.

\[ Q = \frac{1.486 \times A \times R^{2/3} \times S^{1/2}}{n} \]

Where:

- \( Q \) = Volumetric Flow Rate (cfs)
- \( A \) = Cross sectional area of pipe (square feet)
- \( R \) = Hydraulic radius = Area/Wetted Perimeter = \( A/P \)
- \( P \) = Wetted perimeter (feet)
- \( S \) = Slope (ft/ft)
- \( n \) = Manning’s Roughness Coefficient (dimensionless)

Manning’s equation can be rewritten to determine pipe diameter as a function of flow rate, Manning’s roughness coefficient, and slope:

\[ D = 1.559 \left( \frac{n \times Q}{1.486 \times S^{2/3}} \right)^{3/8} \]

A Manning’s Roughness Coefficient \( n \) of 0.013 shall be used for all gravity sewer pipe materials. The City has selected a constant value for the roughness coefficient although studies have shown it can vary as a function of flow depth, pipe size, and material. Use of the constant value simplifies pipe design and provides an accepted standard for designing sewers without compromising the integrity of the sanitary sewer collection system.

The hydraulic grade line shall be calculated to show its elevation at manholes and junction points of flow in pipes, and shall provide for the losses and the differences in elevation as required. The Designer shall determine friction losses of the sanitary sewer collection. Manning’s equation can be rewritten to determine friction losses as either 1) a function of slope, length, and flow velocity or 2) as a function of flow depth, length and velocity:

1).

\[ H_f = \frac{(2.87 \times n^2 \times V^2 \times L)}{S^{4/3}} \]
2).

\[ H_f = \frac{(29 \times n^2 \times V^2 \times L)}{R^{4/3} \times 2g} \]

Where:

- \( H_f \) = Total head loss due to friction (feet)
- \( L \) = Length of pipe (feet)
- \( g \) = Gravitational constant (32.2 ft/s^2)
- \( V \) = Velocity (ft/s)

### 4.3 Pipe Velocity, Slope, and Capacity

Slope is the key criterion in designing a wastewater collection system to avoid sulfide problems. In an effort to provide adequate cleansing velocity and prevent sulfide and odor generation, the Designer should design pipes to provide a minimum velocity of 3.5 feet per second at PWWF. The maximum allowable velocity in a pipe is 8 feet per second.

If the 3.5 feet per second velocity requirement cannot be obtained, the Designer may request a design variance and the minimum pipe slopes shown in Table 4-1 should be provided, as identified in the Ten State Standards.

Designers should assume full flow capacity at a depth of 0.80 of the pipe diameter (d/D = 0.80). The corresponding pipe capacity and pipe velocity at d/D = 0.80 shown in the table were calculated using a Manning’s Roughness Coefficient (n) value of 0.013.

#### Table 4-1. Minimum Slopes

<table>
<thead>
<tr>
<th>Nominal Sewer Size (inches)</th>
<th>Minimum Slope %</th>
<th>Pipe Capacity at d/D = 0.80 (cfs)</th>
<th>Pipe Velocity at d/D = 0.80 (ft/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0.40</td>
<td>0.75</td>
<td>2.50</td>
</tr>
<tr>
<td>10</td>
<td>0.28</td>
<td>1.13</td>
<td>2.42</td>
</tr>
<tr>
<td>12</td>
<td>0.22</td>
<td>1.63</td>
<td>2.43</td>
</tr>
<tr>
<td>15</td>
<td>0.15</td>
<td>2.45</td>
<td>2.32</td>
</tr>
<tr>
<td>18</td>
<td>0.12</td>
<td>3.56</td>
<td>2.35</td>
</tr>
<tr>
<td>21</td>
<td>0.10</td>
<td>4.90</td>
<td>2.37</td>
</tr>
<tr>
<td>24</td>
<td>0.08</td>
<td>6.25</td>
<td>2.32</td>
</tr>
<tr>
<td>27</td>
<td>0.067</td>
<td>7.84</td>
<td>2.30</td>
</tr>
<tr>
<td>30</td>
<td>0.058</td>
<td>9.66</td>
<td>2.29</td>
</tr>
<tr>
<td>36</td>
<td>0.046</td>
<td>13.98</td>
<td>2.31</td>
</tr>
<tr>
<td>42</td>
<td>0.037</td>
<td>18.92</td>
<td>2.29</td>
</tr>
</tbody>
</table>

---

4.4 Depth of Public Sewer

In general, sewers shall be sufficiently deep to receive wastewater from basements and to prevent freezing. The Designer should assume a 1 percent grade from the building lateral. The public sewer should have a minimum depth from finished grade to the top of pipe of 8 feet. Exceptions to the minimum depth are allowed in the presence of a high ground water table or structures with no basements, and at S&ID Outfall sewers where the City allows a minimum depth of 5 feet.

4.5 Private Sewers and Sewer Laterals

Private sewers and sewer laterals shall comply with the Omaha Municipal Code, Chapter 49 and the Plumbing Code.

4.6 Minimum Size of Pipes

The minimum size of pipes permitted for public gravity sewers is 8-inch diameter. Lateral sewer connections to public sewers shall comply with the Omaha Municipal Code, Chapter 49 and the Plumbing Code.

4.7 Alignment

All public gravity sewers shall be designed with straight alignment between manholes. Where possible, public gravity sewers placed in the roadway should be located in the center of the driving lane, because manholes should stay out of the wheel track.

4.8 Increasing Size

Pipe size changes shall occur at a manhole. Match the 0.8 depth point of both sewers (see Section 4.11.4).

4.9 Pipe Material

The sanitary sewer pipe material used should be evaluated carefully for each proposed project. No single pipe product would provide optimum capability for each sanitary sewer location. The Designer is responsible for selecting a pipe material that would provide a properly functioning pipe at a reasonable cost; however, it is not intended for materials listed in the Standard Specifications to be considered equal or generally interchangeable for all applications.

The following pipe materials are acceptable according to the Standard Specifications at the time of publication:

- Rigid:
  - Plastic Lined Reinforced Concrete Pipe (RCP)
  - Vitrified Clay Pipe (VCP)

- Flexible:
  - Lined Ductile Iron Pipe (DIP)
  - Polyvinyl Chloride Pipe (PVC)
  - Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe (CCFRPM)

The City requires Designers to use rigid pipe beneath any Federal Highway Administration (FHWA) classified roadway. In addition, the Designer should review all state and federal
requirements as applicable beneath their roadways, because steel casing pipe may be required (see Section 4.16 for design guidance when using steel casing pipe). MAPA maintains a map of roads in compliance with the FHWA guidance on highway functional classification on its website: [http://mapacog.org/data-maps/federal-functional-classification/](http://mapacog.org/data-maps/federal-functional-classification/).

Determination of pipeline strength design is required for both rigid and flexible pipe (see Section 4.10). The Designer shall include the pipe material, strength class or pipe stiffness, and trench design on the construction plans.

### 4.10 Pipeline Strength Design

The Designer shall design all sewers taking into consideration the combined dead and live loads expected on them for the pipe design life. The Designer shall submit calculations demonstrating that the pipe material, strength class, or pipe stiffness is suitable for the pipe bury depth and trench design conditions.

#### 4.10.1 Dead Loads

A minimum value of the dry unit weight of soil of 125 pounds per cubic foot (lbs/ft\(^3\)) shall be used.

#### 4.10.2 Live Loads

All pipes in streets, highways, and other traveled ways must support the American Association of State Highway and Transportation Officials (AASHTO) H-20 live loads in addition to dead loads.

All pipes within railroad right-of-way or railroad live load zone of influence, whichever is greater, shall be designed to support the American Railway Engineering and Maintenance of Way Association (AREMA) Cooper E-80 live loads.

#### 4.10.3 Rigid Pipe

In the trench, rigid pipe differs from flexible pipe in the way it resists soil and live loading through the internal strength of the pipe material. The use of the Marston-Spangler Theory of Loads and Supporting Strength is applicable for all rigid pipe materials. The Designer is encouraged to reference the National Clay Pipe Institute’s *Vitrified Clay Pipe Engineering Manual* and the American Concrete Pipe Association’s *Concrete Pipe Design Manual* for rigid pipe strength design.

\[
W = CYB^2
\]

Where:
- \(W\) = Vertical load per unit length acting on the sewer pipe (lbs/ft\(^2\))
- \(C\) = Dimensionless coefficient accounting for trench conditions and pipe depth
- \(Y\) = Dry unit weight of soil 125 (lbs/ft\(^3\))
- \(B\) = Trench width or sewer pipe width, depending on installation conditions (ft)
Example Problem: Dead Load on a Rigid Pipe

Given: A rigid pipe is buried in a trench with a width of 4 feet and a trench condition with a C value of 1.30.

Required: Calculate the maximum dead load on the pipe.

\[ W = 1.30 \times 125 \times 4^2 \]
\[ W = 2,600 \text{ lbs/ft}^2 \]

The Designer shall review the rigid pipe strength and determine if the pipe has the strength to withstand the 2,600 lbs/ft² dead load on the pipe.

4.10.4 Flexible Pipe

In the trench, flexible pipe differs from rigid pipe in the way it deflects slightly downward (vertically) and outward (horizontally), transferring the load from the pipe to the surrounding soil side fills. The Standard Specifications allow a maximum 5 percent vertical deflection on all flexible pipe installations. The use of the Modified Iowa Formula developed by Watkins and Spangler is applicable for all flexible pipe materials. The Designer is encouraged to reference the applicable manufacturer provided material for flexible pipe strength design. The minimum parameters listed in Table 4-2 shall be used, which may be modified depending on the results of the geotechnical analysis.

\[ \frac{\Delta Y}{D} = \left( \frac{D_L K P}{0.149(PS) + 0.061E^{'}} \right) 100 \]

\[ \frac{\Delta Y}{D} \] = Pipe Deflection (%)
\[ D_L \] = Deflection Lag Factor (dimensionless)
\[ K \] = Bedding Constant (dimensionless)
\[ P \] = Service load on the crown of the pipe (psi)
\[ PS \] = Pipe Stiffness (psi)
\[ E^{'}, \] = Modulus of Soil Reaction (psi)

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable Maximum Deflection</td>
<td>5%</td>
</tr>
<tr>
<td>Deflection Lag Factor ((D_L))</td>
<td>1.5</td>
</tr>
<tr>
<td>Bedding Constant (K)</td>
<td>0.10</td>
</tr>
<tr>
<td>Modulus of Elasticity (E), PVC</td>
<td>400,000</td>
</tr>
<tr>
<td>Modulus of Elasticity (E), DIP</td>
<td>29,000,000</td>
</tr>
<tr>
<td>Modulus of Soil Reaction ((E^{'}))</td>
<td>1,000-2,000</td>
</tr>
</tbody>
</table>
Example Problem: Flexible Pipe Deflection

Given: PVC SDR 35 sewer pipe with a pipe stiffness of 46 psi is confined in a saturated soil providing $E' = 1,000$ at a burial depth of 10 feet. There is no live load over the pipe. The unit weight of saturated soil ($y$) is 135 lbs/ft$^3$.

Required: What is the pipe deflection, and is it within the allowable limits?

First, calculate the service load on the pipe (psi).

$$P = \frac{yH}{144} = \frac{135 \times 10}{144} = 9.375 \text{ psi}$$

Next, calculate the deflection.

$$\frac{\Delta Y}{D} = \left( \frac{1.5 \times 0.10 \times 9.375}{0.149(46) + 0.061 \times 1000} \right) \times 100 = 2.07\%$$

This calculated value is less than the 5% maximum allowable deflection, therefore the design conditions are ok.

4.11 Manholes

Refer to the Standard Specifications and Standard Plates for sanitary sewer manhole design, material, frame and cover, construction, and testing requirements, which is suitable for most conditions. Manholes greater than 20 feet in depth or in buoyant conditions shall be designed by a Professional Engineer licensed in the State of Nebraska, and included in the plans. The nomenclature of the manhole components is as shown in Figure 4.1.
4.11.1 Manhole Location and Maximum Spacing

Manholes shall be located in areas that are accessible by maintenance vehicles at all times. Manholes shall be installed at the end of each line segment; at all changes in grade, size, or alignment, and at the confluence of two or more separate sewers. Maximum manhole spacing shall be as follows in Table 4-3.

Table 4-3. Maximum Manhole Spacing

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Maximum Manhole Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-inch to 15-inch</td>
<td>400 feet</td>
</tr>
<tr>
<td>18-inch to 30-inch</td>
<td>500 feet</td>
</tr>
<tr>
<td>Over 30-inch</td>
<td>500 feet or greater upon approval of City</td>
</tr>
</tbody>
</table>

4.11.2 Manhole Cover

The manhole cover should be:

- Placed at the finished grade elevation. Manholes cannot be buried unless permission is obtained from the City. If a manhole is buried, as-built survey and location markers are required.
- 1 foot above the 100-year flood elevation if a manhole is located within the floodway or floodplain.
• Watertight where the manhole cover is located in the floodway or the cover may be subject to flooding.

4.11.3 Manhole Size

The minimum manhole diameter shall be 54 inches. The Designer shall determine the diameter required to maintain the structural integrity of the circular manhole, which is dependent on:

1. The diameter of the intersecting pipes
2. The angle of entrance of the intersecting pipes
3. Maintaining a minimum concrete leg of 12 inches between the adjacent pipes, as shown in Figure 4.2.

Determining the required minimum manhole diameter may be done with the following equation, alongside Figure 4.2:

\[ MH_{dia} = \frac{BO_1 + BO_2 + (2 \times CL)}{\theta \times \left( \frac{\pi}{180} \right)} \]

Where:
- \( MH_{dia} \) = Manhole diameter (inches)
- \( BO_1 \) = Blockout diameter of Pipe #1 (inches)
- \( BO_2 \) = Blockout diameter of Pipe #2 (inches)
- \( CL \) = Minimum concrete leg length (12 inches)
- \( \theta \) = Angle between pipe centerline (degrees)

The Designer shall round the minimum manhole diameter calculated up to the next standard manhole size: 54 inches, 60 inches, 72 inches, 84 inches, 96 inches, 108 inches, or 120 inches. The Designer shall then verify that the manhole diameter calculated is sufficient for the largest pipe diameter (see Table 4-4). Designers are encouraged to reference online manufacturer calculators to determine manhole diameter required, which also takes into account the invert elevation of the pipes in question.
Table 4-4. Minimum Manhole Diameter Required

<table>
<thead>
<tr>
<th>Pipe Diameter (inches)</th>
<th>Minimum Manhole Diameter Required (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 27</td>
<td>54</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td>42</td>
<td>72</td>
</tr>
<tr>
<td>48</td>
<td>72</td>
</tr>
<tr>
<td>54</td>
<td>84</td>
</tr>
<tr>
<td>60</td>
<td>96</td>
</tr>
</tbody>
</table>

Example Problem: Manhole Sizing

Given: A manhole adjoins an 18-inch pipe to a 24-inch pipe. The BO\(_{(18''})\) is 28 inches, and the BO\(_{(24'')}\) is 34 inches. The angle between the pipe centerlines is 60°.

Required: Determine the minimum allowable diameter of the manhole.

\[
MH_{dia} = \frac{28 + 34 + (2 \times 12)}{60 \times \left(\frac{\pi}{180}\right)} = 82.12 \text{ inches}
\]

Rounding up to the next standard manhole size, the required manhole diameter is 96 inches.
4.11.4 Invert Drops across Manholes

Invert drops across manholes shall be as follows:

- For the same pipe size, the vertical drop across a manhole should be 0.10 foot.
- For two different pipe sizes, the Designer shall match the 0.8 depth point of all sewers.
- The maximum invert drop across a manhole without requiring construction of a drop manhole is 2 feet.

4.11.5 Drop Manholes

Drop manholes should be used sparingly and generally only when it is not economically feasible to steepen the incoming sewer. Drop connections are required when it is necessary that sanitary flow enter a manhole at a height of more than 2 feet above the manhole flowline. Drop manhole details are included in the Standard Plates.

4.11.6 Manhole Flow Channel and Bench

A manhole flow channel and bench shall be constructed in the manhole as indicated in the Standard Plates. No lateral sewer, service connection, or drop manhole pipe shall discharge onto the surface of the bench.

4.11.7 Corrosion Protection for Concrete Manholes and Structures

All concrete for wastewater structures shall be protected against corrosion using the Standard Specifications concrete mix design, which specifies Type II cement for moderate sulfate resistance. In addition, the following manhole or junction structure locations shall be lined for protection against corrosion:

- The one manhole located upstream of a pumping station;
- Manholes located at the termination of a force main (as discussed in Section 6.3);
- The structures upstream and downstream of an inverted siphon (as discussed in Section 4.14.2);
- All interceptor sewers and S&ID Outfalls.
- At all other locations where corrosive conditions due to septicity is anticipated.

4.12 Utility Crossings and Clearances

The Designer shall provide adequate clearance for crossings of potable water and utilities.

4.12.1 Sewers in Relation to Potable Water

The Designer shall provide separation between sanitary sewers and potable water mains according to the Design and Installation Guide for Water Main and Sanitary/Storm Sewer Separations (DHHS 2010) provided in Appendix F. Sanitary sewer water main crossing details are included in the Standard Plates.

4.12.2 Utilities

Special structural support design from the Designer will be required if there is less than 18 inches of vertical clearance between sanitary sewers and other public sewers. In no case shall there be less than 12 inches of clearance vertically between sanitary sewer and storm
sewer crossings. The minimum horizontal clearance from outside of a storm pipe to the outside of a sanitary pipe is 5 feet.

When crossing below or parallel to brick sewers, an existing condition analysis of the site soils shall be completed to verify the proposed construction would not have an adverse effect (cause collapse or unraveling) on the existing brick sewer.

The Designer shall coordinate with all other utility companies encountered on the project to confirm allowable clearances from their facilities.

4.13 Sewers in Relation to Watercourses

A watercourse is a channel in which a flow of water occurs either continuously or intermittently. For sewers located adjacent to or crossing a watercourse, the 100-year flood elevation boundary shall be shown on the plans, if applicable.

4.13.1 Horizontally

Sewer design and location in relation to streams should be based on the results of geotechnical investigation. Sewers located along waterways shall be located outside of the waterway at least 20 feet from the 3:1 slope projection from the normal water elevation of the waterway, and shall be constructed to remain watertight. Streams shall be protected from erosion in accordance with Chapter 9 of *The City of Omaha Regional Stormwater Design Manual* (City of Omaha 2014).

4.13.2 Vertically

The vertical depth below the stream should be based on channel material determined during the geotechnical investigation. The top of all sewers crossing a stream shall be a minimum of 5 feet below the depth of the natural bottom of the streambed. If the design does not allow for a gravity sewer beneath the stream, the Designer must evaluate the use of an inverted siphon or aerial crossing. See Section 4.14 for inverted siphons and Section 4.15 for aerial crossings. Aerial crossings will only be allowed by approval from the Public Works Director.

4.13.3 Storm Sewer Outfalls

The Designer should take appropriate measures in the placement of the sanitary sewer in relation to storm sewer outfalls. Storm sewer outfalls have historically eroded, causing exposure of the sanitary sewer, which is not acceptable. Protection of the sanitary sewer and/or additional protection of the storm sewer outfall should be incorporated into the design of sanitary sewers crossing beneath storm sewer outfalls.

4.14 Inverted Siphons

If a stream crossing is necessary, inverted siphons are preferred by the City over aerial crossings. Inverted siphon performance is very dependent on its hydraulics. The Designer shall complete a thorough hydraulic analysis. The Designer shall incorporate maintenance considerations into the design of the inverted siphon.

4.14.1 Inverted Siphon Barrels

The inverted siphon barrels should:

- Include a primary and secondary barrel, as a minimum.
- Have a minimum barrel size of 8 inches in diameter.
• Provide a self-cleansing velocity of at least 3.5 feet per second in the primary siphon barrel for the ADWF. The Designer should be aware that in the areas of Omaha with combined flow, this might not be achievable because of the addition of stormwater debris.

• Provide for 5 feet of minimum cover over the inverted siphon barrels beneath the watercourse; however, more cover may be needed depending on the geomorphological characteristics of the stream.

• Include the installation of a wye on the siphon barrel outside of the inlet and outlet structures, on the watercourse-side of the structure, with a riser pipe and secured blind flange allowing access for jetting of the siphon barrels.

### 4.14.2 Inverted Siphon Structures

Structures associated with inverted siphons include inlet and outlet structures. The structures should be sufficiently large to facilitate maintenance of the siphon barrels, including cleaning from either end. A cast-in-place structure with removable top slab panels is recommended for maintenance.

The inverted siphon structures should:

- Direct flows to the primary barrel and include lateral overflow weirs in the siphon inlet structure for flows to enter additional siphon barrels and thereby increase total siphon capacity.

- Include chamfered corners that do not allow for solids deposition in the structure.

- Include manual or automatic gates for each siphon barrel in the siphon inlet structure to allow for isolation of the barrels during maintenance. The gates should be operable from the exterior of the structure. Consider the need for gates in the siphon outlet structure to avoid backflows into siphon barrels dewatered for maintenance.

- Include rectangular maintenance access hatches located to provide a clear view of the siphon barrels when open, and a stainless steel vent with a bug screen on top.

- Be leak-proof and adequately protected from flooding. The top of the structure should be placed at least 2 feet above the 100-year flood elevation.

- Be lined with a suitable corrosion resistant material.

### 4.14.3 Inverted Siphon Hydraulic Design

The Designer should determine the selection of the total number of siphon barrels, diameters, elevation differences, and flow control devices dependent on the Designer’s chosen routing of design flows as determined in Chapter 3. A brief description of this process is as follows:

1. Use Manning’s equation (Section 4.2) for full pipe flow through each siphon to determine the siphon barrel diameters meeting the necessary self-cleansing velocity of at least 3.5 feet per second.

2. Estimate hydraulic losses through the inverted siphon barrels using the equivalent pipe length method to incorporate the variety of fittings used in the inverted siphon barrels.

3. Estimate the head loss through the inverted siphon barrels using the Hazen-Williams Equation. A conservative Hazen-Williams roughness constant of 100 for all pipe materials is recommended:
where:

\( h \) = friction head loss in feet of water per 100 feet of pipe (ft/100 ft)

\( C \) = Hazen-Williams roughness constant (dimensionless).

\( Q \) = Volume of Flow (gallons per minute)

\( D \) = Inside Diameter (inches)

**Example Problem: Estimating Head Loss Through an Inverted Siphon**

Given: An inverted siphon barrel has an inside diameter of 8 inches and a flow volume of 500 gallons per minute.

Required: Estimate the head loss using the Hazen-Williams equation.

\[
 h = 0.84 \left( \frac{100}{D} \right)^{1.852} \left( \frac{Q}{D^{4.8655}} \right)^{0.9} 
\]

\[
 h = 0.84 \left( \frac{100}{8} \right)^{1.852} \left( \frac{500}{8^{4.8655}} \right)^{0.9} 
\]

\[
 h = 0.84 \frac{ft}{100ft} 
\]

4. Determine the invert elevations and the lateral overflow weir heights in the siphon inlet and outlet structure. The elevations are dependent on the flow events into each siphon barrel, the head loss through the barrels, and the water surface elevation of the incoming and outgoing sewers.

**4.14.4 Odor Control for Inverted Siphons**

If the location of the inverted siphon allows for a reliable placement of an aerial air jumper to aid in odor control, such as alongside a bridge, an aerial air jumper should be evaluated for inclusion in the inverted siphon design. Buried air jumpers are discouraged, because they have the tendency to fill with condensation and fail to work properly.

In the absence of an air jumper, the City may require gas phase or liquid phase odor control equipment at siphon inlet structures where the potential for odor generation is deemed significant. The Designer should evaluate future operation, maintenance, and monitoring of the odor control equipment and discuss the options with the City during the early stages of design.

**4.14.5 Maintenance of Inverted Siphons**

Well-designed siphons accommodate maintenance. Using the guidance provided in this section, Designers will produce a siphon accommodating three levels of maintenance:

1. **Visual Inspection:** The inlet and outlet structures should include rectangular access hatches that allow a worker to open the lid and visually see each siphon barrel.

2. **Flushing:** Gates should be provided in the inlet structure to accommodate flushing of the siphon barrels, which would be accomplished by closing the gates in the upstream siphon inlet structure, while the next manhole upstream of the structure is monitored. At the appropriate time, the gate would be opened and the siphon barrel would be flushed with the built-up flows.
3. **Jetting**: The installation of a wye on the siphon barrels outside of the inlet and outlet structures, on the watercourse-side of the structure, with a riser pipe and blind flange allows access for jetting of the siphon barrels.

In addition to visual inspection, flushing, and jetting, the Designer should evaluate the ability to isolate flows temporarily from individual siphon barrels to allow physical entry of the pipe (if the size allows).

The Designer will be required to submit an operation and maintenance plan for all inverted siphons following construction.

### 4.14.6 Construction of Inverted Siphons

Siphon barrels may be constructed through traditional trench method or trenchless. Construction of a siphon would require coordination with the appropriate agencies. Accommodations for construction in a watercourse should be thoroughly evaluated during the design.

An example section view of a siphon inlet structure is shown in Figure 4.3.

**Figure 4.3. Siphon Inlet Structure Section View**

---

**4.15 Aerial Crossings**

Occasionally, aerial crossings will be desirable and economical in a sanitary sewer collection system. The following design requirements apply to aerial crossings:

- Aerial crossings of watercourses must be installed with a 2-foot clearance above the 50-year flood elevation. The Designer shall complete a HEC-RAS analysis to determine the 50-year flood elevation.
- Manholes placed on each side of the watercourse shall be located as follows:
  - Determine the existing normal water surface elevation.
Project a 3:1 (horizontal to vertical) slope projection to the top of bank, starting at the edge of the existing normal water surface elevation.

Place the manhole a minimum of 20 feet horizontally from the slope projection at the top of bank.

- The sanitary carrier pipe shall be placed inside a welded steel casing pipe. The designer shall determine the allowable span for the steel casing pipe and the design of the support piers based on the results of the geotechnical investigation at the site. The steel casing pipe shall extend to each manhole. See Section 4.16 for design guidance when using steel casing pipe.

- The slope banks of the watercourse disturbed during construction shall be stabilized and protected from erosion.

- The Designer shall provide a plan for an odor control system.

- The Designer shall provide access easements to the aerial crossing as discussed in Section 2.11.

### 4.16 Steel Casing Pipe

Steel casing pipe is often required beneath roadways and railroads to support the ground and provide a stable underground excavation for installation of a carrier pipe that is used to convey flow. Steel casing pipes can be used as a combination casing and carrier pipe. When using a steel casing pipe with a carrier pipe, the following should be incorporated into the design:

- Use a restrained joint carrier pipe inside a steel casing pipe. During construction, the use of restrained joint carrier pipe allows the contractor to assemble and pull the carrier pipe inside the steel casing pipe while maintaining secure pipe joints. Post-construction, a restrained-joint provides dependability during an extreme event that the carrier pipe joints remain connected.

- Casing spacers are preferred.

- Hydrostatically test the carrier pipe prior to grouting the annular space between the casing and the carrier pipe.

- Grout the annular space between the casing and the carrier pipe. During the grouting process:
  - Prevent the carrier pipe from floating by filling the pipe with water.
  - If using flexible pipe, do not collapse it.

- The over excavation void produced during trenchless installations shall be filled with contact grout.

### 4.17 Trenchless Design and Construction

Trenchless design and construction is not covered in detail in this Manual because its application is highly variable. The Standard Specifications include information on Trenchless Sewer Pipe that the Designer shall follow. See Section 4.16 for design guidance when using steel casing pipe in trenchless design and construction.
4.18 Sewers on Steep Slopes

The Designer should consider the use of trench plugs for sewers located in clay or silty soils with moderate to steep slopes. Trench plugs should not be used in sandy soils. The recommended spacing for trench plugs is as follows:

- Not over 300 feet center to center on grades of 5 percent to 15 percent.
- Not over 200 feet center to center on grades of 15 percent to 30 percent.
- Not over 100 feet center to center on grades of 30 percent or greater.

As identified in Ten State Standards, sewers on 20 percent slopes or greater shall be anchored securely with concrete, or equal, anchors spaced as follows:

- Not over 36 feet center to center on grades of 20 percent up to 35 percent.
- Not over 24 feet center to center on grades of 35 percent up to 50 percent.
- Not over 16 feet center to center on grades of 50 percent or greater.

4.19 Railroad Crossings

For projects that enter a railroad company’s right-of-way, the Designer shall follow the requirements of the railroad company. See Section 4.16 for design guidance when using steel casing pipe.

4.20 Construction and Testing

All sewers shall be constructed and tested in conformance with the minimum standards as established by the Standard Specifications.

4.21 Abandonment

The Standard Specifications include information on Pipe and Structures Abandonment that the Designer shall follow.
5.1 Introduction

Wastewater pumping stations should be employed only when gravity flow is not feasible. Should a pumping station be a design consideration, prior approval from Public Works will be required.

This section provides the basic guidelines for designing wastewater pumping stations within the jurisdiction of the City. At a minimum, pumping station design is to be in accordance with 123 NAC 1–12, Ten States Standards, and ANSI/HI 9.8.

The pumping station design guidelines presented in this section apply to small and medium stations with capacity up to 3,200 gallons per minute (gpm) and large pumping stations with capacity between 3,200 gpm to 5,000 gpm. Small to medium stations typically include a circular wet well with duplex submersible non-clog pumps. Large pumping stations typically include a circular wet well with triplex submersible non-clog pumps. The Designer shall coordinate with Public Works to determine the number of pumps needed, based on the capacity of the pumping station.

For circular pumping stations larger than 5,000 gpm (7.2 mgd), and not covered by this Manual, a physical model study is required.

5.1.1 References

The Designer shall consult the latest version of the following key references related to pumping station design, where applicable:

- American National Standards Institute (ANSI) and Hydraulic Institute (HI) Design Standards
  - ANSI/HI 1.1-1.2 Nomenclature and Definitions
  - ANSI/HI 1.3 Design and Application
  - ANSI/HI 1.4 Manuals Describing Installation, Operation, and Maintenance
  - ANSI/HI 9.6.1 Guideline for Net Positive Suction Head (NPSH) Margin
  - ANSI/HI 9.6.3 Guideline for Allowable Operating Region
  - ANSI/HI 9.6.4 Vibration Measurements and Allowable Values
  - ANSI/HI 9.6.6 Pump Piping
  - ANSI/HI 9.8 Pump Intake Design
  - ANSI/HI 11.6 Submersible Pumps - Hydraulic Performance, Hydrostatic Pressure, Mechanical, and Electrical Tests
  - ANSI/HI 14.6 Performance Acceptance Tests
- Ten State Standards
5.2 General Requirements for Pumping Station

The pumping station structure typically consists of a below-grade wet well receiving sewage; an adjacent below-grade valve vault housing associated piping and valves; and an above-grade electrical control panel, which may include motor soft starts and the standby emergency generator transfer switch. In some cases, there may be separate buildings housing the emergency generator, electrical equipment, shop facilities, storage area, and other support facilities and functions. The City prefers submersible pumps located in a wet well structure with valves located in an adjacent valve vault.

The structural and electrical design of wastewater pumping stations shall be in conformance with applicable building and industry codes.

The design process typically includes the following steps:

1. Basic pump selection
   a. Determination of influent flows
   b. Evaluation of pump hydraulics
2. Wet-well design
3. Controls and operation design

5.3 Basic Pump Selection

5.3.1 Influent Flow

In accordance with 123 NAC 1–12, pumping stations are required to have a firm pumping capacity equal to or greater than the peak hourly flow. The peak hourly flow is the largest volume of flow to be received at the pumping station during a 1-hour period. Firm pumping capacity is defined as the flow rate a facility is able to discharge with the largest pump out of service.

Wastewater flows shall be determined as discussed in Chapter 3.

5.3.2 Pump Hydraulics

5.3.2.1 System Curve

The first step in the pump selection process is to develop the system curve. The pumping station influent flow rate along with the force main size, material, and alignment are needed to generate a system curve. The calculation of hydraulic losses in the force main at several different flow rates determines the system curve. The hydraulic losses are composed of two elements, the static head and the friction head.

- Static head (ΔH) is defined as the difference between the force main discharge elevation (pipe outlet) and the water elevation in the wet well.
- Friction head is defined as the sum of the friction losses in the force main and the minor losses through fittings and valves. The friction losses are dependent on the flow rate, pipe diameter, and pipe material. There are several methods for calculating friction losses including the Hazen-Williams equation and the Darcy-Weisbach equation.
The Hazen-Williams equation typically is used because of its simplicity. The conventional form of the equation follows:

\[ h_f = \frac{10.44 * L * Q^{1.85}}{C^{1.85} * D^{4.8655}} \]

Where:
- \( h_f \) = head loss due to friction (feet)
- \( L \) = force main pipe length (feet)
- \( Q \) = flow rate (gpm)
- \( C \) = Hazen-Williams coefficient (dimensionless)
- \( D \) = force main pipe diameter (inches)

The Hazen-Williams coefficient depends on the pipe material, fluid to be conveyed, and the age of the pipe. For design purposes, Ten State Standards recommends the aged pipe (design) \( C \) valves to be used, as shown in Table 5-1.

**Table 5-1. Recommended Standards for Aged Pipe**

<table>
<thead>
<tr>
<th>Pipe Materials</th>
<th>Hazen-Williams Coefficient, ( C )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Pipe</td>
</tr>
<tr>
<td>Unlined ductile iron or steel pipe</td>
<td>130</td>
</tr>
<tr>
<td>PVC or High-density polyethylene (HDPE)</td>
<td>150</td>
</tr>
<tr>
<td>Lined ductile iron or steel pipe</td>
<td>140</td>
</tr>
</tbody>
</table>

**Example Problem: Head Loss Due to Friction**

Given: A PVC force main has a length of 2,500 feet and a diameter of 12 inches. Flow through the pipe is traveling at 425 gallons per minute.

Required: Calculate the head loss due to friction using the Hazen-Williams Equation.

\[ h_f = \frac{10.44 * 2,500 * 425^{1.85}}{120^{1.85} * 12^{4.8655}} \]

\[ h_f = 1.52 \text{ feet} \]

Minor losses are those energy losses encountered as wastewater flows through bends, valves, tees, reducers, etc. Minor losses are typically calculated using the following formula:

\[ h_m = \sum K \frac{v^2}{2g} \]

Where:
- \( h_m \) = minor head loss (feet)
- \( K \) = loss coefficient, based upon fitting (see Table 5-2) (dimensionless)
- \( v \) = velocity of flow (feet per second)
- \( g \) = gravity (32.2 feet per second per second)
Typical K values for standard fittings are provided in Table 5-2. These values should be confirmed with specific manufacturer’s recommendations.

Table 5-2. Minor Loss Coefficient - K Values

<table>
<thead>
<tr>
<th>Item</th>
<th>Loss Coefficient, K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance</td>
<td></td>
</tr>
<tr>
<td>Bellmouth</td>
<td>0.05</td>
</tr>
<tr>
<td>Rounded</td>
<td>0.25</td>
</tr>
<tr>
<td>Sharp Edged</td>
<td>0.5</td>
</tr>
<tr>
<td>Projecting</td>
<td>0.8</td>
</tr>
<tr>
<td>Exit</td>
<td>1.0</td>
</tr>
<tr>
<td>90 Bend, standard</td>
<td>0.25</td>
</tr>
<tr>
<td>45 Bend, standard</td>
<td>0.18</td>
</tr>
<tr>
<td>Tee, line flow</td>
<td>0.30</td>
</tr>
<tr>
<td>Tee, branch flow</td>
<td>0.75</td>
</tr>
<tr>
<td>Cross, line flow</td>
<td>0.5</td>
</tr>
<tr>
<td>Cross, branch flow</td>
<td>0.75</td>
</tr>
<tr>
<td>Wye, 45</td>
<td>0.5</td>
</tr>
<tr>
<td>Ball Valve</td>
<td>0.04</td>
</tr>
<tr>
<td>Check Valve</td>
<td></td>
</tr>
<tr>
<td>Ball</td>
<td>0.9 - 1.7</td>
</tr>
<tr>
<td>Swing</td>
<td>0.6 - 2.2</td>
</tr>
<tr>
<td>Gate Valve</td>
<td></td>
</tr>
<tr>
<td>Resilient Seat</td>
<td>0.3</td>
</tr>
<tr>
<td>Knife Gate Valve</td>
<td></td>
</tr>
<tr>
<td>Metal Seat</td>
<td>0.2</td>
</tr>
<tr>
<td>Resilient Seat</td>
<td>0.3</td>
</tr>
<tr>
<td>Plug Valve</td>
<td></td>
</tr>
<tr>
<td>Rectangular (80%) Opening</td>
<td>1.0</td>
</tr>
<tr>
<td>Full Bore Opening</td>
<td>0.5</td>
</tr>
<tr>
<td>Reducer</td>
<td>0.5</td>
</tr>
<tr>
<td>Increaser</td>
<td>1.0</td>
</tr>
</tbody>
</table>


Note: Loss Coefficient, K value, is an approximation, varies with pipe size and material, and could differ by 25 percent among various publications.

Example Problem: Minor Losses

Given: Water enters a piping system at 4 ft/s through a sharp edged entrance, then travels through a 90 degree bend, followed by a reducer, which increases the velocity to 6 ft/s. After the reducer, the water flows through a 45 degree bend, and finally through a gate valve.

Required: Calculate the minor head loss of the system. For a reducer or increaser, use the velocity of the smaller diameter.

\[
h_m = \sum K \frac{v^2}{2g} = 0.5 \frac{4^2}{2g} + 0.25 \frac{4^2}{2g} + 0.5 \frac{6^2}{2g} + 0.18 \frac{6^2}{2g} + 0.3 \frac{6^2}{2g}
\]

\[
h_m = \frac{4^2}{2 \times 32.2} (0.5 + 0.25) + \frac{6^2}{2 \times 32.2} (0.5 + 0.18 + 0.3) = 0.734 \text{ feet}
\]
Total Dynamic Head (TDH) is defined as the total equivalent height that fluid is to be pumped taking into account the friction losses in the pipe:

\[ TDH = \Delta H + h_f + h_m \]

The system curve is developed by calculating TDH values at incremental flow rates. An example system curve is provided in Figure 5.1. The Figure provides the system curve for new PVC pipe with a C value of 150 and aged PVC pipe with a C value of 120. The system curve provided in Figure 5.1 presents the high water level (HWL) and low water level (LWL) variability. As the water level in the wet well increases or decreases, the static head (\( \Delta H \)) changes. For constant speed pumps, the pump selection should account for the change in static head due to varying water levels in the wet well. The Designer should assume higher water levels (HWL) for PWWF and select a pump curve that crosses the system curve at the desired flow rate at firm capacity.

Figure 5.1. System Curve

### 5.3.2.2 Pump Curve

After the influent flow rate has been determined and the system curve has been established, solicitations should be obtained from pump manufacturers. The City’s preference is for constant speed pumping stations and should be communicated for pump selection. Manufacturers will provide a pump selection and an associated pump curve. The pump curve is plotted with the system curve. The optimal operating point is at the intersection of the pump curve and the system curve. For constant speed pumps, the pump selection should be able to operate at both
the LWL and HWL optimum operating points to account for the water level changes in the wet well. An example pump curve is provided in Figure 5.2.

**Figure 5.2. Pump Curve**

Pump curves provided by the manufacturers will typically include pump head capacity curve, efficiency curve, Net Positive Suction Head Required (NPSHr) curve, and the power curve. Each of these characteristic curves are important in the selecting the appropriate pump for the intended application.

- **Efficiency curve**: The efficiency curve provides the ratio of energy delivered by the pump to the energy supplied. Selecting the optimum pumping efficiency improves the reliability of the pump and reduces wear and tear on the rotating parts.
- **NPSHr curve**: The NPSHr curve provides the minimum amount of pressure on the suction side of the pump to overcome pump entrance losses.
- **Power curve**: The power curve provides the horsepower required to operate the pump at a given flow rate.

An example manufacturer pump curve is provided in Figure 5.3. The Figure shows the pump operating condition, pump efficiency, power, and NPSHr for a specified flow rate and associated TDH.
5.3.2.3 Net Positive Suction Head

Net Positive Suction Head Available (NPSHa) is an important parameter in the pump design and selection. The designer needs to determine the NPSHa. The NPSHa is based on the system in which the pump operates and can limit the operation of the pump. As the NPSHa approaches the NPSHr, adverse flow conditions develop at the impeller at the pump, reducing pump efficiency and causing wear on the pump. If the NPSHa is less than the NPSHr, the pump may cavitate causing severe damage to the pump impeller. Typically, the NPSHa should be at least 1.3 times the NPSHr. This provides a safety factor against adverse flow conditions developing at the impeller.

The NPSHa is dependent on the elevation difference between the pump centerline and the water surface in the wet well (static suction head), the head losses in the suction piping, atmospheric pressure in the wet well, and the vapor pressure of the liquid being pumped. The static suction head is positive when the water level is above the pump, and is negative when the water level is below the pump.
NPSHa is calculated with the following equation:

\[ NPSHa = PB + LH - V_P - h_f \]

Where:
- PB = Atmospheric pressure (feet)
- LH = Minimum static suction head (feet)
- VP = Vapor pressure of the liquid being pumped (feet)
- Hf = Friction losses in the suction piping (feet)

5.4 Wet Well Design

Pumping station wet wells shall be designed based on the following objectives:

- Eliminate or minimize the deposition and accumulation of solids and scum to minimize maintenance and reduce septicity, odors, corrosion, and release of hazardous gases.
- Minimize the potential for vortexing, swirling, and excessive turbulence from incoming flow that can result in submerged and free surface vortices, entrainment of air, formation of rag balls, and pump reliability problems.
- Avoid frequent starting of pumps.
- Avoid excessively long wet well detention time.

5.4.1 Site Location

The pumping station site location shall be coordinated with the City. The location must consider access for vehicles, operation and maintenance, overhead obstructions, power, and natural gas utility proximity, odors, and flooding. Protective bollard installation will be determined on a site case-specific basis.

The pumping station site location shall be selected to protect the structure and electrical equipment from damage due to a 100-year flood.

5.4.2 Structural Design

The structural design of wastewater pumping station structures shall be in conformance with applicable building and industry codes. Test borings shall be performed to evaluate the soil characteristics and groundwater conditions at all pumping station sites, and foundations shall be suitably designed.

Built-in-place pumping station below-grade substructures such as wet wells and vaults shall be of reinforced concrete construction. All substructures shall be watertight and shall be provided with exterior waterproofing to keep interior walls dry and minimize corrosion of reinforcing bars. The interior surface shall be lined, coated, or otherwise protected with a suitable corrosion resistant material.

Consideration shall be given to flotation during construction and/or flood conditions and provisions shall be incorporated into the design to counteract the flotation forces if they are present. Calculations shall be based on groundwater at the ground surface or the regulatory flood stage, whichever is higher. Upward forces on the floor slabs due to buoyant forces shall also be considered.

When entering or leaving structures with buried mechanical joint piping, install joint within 2 feet of the point where pipe enters or leaves the structure. Install the second joint 4 feet from the first
joint. Install expansion devices as necessary to allow expansion and contraction movement, and differential settlement.

5.4.3 Station Capacity

The wet well diameter is set by the pump configuration and spacing. It is required to obtain pump spacing requirements and minimum wet well diameter from the pump manufacturer. Pump layout and spacing should be coordinated with HI standards. The diameter of the wet well should be sized to allow space for maintenance and installation access to discharge piping flanges and bolts. Wet wells shall have a minimum inside diameter of 5 feet. The wet well floor shall be sloped toward the pump inlet to minimize wastewater solids accumulation. Refer to 123 NAC 5 003 for additional requirements for pumping stations.

Figure 5.4 presents a wet well section with the critical elevations shown.

Figure 5.4. Wet Well Section

After the horizontal dimensions have been determined, the station storage capacity and the vertical elevations can be established.

5.4.3.1 Floor Clearance

The first critical elevation is to identify the recommended floor clear of the pump inlet above the wet well floor. Typically the floor clearance, C, is between 0.3D and 0.5D. Confirm with minimum HI Standards requirements and manufacturer recommendations.

5.4.3.2 Minimum Submergence

The second critical elevation to identify is the minimum submergence for the recommended pump. Minimum submergence is defined as the distance between the pump inlet and the water
surface elevation necessary to prevent the formation of a vortex. If the water elevation is less than the minimum submergence, a vortex can form, which could allow air to enter the pump. Confirm with minimum HI Standards requirements and manufacturer recommendations.

The minimum submergence is calculated with the following equations:

\[ S = D(1 + 2.3F_D) \]
\[ F_D = \frac{v}{(gD^{0.5})} \]
\[ v = \frac{Q}{A} \]

Where:
- \( S \) = Minimum submergence (feet)
- \( D \) = Inlet diameter (feet)
- \( F_D \) = Hydraulic Froude Number (dimensionless)
- \( v \) = Velocity of flow (fps)
- \( g \) = Gravity = 32.2 fps\(^2\)
- \( Q \) = Pump discharge flow rate (cfs)
- \( A \) = Area of inlet (sq. ft.)

The minimum water surface elevation (LWL) is the sum of the floor clearance and the minimum submergence.

### Example Problem: Minimum Submergence

Given: A pump discharges water at 1.0 cfs into an 8 inch diameter pipe.

Required: What is the minimum submergence for this pump? If floor clearance (C) is 0.4D, what is the minimum water surface elevation (LWL)?

Determine the area of the pipe.

\[ 8 \text{ inches} = 0.667 \text{ feet} \]
\[ A = \frac{\pi}{4} (D^2) = \frac{\pi}{4} (0.67)^2 = 0.349 \text{ ft}^2 \]

Calculate velocity of the water.

\[ v = \frac{1.0}{0.349} = 2.87 \text{ ft/s} \]

Determine the Hydraulic Froude Number.

\[ F_D = \frac{2.87}{32.2 \times 0.67^{0.5}} = 0.109 \]

Determine the minimum submergence.

\[ S = 0.667(1 + 2.3 \times 0.109) \]
\[ S = 0.834 \text{ feet} \]

Find the floor clearance.

\[ C = 0.4 \times 0.667 \text{ ft} \]
\[ C = 0.267 \text{ ft} \]
Example Problem: Minimum Submergence

Calculate minimum water surface elevation:

\[ LWL = C + S \]
\[ LWL = 0.267 + 0.834 \]
\[ LWL = 1.10 \text{ ft} \]

5.4.3.3 Operating Volume

The storage volume between the LWL and the HWL is known as the operating volume or the active wet well volume. For constant speed pump applications, the operating volume must be sufficient to minimize the frequency of pump starts and allow resting periods to prevent damage and overheating of the pumps. Generally, for smaller pumps, pump starts should not be greater than 10 starts per hour for submersible pumps less than 50 HP, and 6 starts per hour for pumps over 50 HP. Designer must confirm pump starts and stops with manufacturer recommendations. The operating volume should not exceed a 30-minute filling time.

The minimum operating volume is calculated using the following equation:

\[ V = \frac{T \times Q}{4} \]

Where:
- \( V \) = Operating volume (gallons)
- \( T \) = Minimum cycle time between pump starts (minutes)
- \( Q \) = Pump discharge flow rate (gpm)

Critical wet well elevations are noted in Table 5-3.

Table 5-3. Critical Wet Well Elevations

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Description</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>High level alarm</td>
<td>Generate alarm when water elevation reaches 12 inches above Lag pump start</td>
<td>Float switch</td>
</tr>
<tr>
<td>Lag Pump On Level</td>
<td>Lag pump starts when water elevation reaches 12-24 inches above Lead pump start</td>
<td>Float switch</td>
</tr>
<tr>
<td>Lead Pump On Level</td>
<td>Lead pump starts at wet well cycle volume</td>
<td>Float switch</td>
</tr>
<tr>
<td>Pump Off Level</td>
<td>Minimum submergence for selected pump</td>
<td>Float switch</td>
</tr>
<tr>
<td>Floor Clearance</td>
<td>Between 0.3D and 0.5D (D = pump inlet diameter)</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

5.4.3.4 Retention Time

Maximum retention time of wastewater in wet wells shall be 30 minutes at average flow. When computing retention time, the Designer shall consider the total volume of wastewater in the wet well.

Wet well sizing shall consider the need for adequate response time in the event of station malfunctions. The Designer shall consult the City for input regarding the minimum desired response time, which may vary depending on such factors as location of the pumping station and travel times, available storage in the collection system, service area flows and flow patterns, and severity of effects related to sewer backups and spills.
5.4.4 Hatch Sizing

The pump(s) access hatch dimensions are determined by the specific pump spacing requirements. The Designer shall obtain pump spacing requirements from the manufacturer. The Designer shall consider the hatch loading criteria based on pedestrian loading or H-20 traffic loading. Access hatches shall be aluminum or stainless steel because of the corrosive environments. The Designer shall include fall protection in the design of the hatches.

5.5 Pumping Equipment

In accordance with 123 NAC 5 003.03, wastewater pumping stations are required to have multiple pumps. “Where two pumps are provided each shall be capable of pumping the peak hourly flow. Where three or more pumps are provided, they shall be sized to pump the peak hourly flow when the largest pump is out of service” (123 NAC 5 003.03). The typical operating configuration is an alternating lead and lag pump operation. Article 003.05 requires pumps handling raw wastewater to have a minimum 4-inch diameter suction and discharge openings, and have the ability to pass a 3-inch diameter spherical solid.

Generally, non-clog centrifugal pumps are used for wastewater pumping station applications. These pumps can be installed in a dry-pit or submersible configuration. Dry-pit non-clog pumps require a dry well or pump control building for housing the pumps. Submersible, non-clog pumps do not require a dry well and are the most used in wastewater pumping stations.

Pumps can be provided as constant speed or variable speed depending on the pumping station wastewater influent flow rates and variability. Constant speed pumps are used for pumping stations that have consistent flows and infrequent spikes in flow rate. Constant speed pumps require a larger wet well operating volume between HWL and LWL to limit pump cycling frequency. Variable speed pumps can adjust to the influent flow rate allowing for a smaller wet well operating volume. Variable speed pumps require a Variable Frequency Drive (VFD) to modulate the pump motor speed. The City’s preference is for a constant speed pump configuration.

5.6 Screening Devices

Inlet screens or pump intake screens may be necessary for stations that realize unusual quantities of solids and debris. It is recommended to attempt to pump solids without screening, to the extent possible, because screens are extremely maintenance intensive. If screening is deemed necessary, the Designer shall coordinate with Public Works on screen type preference.

5.7 Piping and Fittings

Exposed piping and fittings for pump discharge and suction lines should be ductile iron pipe (DIP) because of the corrosive environment, pumping pressures, and pipe strength. Additional requirements for piping, fittings, joints and flanges include:

- DIP should conform to American Water Works Association (AWWA) C151 and should be minimum thickness Class 53. Buried DIP should have flexible polyethylene plastic wrap conforming to AWWA C105 or other City approved corrosion protection.
- DIP fittings should conform to AWWA C110.
- Exposed joints should be flanged with DIP flanges faced and drilled to conform to ANSI A21.15 and AWWA C115, Class 125 standard with full-face gaskets. Restrained joints should be used for buried DIP.
• Flanges should be threaded-on flanges conforming to ANSI A21.15 and AWWA C115, or cast-on flanges conforming to ANSI 21.10 and AWWA C110. Flanges should be adequate for minimum 250 pounds per square inch (psi) working pressure.

• Transition to a different force main pipe material can be made generally 5 to 10 feet beyond the valve vault.

5.8 Valve Vaults

Typical valve vault construction consists of a concrete manhole with an access hatch. Swing check valves and isolation valves (gate valves) are required on the discharge pipe of each pump. The valves should be located within a valve vault or pump control building to allow for access and maintenance. A quick connect for bypass pumping shall be installed downstream of the check and gate valves. A separate isolation valve shall be installed between the force main and the quick connect fitting. In accordance with 123 NAC 5 003.08, valve vaults are required to have a drain line from the vault to the wet well with a gate valve installed on the drain line in the valve vault to prevent gas passage.

5.9 Electrical Equipment and Enclosures

Submersible pump motors must be designed and rated to operate while immersed in sanitary wastewater. Motor housing with watertight sealing is required. The City’s preference is to install soft starts on constant speed pumps. Variable speed pump operation will be decided on a case-specific basis in coordination with the City.

Electrical controls and the programmable logic controller (PLC) unit shall be enclosed in a stainless steel NEMA 4X panel. The pump control system shall be connected to the float level sensors through intrinsically safe barriers and relays. City preference is for three-phase, 480-volt power where possible. The Designer shall consider the area classification for selection of the enclosure type.

A generator transfer switch is required for emergency operation. Onsite generators should be natural gas powered according to gas utility availability. The Designer should coordinate with the City regarding generator placement and requirements.

5.10 Maintenance

Maintenance will be performed in accordance with the manufacturers’ recommendations. An Operation and Maintenance (O&M) manual shall be provided by the pump manufacturer. The Designer shall provide the City with an electronic copy (PDF format) and a minimum of two hard copies. The Contractor shall be required by the Designer to furnish all spare parts recommended in the manufacturer’s O&M manual.

5.11 Appurtenances

Pumping stations shall include the following appurtenances:

• Stainless steel lifting chains.
• Stainless steel guide rails.
• Stainless steel mounting brackets and hardware.
• Standard weighted floats.
• Fall protection.
### 5.12 Instrumentation and Control

A four-float system connected to the pump control panel is used for pump operation. As noted in Table 5-3 in Section 5.4.3.3, the floats shall be positioned in the wet well to control the following:

1. One float installed at minimum submergence water elevation to turn all pumps off.
2. One float installed at operating volume water elevation to activate lead pump.
3. One float installed 12 to 24 inches above lead pump float to activate lag pump.
4. One float installed at high water elevation to generate alarm.

The pumping station control strategy will be developed and coordinated with the City. The Designer shall coordinate with the City regarding PLC manufacturer (currently using Schneider Modicon M340). At a minimum, the following shall be provided:

- Radio or autodialer.
- The pumps shall alternate lead and lag after each pumping sequence.
- Elapsed runtime meter.
- Pump run status indication.
- High wet well level alarm.
- Pump fail alarm.

### 5.13 Design package submittal

The Designer shall prepare a design package for submittal to the City for review and approval. The following shall be included in the deliverable:

- Complete drawing set.
- Technical specifications.
- Pump manufacturer pump curves and O&M manual.
Chapter 6  Force Main Design

Design and installation of pumping suction and discharge piping shall conform to the requirements in the following; 123 NAC 5; ANSI/HI 9.6.6, “Pump Piping”; and ANSI/HI 9.8, Pump Intake Design.

6.1 Velocity and Diameter

Force main design is dependent on velocity of the fluid flowing through the pipe and the pipe diameter. Maintaining a minimum velocity is necessary for flushing and preventing deposition of solids. Pipe diameter varies between differing pipe materials. The pipe diameter directly affects flow velocity and friction losses. Selection of the force main pipe diameter is critical in maintaining the optimal velocity yet reducing the friction losses. The following applies to force main velocity and diameter:

- The minimum velocity in the force main is 2.5 feet per second; 3.5 feet per second is recommended to move grit.
- A practical maximum velocity of 8 feet per second is typically used for force main design.\(^4\)
- In accordance with 123 NAC 5 004.02, force main piping minimum diameter is 4 inches.
- Grinder pumping station force main diameter is an exception to the minimum diameter requirement. Grinder pumping stations may connect to a minimum force main diameter of 2 inches.

6.2 Air and Vacuum Relief Valves

In accordance with 123 NAC 5 004.03, force main piping, at minimum, shall be designed with wastewater air relief valves installed at all high points along the pressure force main alignment. Vacuum relief valves may be required where an evaluation of the design indicates they are needed. The valves should be housed in a concrete manhole structure. Figure 6.1 Error! Reference source not found. provides a standard combination air and vacuum relief valve vault detail. Odor control potentially may be needed at the valve vault. The Designer shall coordinate with Public Works for odor control determination.

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6.3 Termination

In accordance with 123 NAC 5 004.04, force main piping termination into a manhole shall be no more than 2 feet above the invert flow line. The receiving manhole shall be lined for protection against corrosion.

6.4 Pipe Material

Wastewater is corrosive regardless of location and therefore pipe material should be chosen accordingly. The selection of pipe material, thickness, pressure class, and type of joint shall be based on evaluation of project-specific conditions. The Designer shall consider the following:

- Quality of wastewater, including septicity and high grit content that may aggravate corrosion and abrasion concerns.
- Soil characteristics and pipe loads, including potential for settlement, external corrosion, pipe depth, loads from other utilities, and traffic loads.
- Potential for hydraulic transients, including both pressure surges and vacuum conditions.
- Construction methods and associated advantages and disadvantages, including equipment requirements and accessibility, pipe depth, trench widths, open trench versus
trenchless installation, traffic control requirements, and need for and ease of future maintenance and repair.

- Traditionally, DIP, PVC, and HDPE pipe materials are used for force main construction. Pipe material and wall thickness shall be selected to exceed design pressures in the force main. The Designer shall consider vacuum conditions from transients in selection of pipe material and wall thickness.
- If applicable, corrosion protection for buried DIP should be included in the design.
- If HDPE pipe is used, joints should be made using thermal butt fusion (ASTM D3261). Electro-fusion joints and couplings are not acceptable.

### 6.5 Hydraulic Transients

Hydraulic transients, which may be referred to as water hammer or hydraulic surge, shall be evaluated for all pumping stations and force mains. Measures shall be included in the design as required to mitigate adverse effects.

The Designer shall give special attention to pumping systems with the following characteristics:

- Flow is greater than 500 gpm and the total dynamic head is greater than 50 feet.
- Velocities are more than 4 feet per second.
- There is potential for vacuum conditions and column separation due to a high point in the force main profile, and/or there is a long steep force main gradient of more than 300 feet followed by a long flat section of pipeline.
- The force main is longer than 1,000 feet and larger than 8 inches in diameter.
- Particularly for pumping systems that are not provided with soft starting and stopping features, it shall be recognized that frequent surges can result in failure due to cyclic fatigue of pump and force main materials. Consultants and technical staff with a high degree of expertise and experience in performing similar analyses shall perform hydraulic transient analyses.

### 6.6 Pipe Restraint

Force main piping should be restrained pipe at all changes in flow direction including bends, tees, crosses, valves, and dead ends.

### 6.7 Special Construction

In accordance with 123 NAC 5 004.06, force main piping is required to meet the following water main separation criteria:

1. Maintain minimum horizontal separation of 10 feet from any water main.
2. Maintain minimum vertical separation of 18 inches from any water main crossing.

To reduce the potential for clogging, the Designer shall consider the use of two 45-degree elbows in lieu of a 90-degree elbow where a 90-degree change in direction is required.

### 6.8 Design Friction Losses

Refer to Section 5.3.2 for discussion on force main piping design friction losses.
6.9 Identification

Underground tracer wire shall be installed on buried PVC and HDPE force main pipes.

6.10 Leakage Testing

The Designer shall provide force main hydrostatic pressure testing methodology.

6.11 Maintenance Considerations

Pig launching and recovery stations provided for cleaning of force mains will be determined on a site case-specific basis. The Designer shall coordinate maintenance considerations with the City.

6.12 Cover

Force main piping shall be installed below the established frost depth of the region, refer to Section 4.4.
Chapter 7 Private Sewage Treatment Systems

7.1 Applicability

The City of Omaha Municipal Code addresses Private Sewage Treatment Systems. The following sections from the Municipal Code have been included in this Manual to summarize the topic in relation to the design of new wastewater collection systems.

From Section 49 – Plumbing:

- Sec. 49-2130 – Application of Article. “When a public sewer is not available for use, all liquid waste from buildings shall be connected to a private sewage treatment system approved by the health director. The provisions of this article shall apply to all private sewage treatment systems in the city and the area within three miles of the corporate limits thereof.”

- Sec. 49-2146 – Sanitary sewer connection required. “When a sanitary sewer is adjacent or parallel to the property, connection to the public sewer system shall be required. No private sewage treatment system shall be maintained within one year after a public sewer becomes available.”

- Sec. 49-2177 – Abandonment of septic tanks. “Whenever the use of a septic tank system is discontinued following the connection to a sanitary sewer or following condemnation or demolition of a building or property or due to the construction of other on-site sewage treatment system, the septic tank system shall be properly abandoned and any other further use of the system for any purpose shall be prohibited. The abandoned septic tank shall be pumped of all liquids, the top of the tank shall be destroyed, and the tank shall be filled with sand or compacted earth, or the tank may be removed after pumping.”

From Section 53 – Subdivisions:

- Sec. 53-9 – Improvements. “(5) Sanitary sewer. Where a city sanitary sewer is accessible by gravity flow within 500 feet of the final plat, the subdivider shall connect thereto and provide adequate sewer lines and stubs to benefit each lot. Where a city sanitary sewer is not accessible by gravity flow within 500 feet of the final plat, the subdivider shall make provisions for the disposal of sewage as required by law. Where a city sanitary sewer accessible by gravity connection is not within 500 feet of the final plat, but where plans for the installation of city sanitary sewers within such proximity to the plat have been prepared and construction will commence within 12 months from the date of the approval of the plat, the subdivider shall be required to install sewers in conformity with such plans.”
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Appendix A

Manhole Inspection Form
CITY OF OMAHA, NE
SANITARY MANHOLE INSPECTION FORM

| CITY OF OMAHA | STREET ADDRESS: |
| MANHOLE NO.: |
| INSPECTOR NAME: |
| INSPECTOR PHONE: |
| INSPECTION DATE: |
| INSPECTION TIME: |

| ODORS PRESENT | ABOVE GRADE: YES / NO |
| ODORS PRESENT | ABOVE GRADE: YES / NO |
| TOP PHOTO: YES / NO | DEPTH FEET IN _________ |
| INTERIOR PHOTOS: YES / NO | COVER DIAMETER INCHES IN _________ |
| OVERALL CONDITION: GOOD | MANHOLE DIAMETER FEET IN _________ |
| FAIR | FLOW DEPTH INCHES IN _________ |
| NEEDS REPAIR DROP MANHOLE YES / NO OUT_______ |

I. GENERAL INSPECTION

A. LOCATION
1. PAVED STREET
2. PAVED INTERSECTION
3. SIDEWALK
4. CURB AREA
5. GRASSED AREA
6. OTHER_________________

B. MANHOLE MATERIAL
1. BRICK
2. PRECAST CONCRETE
3. Poured IN PLACE CONCRETE
4. INTERIOR LINING PRESENT
5. OTHER_________________

C. COVER
1. MISSING
2. CRACKED
3. CORRODED
4. Holes # IF ANY__________
5. NOT ABLE TO OPEN
6. OTHER_________________

D. FRAME
1. CRACKED/BROKEN
2. CORRODED
3. OFFSET
4. NO FRAME SEAL
5. NEEDS RAISING/LEVELING
6. NEEDS LOWERING/LEVELING
7. OTHER_________________

E. CHIMNEY (SHAFT)
1. CRACKED/BROKEN
2. LOOSE MORTAR
3. ROOT INTRUSION
4. I/I EVIDENCE
5. OTHER_________________

F. REDUCER
1. CONCENTRIC
2. ECCENTRIC
3. CRACKED/BROKEN
4. LOOSE MORTAR
5. ROOT INTRUSION
6. I/I EVIDENCE
7. OTHER_________________

II. HYDRAULIC INSPECTION

A. SURCHARGE INDICATIONS
1. GREASE/STAIN ON WALLS
2. GREASE/STAIN ON BENCH

B. FLOW CONDITIONS
1. NO FLOW
2. SLUGGISH/STANDING WATER
3. STEADY
4. PULSING
5. TURBULENT
6. SURCHARGING (INSPECTOR: NOTIFY SEWER MAINTENANCE AT 402-444-5332)

WRITTEN OBSERVATIONS:

_________________________
_________________________
_________________________
Appendix B

Potential Permits List
<table>
<thead>
<tr>
<th>Issuing Agency</th>
<th>Permit</th>
<th>Description of Permit Purpose</th>
<th>City</th>
<th>Designer</th>
<th>Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States Army Corps of Engineers (USACE)</td>
<td>Clean Water Act (CWA) 404 Permit - Nationwide Permit</td>
<td>Covers dredging or filling of Waters of the United States, including, but not limited, to wetlands.</td>
<td>Holds permit</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>USACE</td>
<td>CWA 404 Permit – Individual</td>
<td>Covers dredging or filling of Waters of the United States, including, but not limited, to wetlands.</td>
<td>Holds permit</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>USACE</td>
<td>Proposed Modifications to Flood Risk Reduction Project (FRRP) 33 CFR 408 Authorization</td>
<td>A 408 authorization covers levee alteration or occupation, or any work within the levee critical area.</td>
<td>Holds permit, Implements</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>Federal Emergency Management Agency (FEMA)</td>
<td>Conditional Letter of Map Revision/Letter of Map Revision</td>
<td>Covers projects proposed within the Special Flood Hazard Area.</td>
<td>Holds permit, Prepares</td>
<td>Implements</td>
<td></td>
</tr>
<tr>
<td>U.S. Fish and Wildlife Service (USFWS)</td>
<td>Depredation Permit</td>
<td>Allows the taking of migratory birds, their parts, nests, or eggs.</td>
<td>Holds permit, Prepares</td>
<td>Implements</td>
<td></td>
</tr>
<tr>
<td>Nebraska Department of Environmental Quality (NDEQ)</td>
<td>Underground Injection Control Permit</td>
<td>Deals with discharge into wells that could impact drinking water aquifers.</td>
<td>Holds permit, Implements</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>Nebraska Department of Transportation (NDOT)</td>
<td>Utilities/Occupy Right-of-Way (ROW)</td>
<td>Occupies/ROW permits are used for those elements of a project that would go over or under a state highway.</td>
<td>Holds permit, Prepares</td>
<td>Implements</td>
<td></td>
</tr>
<tr>
<td>NDOT</td>
<td>Access Permit</td>
<td>Permit is used for commercial approach roads, private driveways.</td>
<td>Holds permit, Prepares</td>
<td>Implements</td>
<td></td>
</tr>
<tr>
<td>City of Omaha Public Works</td>
<td>NDEQ - Air Pollution Emission and Construction Permit</td>
<td>Permit is required for construction activities that include earth-moving equipment.</td>
<td>Holds permit, Prepares</td>
<td>Implements</td>
<td></td>
</tr>
<tr>
<td>City of Omaha Public Works</td>
<td>NDEQ - Air Pollution Emission Notice and Operating Permit</td>
<td>Air operating permit for emission points.</td>
<td>Holds permit, Prepares</td>
<td>Implements</td>
<td></td>
</tr>
<tr>
<td>NDEQ</td>
<td>Asbestos Regulations</td>
<td>Includes requirements for the certification of workers, controls to have in place when working with asbestos, and notification and reporting requirements.</td>
<td>Reviews</td>
<td>Prepares, Holds Permit</td>
<td></td>
</tr>
<tr>
<td>NDEQ</td>
<td>Construction Stormwater General Discharge Permit</td>
<td>Covers stormwater discharges associated with small and large construction sites.</td>
<td>Holds permit</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>NDEQ</td>
<td>Construction Dewatering General Discharge Permit</td>
<td>Covers discharge of groundwater and stormwater from excavation sites into state waters.</td>
<td>Prepares, Assists</td>
<td>Prepares, Holds Permit, Implements</td>
<td></td>
</tr>
<tr>
<td>NDEQ</td>
<td>General NPDES Permit Authorizing Dewatering Discharge from Contaminated Sites within the City of Omaha</td>
<td>Covers dewatering discharge to the Missouri River (only) from contaminated sites such as construction excavations, foundation sumps, or utility vaults within the City of Omaha.</td>
<td>Prepares</td>
<td>Prepares, Holds Permit, Implements</td>
<td></td>
</tr>
<tr>
<td>NDEQ</td>
<td>Hydrostatic Testing/Dewatering Permit</td>
<td>Covers the discharge of testing fluids and ground water dewatering where some contamination is present or could be present.</td>
<td>Holds permit</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>NDEQ</td>
<td>NPDES for Process Water Permit</td>
<td>This permit covers those discharges not capable of being covered by a general permit.</td>
<td>Holds permit</td>
<td>Prepares</td>
<td>Implements</td>
</tr>
<tr>
<td>NDEQ</td>
<td>Construction Permit (Plan Review)</td>
<td>NDEQ reviews the plans and specifications for projects and issues a construction permit upon approval.</td>
<td>Provides data as requested</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDEQ</td>
<td>CWA 401 Water Quality Certification</td>
<td>Water quality certification of a federal action, such as the issuance of a 404 permit, provided by the State of Nebraska.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>NDNR</td>
<td>Water Well Permit</td>
<td>Covers the discharge from new dewatering wells if in use for 90 days or more, even intermittent use. A well registration permit along with a decommissioning notice is also required. DNR requires test holes to be registered if they are in use more than 10 days.</td>
<td>Holds approval</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>NDNR</td>
<td>Dam Approval for Detention Basins</td>
<td>Approval required for all high hazard potential dams, dams with a height of 25 feet or more from downstream lowest toe and/or dams with a total storage capacity of 50 acre-feet or more.</td>
<td>Holds permit (Obtains clearances)</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>State Historical Preservation Officer (SHPO)</td>
<td>Cultural Resources Evaluation</td>
<td>Deals with the need to preserve the historical, prehistoric, and archaeological resources of the state. Federal agencies are required to evaluate this as part of their actions. Likely required as part of a federal action, such as a 404 Permit.</td>
<td>Reviews, Assist</td>
<td>Prepares, Holds permit, Implements</td>
<td></td>
</tr>
<tr>
<td>City of Omaha</td>
<td>Building, Electrical, Mechanical and Plumbing Permits</td>
<td>Demonstrates that a building project is being constructed under processes for insure code compliance and public safety.</td>
<td>Assist</td>
<td>Reviews, Assist, Holds permit, Implements</td>
<td></td>
</tr>
<tr>
<td>City of Omaha</td>
<td>Wrecking Permit</td>
<td>Ensures that asbestos regulations are followed and to ensure that measures have been taken for pest control and to safeguard the workers and surrounding neighborhoods.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>City of Omaha Public Works</td>
<td>Floodplain Development Permit</td>
<td>Regulates new development, minor improvements, or substantial improvements that occur within a designated floodplain.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>City of Omaha Public Works</td>
<td>Grading Permit</td>
<td>Covers projects that disturb more than 1 acre.</td>
<td>Holds permit, Implements</td>
<td>Prepares</td>
<td></td>
</tr>
<tr>
<td>City of Omaha Papio Runnel Partners</td>
<td>Post Construction Stormwater Management Plan</td>
<td>For projects disturbing more than 5,000 square feet, their will be required to comply with the City’s Post Construction requirements for stormwater.</td>
<td>Holds Permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>Papio-Missouri River Natural Resource District (P-MRRD)</td>
<td>Easement Agreement for Occupation of Levee/Channel Right-of-Way</td>
<td>Allows grantee to install, operate, maintain, and replace certain improvements in a portion of the P-MRRD levee/channel ROW.</td>
<td>Holds Permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>P-MRRD</td>
<td>Permit for Occupation of Levee Right-of-Way</td>
<td>Allows for the access and occupation of levee ROW for the purpose of constructing improvements in a portion of the P-MRRD levee/channel ROW.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>Burlington Northern Santa Fe (BNSF) Railroad</td>
<td>Utility License Agreement</td>
<td>Required when utility facilities are installed, located, removed, or maintained along or across BNSF property.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>BNSF</td>
<td>Temporary Occupancy</td>
<td>Needed for access onto BNSF ROW for surveys, access, or geotechnical work.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>BNSF</td>
<td>Environmental Access</td>
<td>Needed for access onto BNSF property for soil sample for contamination, installation of monitoring wells, topographical survey for contamination.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>Union Pacific Railroad (UPRR)</td>
<td>Pipeline Crossing License and Pipeline Encroachment License</td>
<td>Required for any pipeline installation on UPRR ROW.</td>
<td>Holds permit</td>
<td>Prepares, Implements</td>
<td></td>
</tr>
<tr>
<td>UPRR</td>
<td>Right of Entry Agreement</td>
<td>Allows access to UPRR ROW.</td>
<td>Holds Permit, Implements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) The Contractor is not solely responsible for the implementation of the permit requirements. The Contractor is responsible for those requirements that are included in the specifications.

(2) Under unique circumstances, the City may obtain the permit and transfer to the Contractor.
Appendix C

Gravity Sewer Design Calculation Form
### Gravity Sanitary Sewer Design Form

#### Quantity of Wastewater Calculations

<table>
<thead>
<tr>
<th>Trib. Area</th>
<th>From</th>
<th>To</th>
<th>No. of D.U.</th>
<th>Density per D.U.</th>
<th>Eq. Pop.</th>
<th>Unit Flow Rate (gpd)</th>
<th>Population</th>
<th>Eq. Pop.</th>
<th>Unit Flow Rate (gpd)</th>
<th>Population</th>
<th>Pop. Served</th>
<th>Unit Flow Rate (gpd)</th>
<th>Population</th>
<th>Pop. Served</th>
<th>Unit Flow Rate (gpd)</th>
<th>Population</th>
<th>Pop. Served</th>
<th>Unit Flow Rate (gpd)</th>
<th>Population</th>
<th>Pop. Served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>A</td>
<td>MH1</td>
<td>MH2</td>
<td>30</td>
<td>2.47</td>
<td>124</td>
<td>274</td>
<td>17</td>
<td>4,650</td>
<td>19,400</td>
<td>3.28</td>
<td>100</td>
<td>0013</td>
<td>8</td>
<td>0.30</td>
<td>0.20</td>
<td>0.75</td>
<td>2.50</td>
<td>YES</td>
<td>YES</td>
<td>1.41</td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>MH2</td>
<td>MH3</td>
<td>100</td>
<td>2.47</td>
<td>247</td>
<td>547</td>
<td>17</td>
<td>13,949</td>
<td>43,450</td>
<td>3.04</td>
<td>100</td>
<td>0013</td>
<td>8</td>
<td>0.30</td>
<td>0.20</td>
<td>2.05</td>
<td>6.83</td>
<td>YES</td>
<td>YES</td>
<td>3.74</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>MH3</td>
<td>MH4</td>
<td>200</td>
<td>2.47</td>
<td>494</td>
<td>944</td>
<td>17</td>
<td>25,997</td>
<td>84,499</td>
<td>2.88</td>
<td>100</td>
<td>0013</td>
<td>8</td>
<td>0.30</td>
<td>0.20</td>
<td>1.45</td>
<td>4.83</td>
<td>YES</td>
<td>YES</td>
<td>3.51</td>
</tr>
</tbody>
</table>

#### Design Flow

| Trib. Area | From | To | No. of D.U. | Density per D.U. | Eq. Pop. | Unit Flow Rate (gpd) | Population | Eq. Pop. | Unit Flow Rate (gpd) | Population | Pop. Served | Unit Flow Rate (gpd) | Population | Pop. Served | Unit Flow Rate (gpd) | Population | Pop. Served | Unit Flow Rate (gpd) | Population | Pop. Served | Unit Flow Rate (gpd) | Population | Pop. Served |
|------------|------|----|-------------|-----------------|---------|---------------------|------------|---------|---------------------|------------|-------------|---------------------|------------|-------------|---------------------|------------|-------------|---------------------|------------|-------------|
|            |      |    |             |                 |         |                     |            |         |                     |            |             |                     |            |             |                     |            |             |                     |            |             |
| A          | MH1  | MH2| 30          | 2.47            | 124     | 274                 | 17         | 4,650   | 19,400              | 3.28       | 100         | 0013                | 8          | 0.30        | 0.20                | 0.75       | 2.50        | YES                 | YES        | 1.41        |
|            |      |    |             |                 |         |                     |            |         |                     |            |             |                     |            |             |                     |            |             |                     |            |             |
| B          | MH2  | MH3| 100         | 2.47            | 247     | 547                 | 17         | 13,949 | 43,450              | 3.04       | 100         | 0013                | 8          | 0.30        | 0.20                | 2.05       | 6.83        | YES                 | YES        | 3.74        |
|            |      |    |             |                 |         |                     |            |         |                     |            |             |                     |            |             |                     |            |             |                     |            |             |
| C          | MH3  | MH4| 200         | 2.47            | 494     | 944                 | 17         | 25,997 | 84,499              | 2.88       | 100         | 0013                | 8          | 0.30        | 0.20                | 1.45       | 4.83        | YES                 | YES        | 3.51        |

**Notes:**
- User input in Blue, Calculated values in Black
- See description tab for details on each column
- Assumed d/D = 0.8

**Pipe Set at Min. Slope, 3.5 fps requirement deepens system by 5.1 feet.**
Appendix D

Guidance Document for Plan Submittals
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The OPW Project number shall be included on all sheets. At a minimum, the sheets shall contain the following items (as applicable):

1. **COVER SHEET**
   - Title of Project, including OPW project number
   - Vicinity Map (Large scale showing project location relative to major streets)
   - Enlarged Vicinity Map (show project area at smaller scale, proposed pipes shown)
   - Sheet Index
   - Legend
   - General Notes (Attached at the end of this document)
   - One Call Information
   - Note the status of the plans (30%, 90%, Final)
   - Date set is issued (Month and Year)
   - Project ID Box

2. **STORM SEWER CALCULATIONS SHEET**
   - Storm sewer tributary areas with directional drainage arrows
   - Storm sewer calculations

3. **SANITARY SEWER CALCULATIONS SHEET**
   - Sanitary sewer tributary areas
   - Sanitary sewer calculations

4. **GENERAL UP-FRONT SHEETS**
   - Utility Notes
   - Sewer Notes
   - Contact Notes (City contacts, Utility company contacts, other key contacts)
   - Traffic Control Notes
   - Structural Notes
   - Overall Quantities Table including:
     - City of Omaha Standard Bid Item Number
     - Plan Set Bid Item Number (consecutive numbering starting at “1”)
     - Description of Bid Item which matches the City of Omaha Standard Bid Item description
     - Units of Bid Item
     - Quantity of Bid Item
   - Sheet Layout Index Map
   - Horizontal and Vertical Control Map and Information including the following:
     - Description of individual control points (Cut “X” in concrete sidewalk, etc.)
     - Northing and Easting of each control point
     - Elevation of each control point
     - Horizontal and Vertical Datum of the control
     - Ground to Grid Adjustment Factor used
5. ALIGNMENT LINE TABLES SHEET

North arrow and scale

Include alignment layout tables for each alignment including the following:
- Line Number
- Length
- Start Station
- End Station
- Start Northing and Easting
- End Northing and Easting
- Pipe Number (If Applicable)

6. CONSTRUCTION STAGING SHEET

North arrow and scale

Show and note staging area(s) on map showing entire project area

Staging notes (detailed but no days stated; include note that "No more than 4 blocks can be disturbed at any one time unless a variance is requested in writing and approved by the City.")

Erosion control notes for staging

7. REMOVAL SHEET

North arrow and scale

Removal hatching

Removal quantities are to be in removal sheet tables. The quantities should be from within the match lines of the individual sheets only.

Removal legends with items that are applicable to the individual sheets. If any removal items are not covered by the index, note these items individually with clear leader notes.

8. PLAN AND PROFILE SHEET

a. PLAN VIEW

Proposed pipes and structures with labels. Plan view labels are to include:
- Pipe and Structure names/numbers
- Applicable leader notes as necessary
- Provide bold contrast to the new pipe system for clarity

Alignment Stationing

North arrow and plan view scale

Pipes referenced in tables with the following:
- Number (Add City GIS identification numbers at 90%)
- Location (structure to structure)
- Strength class or pipe stiffness
- Length
- Diameter
- Material

Structures referenced in tables with the following:
- Number (Add City GIS identification numbers at 90%)
- Location (alignment station location and offset, northing and easting)
- Type or Size
- Rim elevation
- Vertical feet
- Incoming and outgoing pipe information (flow lines, inverts, directions)

Street labels
### Match lines

New pipe service location to each lot (as applicable)

**Existing information, including:**
- Surveyed contours
- Topo features such as streets, curbs, sidewalks, manholes, trees, fences, etc.
- Buildings/structures with finished floor elevations and address shown
- Property/Right-of-way lines/Easements
- Existing utility conflicts (provide supporting notes as applicable summarizing important information that the contractor should be aware of and include approximate location of utilities to be relocated by others)
- Sanitary sewer services / storm sewer services

### b. PROFILE VIEW

**Profile view scale**

Proposed pipes and structures with labels. Profile view labels should include:

**Pipes:**
- Number (Add City GIS identification numbers at 90%)
- Length
- Diameter
- Material
- Slope

**Structures:**
- Number (Add City GIS identification numbers at 90%)
- Station
- Type
- Rim elevations
- Incoming and outgoing pipe information (flow lines, inverts, directions)

Existing ground elevation profile over proposed pipe

Proposed ground elevation profile over pipe

Stations and elevations of existing and proposed infrastructure, both parallel and crossing

### 9. PAVING REPLACEMENT SHEET

**a. if full street width replacement**

Existing street profiles should be shown. If these profiles will be replaced to the original grades, then this needs to be noted or clarified.

Provide spot elevations at driveways or flat intersections as necessary to ensure proper drainage

Provide sheet cross-referencing to plan and profile sheets

Provide plan and profile views, stationing, and street names

Provide intersection details with proposed spot elevations

Provide pavement section details

ADA ramps

North arrow and scale

**b. if partial street width replacement**

Provide spot elevations along the curbl ine of the pavement section to be removed and replaced on the Plan and Profile drawings

Provide spot elevations at driveways or flat intersections as necessary to ensure proper drainage

If necessary, provide intersection details with proposed spot elevations

ADA ramps

North arrow and scale
### 10. DETAIL SHEET

Pipe trench details

Provide structural details and any other details for specialty items not limited to:

- Pump stations
- Retaining walls
- Junction boxes
- Outlet structures
- Existing street crossings with pavement replacement

### 11. SWPPP SHEET

As per omahastormwater.org

### 12. ROW AND EASEMENT STRIP MAP SHEET

North arrow and scale

ROW strips maps with temporary, permanent or partial land acquisition hatched, with a legend.

Table with:
- Tract number
- Owner name
- Owner address
- Temporary, permanent or partial land acquisition square footage required

### 13. BORING LOG SHEET

Boring location map with North arrow

Boring log results
Appendix E

Guidance Document for As-Built Plan Submittals
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All new wastewater collection systems shall be surveyed upon completion of the project and a record submittal of the completed project shall be submitted to the City.

At a minimum, the record submittal shall contain the following items:

<table>
<thead>
<tr>
<th>RECORD DRAWINGS (PDF’S) CONTAINING THE FOLLOWING INFORMATION OF THE BUILT CONDITIONS (AT A MINIMUM):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe sizes</td>
</tr>
<tr>
<td>Pipe materials</td>
</tr>
<tr>
<td>Pipe slopes</td>
</tr>
<tr>
<td>Structure locations including all rim and invert elevations</td>
</tr>
<tr>
<td>Easement recording information</td>
</tr>
<tr>
<td>Updated quantities</td>
</tr>
<tr>
<td>Engineer’s stamp certifying the as-built drawings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADDITIONAL ITEMS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-Built Certification Form (Private Plan Projects)</td>
</tr>
<tr>
<td>CCTV inspection</td>
</tr>
<tr>
<td>Operating and Maintenance Manuals</td>
</tr>
<tr>
<td>Maintenance Plans</td>
</tr>
<tr>
<td>Test and Inspection Reports</td>
</tr>
<tr>
<td>Shop Drawing Log and approval list</td>
</tr>
<tr>
<td>AutoCAD File</td>
</tr>
<tr>
<td>Project Costs</td>
</tr>
<tr>
<td>Certificate of Substantial Completion with date</td>
</tr>
<tr>
<td>Certificate of Final Completion with date</td>
</tr>
</tbody>
</table>
Appendix F

Nebraska Department of Health and Human Services Guide for Water Main and Sanitary/Storm Sewer Separation
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Design and Installation Guide for Water Main and Sanitary/Storm Sewer Separations

The Department recognizes the challenges and difficulties in designing and installing distribution mains, especially in areas fraught with existing utilities. This guide was developed to assist design engineers with sanitary/storm sewer and water main separation design and installation. In the design and installation of water mains, design engineers must strive to achieve the separation distances required for water mains and fire hydrants from sanitary sewers, storm sewers and other potential sources of contamination as per the Recommended Standards for Water Works, 2007 Edition (Standards). In cases where it is impractical to achieve those separation distances required in the Standards, the protocols provided in this document must be followed to be considered in substantial conformance by the Department.

A. Sanitary Sewer and Water Main Separations
   1. Sanitary Sewer and Water Main Horizontal Separations for Parallel Installations
      a. Scenario 1. A 10 foot radial separation is considered equivalent to the 10 foot horizontal separation requirement if the water main is above the sanitary sewer and not within 5 feet horizontally.
      b. Scenario 2. If the horizontal separation is greater than 8 feet but less than 10 feet, the installation would be acceptable if the following is provided:
         1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and
         2) Reasons are provided as to why it is not practical to provide the 10 foot separation.
      c. Scenario 3. If the horizontal separation is greater than 4 feet but less than 8 feet, the installation would be acceptable if the following is provided:
         1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and
         2) Reasons are provided as to why at least 8 feet of separation cannot be provided; and
            (a) The water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sanitary sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sanitary sewer; or
            (b) The engineer may encase the water main or sanitary sewer pipe for protection (rigid welded piping or cement/concrete at least 4 to 6 inches thick, etc.) at locations where the separation cannot be met; or
            (c) The sanitary sewer pipe needs to be water works grade 150 psi pressure rated meeting AWWA Standards and pressure tested to ensure water tightness; or
            (d) An alternate method of protection with approval from the Department prior to construction.
      d. Scenario 4. If the horizontal separation is less than 4 feet, the installation must not proceed prior to consulting and obtaining written approval from the Department.
   2. Sanitary Sewer and Water Main Vertical Separations at Crossings
      a. Scenario 1. If the water main is above the sanitary sewer pipe and the vertical separation is greater than 12 inches but less than 18 inches, the installation would be acceptable if the following is provided:
         1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and
         2) Reasons are provided as to why the 18-inch separation cannot be met; and
         3) One full length of water pipe needs to be located so that both joints will be as far from the sanitary sewer crossing as possible.
      b. Scenario 2. If the water main is above the sanitary sewer pipe and the vertical separation is greater than 6 inches but less than 12 inches, the installation would be acceptable if the following is provided:
1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and

2) Reasons are provided as to why at least 12 inches of separation cannot be met; and

3) One full length of water pipe needs to be located so that both joints will be as far from the sanitary sewer crossing as possible; and

4) Proper support is provided to prevent settlement and breaking pipe; and
   (a) The engineer may encase either the water main or sanitary sewer pipe for protection (rigid welded piping or cement/concrete at least 4 to 6 inches, etc.) for at least 10 feet on each side of the crossing with the ends properly sealed; or
   (b) The sanitary sewer pipe needs to be water works grade 150 psi pressure rated meeting AWWA Standards and be pressure tested to ensure water tightness; or
   (c) An alternate method of protection with approval from the Department prior to construction.

c. Scenario 3. If the water main is below the sanitary sewer, the vertical separation is greater than 6 inches but less than 18 inches, the installation would be acceptable if the following is provided:
   1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and
   2) Reasons are provided as to why at least 18 inches of separation cannot be met; and
   3) One full length of water pipe needs to be located so that both joints will be as far from the sanitary sewer crossing as possible; and
   4) Proper support is provided to prevent settlement and breaking pipe; and
      (a) The engineer may encase either the water main or sanitary sewer pipe for protection (rigid welded piping or cement/concrete at least 4 to 6 inches thick, etc.) for at least 10 feet on each side of the crossing with the ends properly sealed; or
      (b) The sanitary sewer pipe needs to be water works grade 150 psi pressure rated meeting AWWA Standards and be pressure tested to ensure water tightness; or
      (c) An alternate method of protection with approval from the Department prior to construction.

d. Scenario 4. If the vertical separation between the sanitary sewer line and the water main will be less than 6 inches, the installation must not proceed prior to consulting and obtaining written approval from the Department.

B. Storm Sewer and Water Main Separations. In general, the pollution hazards from a storm sewer are not as significant as a sanitary sewer since the storm sewer does not have flow in year round. However, during rainstorm events, it may carry surface runoff which contains chemical pollutants but the pathogenic microbical impact is likely to be less than that of a sanitary sewer. For storm sewer and water main separations, the protocols provided in Section B.1 or B.2 must be followed.

1. Storm Sewer and Water Main Horizontal Separations for Parallel Installations AND Storm Sewer and Water Main Joints Horizontal Separations at Crossings
   a. Scenario 1. If the horizontal separation is greater than 4 feet but less than 10 feet, the installation would be acceptable if the following is provided:
      1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and
      2) Reasons are provided as to why the 10 foot separation cannot be met; and if necessary
      3) Additional protection deemed necessary by the design engineer.
   b. Scenario 2. If the horizontal separation will be less than 4 feet, the installation must not proceed prior to consulting and obtaining written approval from the Department.

2. Storm Sewer and Water Main Vertical Separations at Crossings
   a. Scenario 1. If the water main is above the storm sewer pipe and the vertical separation is greater than 6 inches but less than 18 inches, the installation would be acceptable if the following is provided:
      1) Engineer’s professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and
      2) Reasons are provided as to why the 18-inch separation cannot be met; and
3) One full length of water pipe needs to be located so that both joints will be as far from the storm sewer crossing as possible. Preference shall be given to keep joints further from any sanitary sewer than a storm sewer.

4) Proper support is provided to prevent settlement and breaking pipe.

b. Scenario 2. If the water main is below the storm sewer pipe and the vertical separation is greater than 6 inches but less than 18 inches, the installation would be acceptable if the following is provided:

1) Engineer's professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and

2) Reasons are provided as to why the 18-inch separation cannot be met; and

3) One full length of water pipe needs to be located so that both joints will be as far from the storm sewer crossing as possible. Preference shall be given to keep joints further from any sanitary sewer than a storm sewer; and

4) Proper support is provided to prevent settlement and breaking pipe; and

(a) The engineer may encase either the water main or storm sewer pipe for protection (rigid welded piping or cement/concrete at least 4 to 6 inches, etc.) for at least 10 feet on each side of the crossing with the ends properly sealed; or

(b) The storm sewer pipe needs to be water works grade 150 psi pressure rated meeting AWWA Standards and be pressure tested to ensure water tightness (the storm sewer pipe needs to be watertight when pressure tested to at least 10 psi); or

(c) An alternate method of protection with approval from the Department prior to construction.

c. Scenario 3. If the vertical separation between the storm sewer and the water main will be less than 6 inches, the installation must not proceed prior to consulting and obtaining written approval from the Department.

C. Sanitary Sewer Force Main Separations

1. At least 10 feet of horizontal separation between water mains and sanitary sewer force mains must be provided. There must be at least 18 inches of vertical separation at crossings between water mains and sanitary sewer force mains and one full length of water pipe shall be located so both joints will be as far from the sewer as possible at the crossing.

2. Where it is impossible to meet these separation requirements for sanitary sewer force mains, the installation must not proceed prior to consulting and obtaining written approval from the Department.

D. Fire Hydrants Separations

1. Fire Hydrant and Sanitary Sewer Separations

a. Hydrant drains must not be connected to, or located with 10 feet of sanitary sewers.

b. Where it is impossible to meet the 10 foot horizontal separation between sanitary sewers and fire hydrant drains, the installation must not proceed to consulting and obtaining written approval from the Department.

2. Fire Hydrant and Storm Sewer Separations

a. Where it is impossible to meet the 10 foot horizontal separation requirement for storm sewers and hydrant drains, a less than 10 foot horizontal separation would be acceptable if the following is provided:

1) Engineer's professional opinion that the water quality in the water main will not be impacted based on an evaluation of the proposed installation and soil conditions; and

2) Reasons are provided as to why the 10 foot horizontal separation cannot be met; and

3) At least 5 feet of horizontal separation is provided.

b. Where it is impossible to provide at least 5 feet of horizontal separation of storm sewers to hydrant drains, the installation must not proceed prior to consulting and obtaining written approval from the Department.
October 7, 2010

James Bartels
Metropolitan Utilities District
3100 South 61st Avenue
Omaha, NE 68106-3621

Re: PWS – Metropolitan Utilities District - Three Year Agreement - Design and Installation Guide for Water Main and Sanitary/Storm Sewer Separations

Dear Mr. Bartels:

The Department recognizes the challenges and difficulties in designing and installing distribution mains for a public water system, especially in areas fraught with existing utilities. To help with these challenges, the Department has developed the "Design and Installation Guide for Water Main and Sanitary/Storm Sewer Separations" (copy enclosed) to assist design engineers in dealing with situations where it is impractical or impossible to meet the separations requirements in the Recommended Standards for Water Works, 2007 Edition (Standards). Title 179 NAC 7 requires the physical separation to be in substantial conformance with the Standards. As a Three Year Agreement public water system, you are not required to send in plans and specifications for distribution main construction to the Department for review and written approval. However, the design and installation of the distribution main must be in substantial conformance with the Standards.

Currently, deviations from the separation standards in the Standards are reviewed by the Department on a case-by-case basis for substantial conformance. In order to streamline this process, in situations where it is impractical or impossible to meet the separation requirements in the Standards, the Department will consider water main construction to be in substantial conformance if the protocols in the "Design and Installation Guide for Water Main and Sanitary/Storm Sewer Separations" are followed.

We hope that you will find the design and installation guide helpful for your distribution main construction. If you have any questions, please feel free to contact me at 402/471-0522.

Sincerely,

Chin F. Chew, P.E., Program Manager
Engineering Services Program
Office of Drinking Water and Environmental Health
Division of Public Health
Department of Health and Human Services

CFC:jem

Enclosure

xc: Jeffrey Loll, P.E.
Doug Woodbeck, DHHS
Appendix G

Design Variance Request Form
# Design Variance Request Form

## Project Information

<table>
<thead>
<tr>
<th>Project Name</th>
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<tbody>
<tr>
<td>Project Number</td>
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<tr>
<td>Project Description</td>
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</tbody>
</table>

## Description of Design Variance

*(Include Manual Section)*

## Reason for Deviation

## Mitigation Measures for Deviation

## Submitted By:

<table>
<thead>
<tr>
<th>Designer (Print Name)</th>
<th>Signature</th>
<th>Date</th>
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## Approved By:

<table>
<thead>
<tr>
<th>City of Omaha (Print Name)</th>
<th>Signature</th>
<th>Date</th>
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