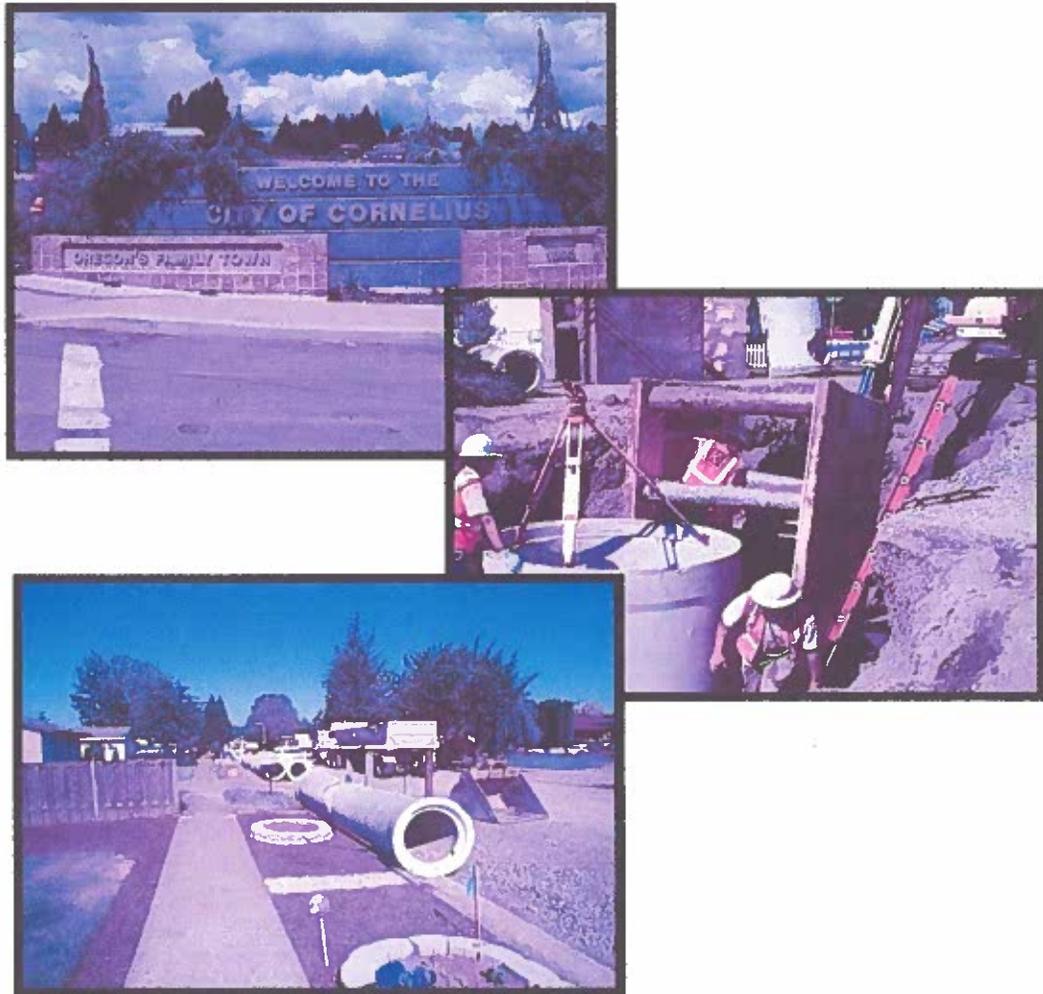


City of Cornelius



Sanitary Sewer System Master Plan Final Report

August 2004

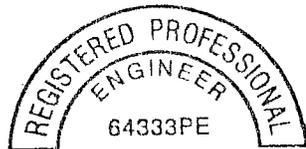


Adopted by Cornelius City Council, 9/20/04 Ordinance 856
Produced by EES, Economic and Engineering Services, Inc.

Certificate of Engineer

**City of Cornelius
Sanitary Sewer System Master Plan – Final Report
August 2004**

The material and data contained in this report were prepared under the direction and supervision of the undersigned, whose seal as a professional engineer, licensed to practice in the State of Oregon, is affixed below.



EXPIRES: 12/04

A handwritten signature in black ink, appearing to read "Nebojsa Mucibabic".

Nebojsa (Nesh) Mucibabic, P.E.
Oregon No. 64333 PE

Economic and Engineering Services, Inc.
Portland, Oregon

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Certificate of Engineer
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- B Intergovernmental Agreement between City of Cornelius and Clean Water Services
- C CMOM Program and Self Assessment Checklist

List of Acronyms

ADD	Average Day Demand
ADWF	Average Dry Weather Flow
ADWWF	Average Day Wet Weather Flow
AI	Areas of Interest
AMSL	Above Mean Sea Level
APWA	American Public Works Association
AQMA	Air Quality Maintenance Area
ASTM	American Society of Testing and Materials
AWWA	American Water Works Association
CC	Council Creek
CCI	Construction Const Index
cfs	Cubic Feet per Second
CIP	Capital Improvement Program
City	City of Cornelius
CMOM	Capacity, Management, Operation & Maintenance
Comprehensive Plan	City of Cornelius Comprehensive Plan
CPWC	Cornelius Public Works Committee
CWA	Clean Water Act
CWS	Clean Water Services
DEQ	Department of Environmental Quality
DLCD	Department of Land, Conservation and Development
DI	Ductile Iron
DWF	Dry Weather Flow
EES	Economic and Engineering Services, Inc.
EPA	Environmental Protection Agency
ERU	Equivalent Residential Unit
FOG	Fat, Oil & Grease
GC	General Commercial
GIS	Geographical Information System
Gpad	Gallons per Acre per Day
Gpcd	Gallons per Capita per Day
gpd	Gallons per Day
gpm	Gallons per Minute
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
ID	Internal Diameter

IE	Invert Elevation
I/I	Infiltration/Inflow
IGA	Intergovernmental Agreement
JWC	Joint Water Commission
KVA	Kilo Volt Amps
LI	Light Industrial
MFR	Multi Family Residential
MG	Million Gallons
MGD	Million Gallons per Day
N/A	Not Applicable
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NTL	North Transmission Line
OAR	Oregon Administrative Rule
ODEQ	Oregon Department of Environmental Quality
OERP	Overflow Emergency Response Plan
O&M	Operation and Maintenance
OSHA	Occupational Health and Safety Act
PDD	Peak Day Demand
POS	Parks and Open Space
PRV	Pressure Reducing Valve
PVC	Polyvinyl Chloride
Sanitary CAD	The Name of the Sanitary Sewer Computer Modeling System
SDC	System Development Charge
SDWA	Safe Drinking Water Act
Sewer Plan	City of Cornelius Sewer Plan (1981)
SFR	Single Family Residential
SRF	State Revolving Fund
SRI	Storm Responsive Infiltration
SSO	Sanitary Sewer Overflow
TDH	Total Dynamic Head
TV	Tualatin Valley
UFC	Uniform Fire Code
UGA	Urban Growth Area
UGB	Urban Growth Boundary
UPC	Uniform Plumbing Code
USA	Unified Sewerage Agency

USEPA
USGS

United States Environmental Protection Agency
United States Geological Survey

WWI
WTP
WWTP

Wet Weather Infiltration
Water Treatment Plant
Wastewater Treatment Plant

Section 1

Introduction and Overview

1.1 Introduction

The City of Cornelius (City) owns and operates a sanitary sewer collection system, which presently serves a population of approximately 10,000 people (roughly 2,600 connections) in Washington County, Oregon. Wastewater is collected within two major (north and south) drainage basins and routed to transmission and treatment facilities owned and managed by Clean Water Services (CWS). CWS treatment facilities include the Forest Grove and Hillsboro Wastewater Treatment Plants (see Exhibit 3-1).

As a part of planned activities, the City has retained Economic and Engineering Services, Inc. (EES) to prepare a 20-year Sanitary Sewer System Master Plan designed to assist the City in accommodating growth and identifying recommended future system improvements through the year 2024.

The plan includes an evaluation of both current and future collection system requirements with the intent of estimating future wastewater flow rates and comparing present day capacities in meeting those needs. The goal of this report is to provide the City with a planning document that will ensure an adequate collection and conveyance system for wastewater flows from within the City's service area. The plan is further designed to satisfy all existing regulatory standards and policies including those established by the City, CWS, Washington County, METRO, Oregon Department of Environmental Quality (ODEQ), Oregon Department of Land, Conservation and Development (DLCD), and federal agencies.

1.2 Authorization

This Sanitary Sewer System Master Plan was prepared by EES for the City of Cornelius, under the authority of the Cornelius City Council with supervision provided by the City Engineer, Cornelius Public Works Committee (CPWC), Cornelius Planning Commission, and DLCD through Goal 11 and OAR 660-011.

1.3 Purpose of the Plan

The purpose of this plan is to provide the City of Cornelius with a planning document for meeting its wastewater collection system needs through the year 2024 within the existing city limits, the urban growth boundary (UGB), and areas of interest (AI).

The current Sanitary Sewer Master Plan is 23 years old and does not meet the current planning needs of the City. It neither addresses proposed future system developments nor provides

relevant information to CWS necessary for upgrade and development of their existing transmission and treatment facilities.

The overall objective of this plan is to evaluate the existing capabilities and limitations of the system, project its future wastewater flows, and establish a schedule of system improvements necessary to provide adequate service to existing and new customers. As part of this effort, a list of improvements have been developed and incorporated into a recommended 20-year capital improvement program, including an estimate of related capital improvement costs and recommended schedule of implementation.

1.4 Scope of Work

The general scope of work for this study was to develop a Sanitary Sewer System Master Plan for the City that includes:

- Review of existing information regarding the adequacy and capacity of the present sanitary collection system,
- Development of an inventory of existing sanitary sewer facilities within the study area,
- Analysis of future wastewater flow projections,
- Development of evaluation criteria and goals to be used in evaluating the existing system capacities against future system needs,
- Analysis and evaluation of the existing hydraulic capacities within the collection system for serving the existing and future City's customer base,
- Identification of system improvements and system expansion alternatives needed to support anticipated growth and development,
- Creation of a 20-year Capital Improvement Program (CIP), along with a prioritization of the most beneficial sanitary sewer improvements, phased schedule of project implementation, and planning-level cost estimates for the recommended projects,
- Review of the financial fund organization and identification of available sources for conducting the CIP,
- Update of existing system operating strategy, and
- Preparation of an approved Master Planning Document.

1.5 Related Studies

A number of related studies and reports were used in the development of this report. These reports have been used as references in this document. In many cases, data, design criteria, and

other recommendations from those documents were used or even duplicated in this study. Those reports included the following:

- Comprehensive Plan for City of Cornelius, adopted July 1978, revised June 1984 and January 1998, and amended in April 3, 2000 and July 21, 2003,
- 2000 Sanitary Sewer System Master Plan Update for Unified Sewerage Agency of Washington County, OR, PMA Engineering, April 2001,
- Design and Construction Standards for Sanitary Sewer and Surface Water Management, Clean Water Services, March 2004,
- Sewer System Master Plan Update 1995 for Unified Sewerage Agency of Washington County, OR, David Evans and Associates and HDR Engineering Inc., April 1995,
- Sewer System Master Plan for City of Cornelius, R.A Wright Engineering Inc, February 1981,
- Water Master Plan for the City of Cornelius, Cornelius Public Works Department, February 2004, and
- Storm Drainage/Surface Water Management Master Plan for City of Cornelius, Cornelius Development and Operations Department, May 2004.

1.6 Sanitary System Ownership and Operation

The City fully owns, maintains, and operates its sanitary sewer collection system. It collects and routes wastewater flows to the CWS major transmission facilities: 1) a 42-inch Council Creek trunk along the north City's boundary, and 2) to Linden Street lift station on the City's south side. Since 1974, the City has had an agreement with CWS regarding conveyance, wastewater treatment, and other operational issues.

In this agreement, CWS takes full responsibility for all construction, maintenance, inspection, and operation of wastewater treatment plants, lift stations, transmission lines, and collection pipelines 24-inches or larger. The City is responsible for maintenance, replacement, and upgrade of its collection system consisting of gravity lines sizes 21-inches and under.

CWS also takes full responsibility for non-structural line sealing and point repair, manhole rehabilitation on all sanitary collection and transmission pipelines (24-inch and larger), as well as for developing and performing flow monitoring, industrial waste, fat, oil and grease programs. CWS shares responsibility with the City regarding infiltration and inflow (I/I) abatement and system rehabilitation projects, and in several other areas including engineering, inspection and support elements as described in Appendix B of this study.

1.7 Summary of Recommended System Improvements

1.7.1 Goals for Collection System Improvements

Accommodate Growth

The City is expected to experience growth over next 20 years and to double its population to approximately 20,000 people by year 2024. As part of this anticipated growth, the City's service territory will likely be increased through the addition of one or more Areas of Interest (AIs). The first group of AIs for residential development covering an area of 674 acres approximately is located on the south and southeast side of the city, between Tualatin Valley (TV) Highway, Dairy Creek, existing City's limits and the Tualatin River. The second group includes 130 acres, located on the northeast side of the city, between TV highway and Council Creek, and an additional 230 acres of land located adjacent, just north of Council Creek.

Furthermore, light industrial development on 920 acres of land located mostly north of Council Creek, and 70 acres of commercial development along TV Highway are all planned to provide economic support for the anticipated population growth.

Based on current water master planning documents those numbers translate into an overall increase in average daily water demand from its present numbers of 1.30 MGD to approximately 1.60 MGD by year 2014 and 2.28 MGD by year 2024. Those water demands have direct influence on the amount of wastewater flows and proposed future upgrades and development of the existing sanitary collection system components.

Upgrade Existing Collection System

The sewer collection system within the City's service area is comprised of approximately 27 miles of sanitary lines ranging from 6- to 18-inch diameter (Exhibit 3-1). The majority of the system lines are 8-inch diameter. The collection system consists of various pipe materials depending on the date of installation and size. The original City system, built in 1959, is made of concrete sewer pipes. A majority of those pipes were later rehabilitated by the City and CWS to reduce large infiltration rates. Since the 1980's the City has been using PVC pipes for all new system developments.

For the most part, the City's network of collection lines is in good shape. The capacity and serviceability of those lines will generally meet the overall system needs for the next 20 years. There are, however, a few areas recommended for improvement. The recommended improvements are primarily due to future build-out of the UGAs, narrow access for maintenance and other operational issues, and the proposed removal of the existing overflow lift station and associated lines along 12th Avenue. This plan is further refined in Section 7 with respect to timing of pipeline replacement and repair of discovered pipe damages and deficiencies, including infiltration areas, holes, cracks, areas with local low pipe velocity, flow backup, and build up of grease and sediment.

Expand Existing Collection System

The City's collection system in the North Drainage basin will need to be slightly expanded by adding 8- and 10-inch sanitary lines to collect wastewater from small infill areas within the existing UGB adjacent to Council Creek. There is also a small residential area (approximately 30 acres) located within an AI just east of 18th Avenue and adjacent to Ginger Street (Subbasin No. 27, Exhibit 7-1) that may be connected to the existing collection system in South Drainage Basin. A similar possibility exists for the 45 acre Area of Interest (AI) adjacent to the east city limits and south of TV Highway. This AI could be temporarily connected to the existing system at Dogwood Street and 28th Avenue. It is expected that all other AIs will be drained toward the Council Creek trunk as described in the following section.

Possible New Collection System Facilities to Serve Areas of Interest

Due to topography and the capacity of the existing collection lines it is expected that several separate gravity collection systems will be built in the future to serve proposed industrial and residential areas adjacent to or located north of Council Creek. Those collection systems will mostly be built of 8- and 10-inch lines and will be connected to the Council Creek trunk at several locations. Estimated wastewater flows are shown on Exhibit 6-1.

All other residential, commercial, and part of industrial AIs located northeast, southeast, and east of the existing City limits would probably be served by a separate sewer system. Based on topography and wastewater flow estimates, such a system might consist of a 15- to 18-inch wastewater trunk with two major branches (collectors) serving areas generally located west and east of Job's Ditch. Two smaller lift stations possibly could be added at the end of each branch to serve local areas between elevations 155 and 165 feet. Sanitary collection lines within AIs might be built mostly of 8-inch sanitary PVC lines.

The collection systems to service these AIs could possibly be served by a main trunk crossing TV Highway and Burlington Northern Railroad approximately 0.4 miles west of Dairy Creek Bridge and be connected to a Council Creek trunk just north of railroad crossing.

1.7.2 Recommended Sanitary System Improvement Plan

The recommended improvements to the existing collection system and additional infrastructure required to meet future growth requires an estimated capital expense of approximately \$1.58 million. These capital projects are generally divided into the following three categories: pipelines, manholes, and recommended studies. The list of projects is staged based on relative priority and timing of anticipated growth within the next 20 years.

In summary, recommendations are made to either install new or replacement piping for approximately 2.1 miles of sanitary collection pipelines ranging in size from 8- to 18-inches, rehabilitation of ten manholes, and four additional engineering and planning related studies.

Sections 6 and 7 provide more detailed discussion of the recommended improvements. For convenience, the capital improvements plan from that section has also been included here as Table 1-1.

1.8 Financial Review of CIP

A financial review of recommended CIP is provided in Section 8.

1.9 Organization of This Plan

Section 2 is the Study Area description and covers existing and proposed UGB and describes geography, climate and air conditions, and water sources, flooding areas, water sources, administrative boundaries, existing and proposed zoning and land use.

Section 3 describes Existing Sanitary Collection System and includes regulatory review, system inventory and system deficiencies.

Section 4 is a Planning Data section, which provides information on current and future population, estimation of wastewater flows, selects planning criteria and for evaluation of the existing and standard design criteria for planning and design of new system components.

Section 5 deals with Selection and Evaluation of Alternatives for upgrade and development of the existing collection system within proposed urban growth boundaries.

Section 6 is a Collection System Evaluation section. This section analyze existing system capacities, compares the existing system with current and future flow conditions and identifies deficiencies in existing system components based on selected evaluation criteria.

Section 7 is the development of the sanitary collection system Capital Improvement Program which combines the improvements for the system (from Sections 5 and 6) into a scheduled program of costs and priorities for each project.

Section 8 provides Financial Review of the proposed CIP activities and describes available sources (funding) for their implementation.

Section 9 describes current system Operating Strategy and provides recommendations for its improvements.

**Table 1-1
City of Cornelius Sanitary Sewer System
Capital Improvement Program**

CIP No.	Project	Length (feet)	Diameter (inches)	Project Need	Est.Total Cost in 2004 \$	O&M Costs	SDC Eligible Costs	Anticipated Implementation Period			
								2004	2005-2009	2010-2014	2015-2024
Operations / Maintenance											
Collection System Pipelines											
P-1	8-inch PVC sewer pipeline along Magnolia St	905	8	O&M	\$128,655	\$128,655		\$128,655			
P-2	8-inch PVC sewer pipeline along Heather St	590	8	O&M	\$83,875	\$83,875		\$83,875			
P-3	8-inch PVC sewer pipeline along Ginger St	588	8	O&M	\$83,591	\$83,591		\$83,591			
P-4	8-inch PVC sewer pipeline along Fawn St	306	8	O&M	\$43,501	\$43,501		\$43,501			
P-8	18-inch PVC sewer pipeline along S 12th Avenue	896	18	O&M	\$143,990	\$143,990	\$143,990				
P-9	10-inch sewer pipeline rehabilitation, S 13th Avenue	1,054	10	O&M	\$104,235	\$104,235			\$104,235		
P-10	10-inch sewer pipeline rehabilitation, S/N 14th Avenue	770	10	O&M	\$76,149	\$76,149				\$76,149	
P-11	Repair/Modify existing sewer siphon lines	165	6	O&M/Capacity	\$23,457	\$18,766	\$4,691	\$23,457			
P-12	Repair/Modify existing sewer siphon lines	235	10	O&M/Capacity	\$33,408	\$26,726	\$6,682	\$33,408			
P-13	8-inch PVC sewer line in Drainage Area 31	1,668	8	New Development	\$237,124		\$237,124	\$237,124			
Subtotal		7,177			\$957,985	\$709,488	\$248,497	\$143,990	\$633,611	\$104,235	\$76,149
Major Collector Pipelines											
P-5	18-inch PVC sewer pipeline, Future Drainage Area 20	1,250	18	New Development	\$146,796		\$146,796	\$146,796			
P-6	15-inch PVC sewer pipeline, Future Drainage Area 21	1,400	15	New Development	\$147,105		\$147,105	\$147,105			
P-7	15-inch PVC sewer pipeline, Future Drainage Area 22	1,320	15	New Development	\$138,700		\$138,700	\$138,700			
Subtotal		3,970			\$432,601		\$432,601	\$432,601			
Total Pipelines		11,147									
Manholes											
MH-1	Selected Manhole Rehabilitation	10 manholes	60	O&M	\$20,000	\$20,000		\$20,000			
Subtotal					\$20,000	\$20,000		\$20,000			
Recommended Studies											
R-1	Sanitary Master Plan 2009			Regulatory	\$35,000	\$17,500	\$17,500	\$35,000			
R-2	Sanitary Master Plan 2014			Regulatory	\$35,000	\$17,500	\$17,500		\$35,000		
R-3	Sanitary Master Plan 2019			Regulatory	\$35,000	\$17,500	\$17,500			\$35,000	
R-4	Pipe Alignment Study and Final Design for South Part of Areas 20, 21 and 22, N.West of City			New Development	\$60,000		\$60,000	\$60,000			
Subtotal					\$165,000	\$52,500	\$112,500	\$95,000	\$35,000	\$35,000	
Total					\$1,575,586	\$781,988	\$793,598	\$143,990	\$1,181,212	\$139,235	\$111,149

Section 2

Study Area

2.1 Location and Boundaries

The City of Cornelius (City) is located in the Tualatin River Valley in Washington County, Oregon, approximately 25 miles west of Portland. It sits along the Tualatin Valley Highway (Baseline and Adair Streets) corridor between the cities of Hillsboro and Forest Grove. The City's current Urban Growth Areas (UGAs) cover approximately 1,260 acres, extending west to the city limit with Forest Grove, north to Council Creek, south to the Tualatin River, and east to approximately 336th Avenue. The City's character reflects unique blends of new and old, natural and manmade environments. It enhances the quality of local natural, historic, and cultural resources.

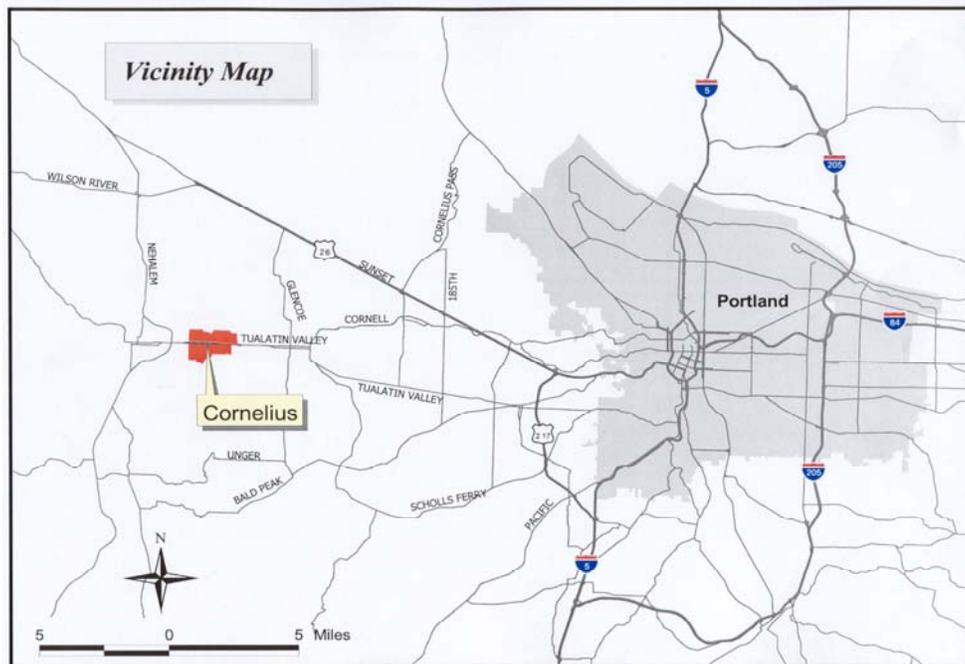


Exhibit 2-1
City of Cornelius
Geographic Location

2.2 Topography and Drainage Areas

The City of Cornelius is located on a relatively flat plateau of the western Tualatin Valley with an average elevation of 170 feet. The majority of the City's service area slopes in two directions: (1) from the administrative boundary with Forest Grove and Burlington Northern Railroad

toward Council Creek on the north (North drainage basin) and (2) south and southeast from the Burlington Northern Railroad toward the Tualatin River (South drainage basin). Portions of the City's eastern service area slopes toward Dairy Creek at the City's east boundary (Exhibit 2-2).

2.3 Geology and Soils

The oldest geologic units in the Tualatin Basin are volcanic rocks, mainly basaltic lavas and tuffs, overlain by the sedimentary rock layers: (1) the lower layer or pre-Quaternary sediments, termed the Troutdale Formation and the Sandy River Mudstone equivalent, and (2) the upper layer dating from the Missoula Floods consisting of 30 feet to 1,400 feet thick layers of clay, silt, fine sand, and lenses of coarse sand and gravels.

Soils in the area are described as Aloha, Quatama, and Woodburn silty clay and clay loams. Those soils are very fertile in the flood plains of the Tualatin River and its tributary creeks. Those soils are characterized by high seasonal ground water level rising roughly four feet below the surface. They have poor permeability, saturate easily, and might cause appreciable runoff from undeveloped areas. Some of these soils are also acidic in nature and could be corrosive to concrete, ductile iron and steel pipes.

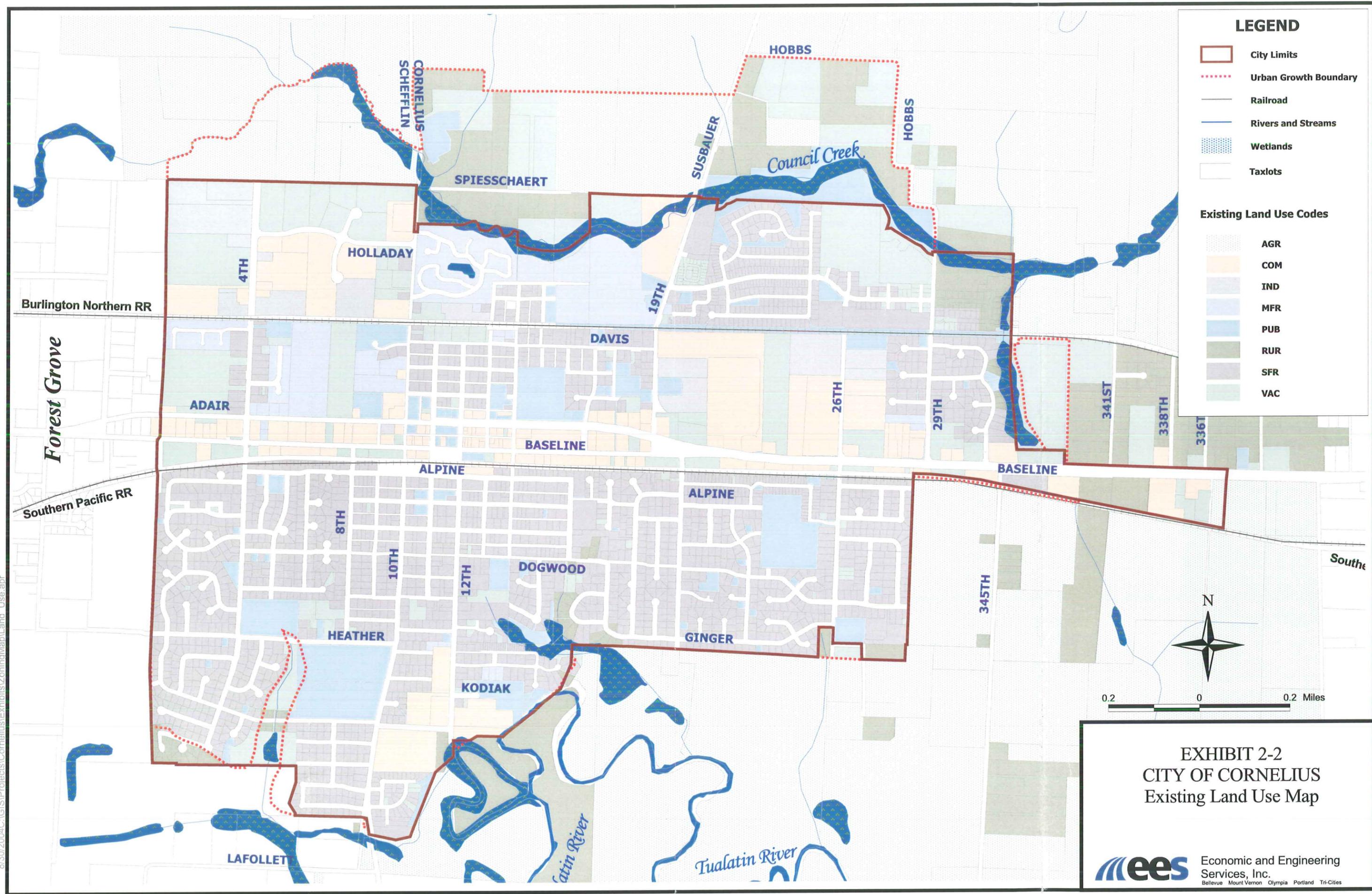
2.4 Surface Water Bodies and Flood Plains

There are only three significant surface water bodies affecting the City of Cornelius development. They are Council Creek on the north, Dairy Creek on the east, and the Tualatin River along the City's existing south and southeast UGB. Stream flow and water quality data is monitored by CWS. According to Federal Emergency Management Agency (FEMA), the floodplain elevation for the City of Cornelius is 151.6 feet and the City's code calls for no development below elevation 155 feet. Previously, the 100-year flood plain zones and elevations were also established by FEMA and shown on 1982 Flood Insurance Rate maps. The 100-year flood plain elevation on the north varies from 146 feet for Job's ditch to 151 feet for Council Creek and its tributaries. Flood plain elevations for the Tualatin River vary from 153 feet at the upstream, southwest boundary of the City, to 148 feet at the downstream southeast City boundary.

2.5 Climate

The City of Cornelius is located approximately 55 miles inland from the Pacific Ocean and has a modified marine climate. The prevailing western airflow from the ocean moderates the colder temperatures of the winter and the heat of the summer. Occasional extreme temperatures are associated with outbreaks of dry continental air pushing through the Columbia River Gorge and across the Cascade Mountains.

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LEGEND

-  City Limits
-  Urban Growth Boundary
-  Railroad
-  Rivers and Streams
-  Wetlands
-  Taxlots

Existing Land Use Codes

-  AGR
-  COM
-  IND
-  MFR
-  PUB
-  RUR
-  SFR
-  VAC



0.2 0 0.2 Miles

**EXHIBIT 2-2
CITY OF CORNELIUS
Existing Land Use Map**

2.5.1 Precipitation

Precipitation information is based on data from a precipitation gauge in Hillsboro, OR with data collected from 1948 to 2002. The gauge is at an elevation of 160 feet above mean sea level. Exhibit 2-3 shows the average day and average month precipitation from this gauge located near Cornelius. Precipitation in the area consists mostly of rainfall from November to April. Dry months are July, August, and September. Seasonal characteristics are well defined, and changes between seasons are gradual. The average annual rainfall is 38-inches. Approximately 26 percent of the total annual rainfall is received in fall, 46 percent in winter, 21 percent in spring and only seven percent in summer. Extremes in rainfall for individual years have varied from 24 to 61 inches. Snowfall amounts are low in Cornelius.

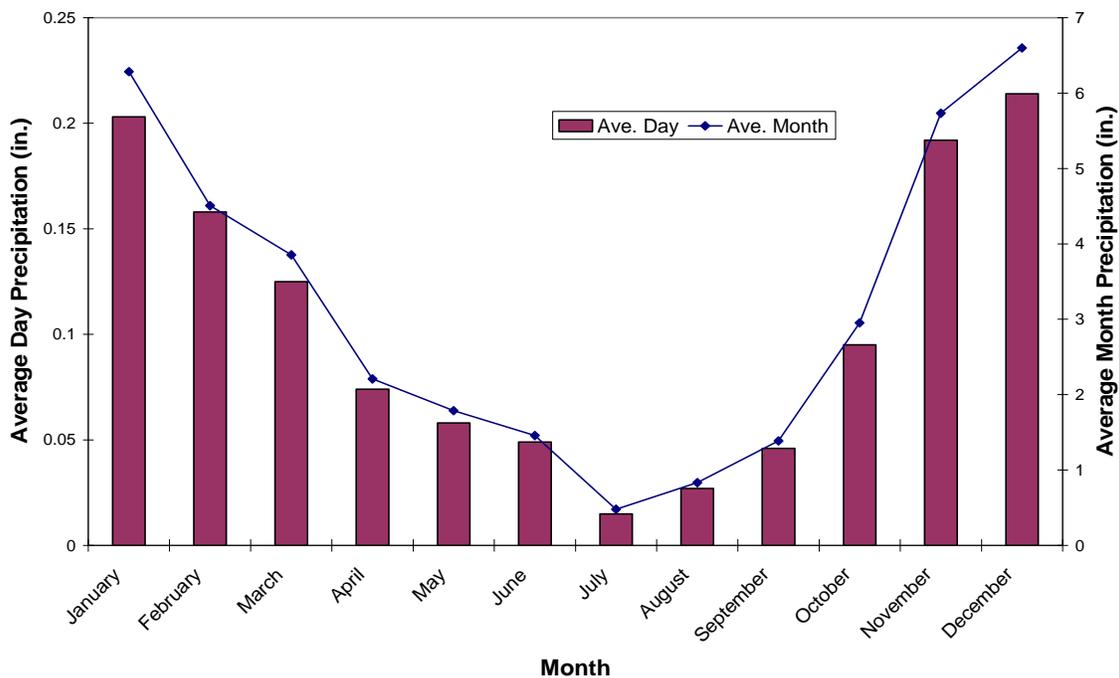


Exhibit 2-3
City of Cornelius
Historic Rainfall Data

2.5.2 Temperatures

Temperatures in Cornelius are generally moderate, with the average daily low for January being 32° F, with an average July maximum of 82° F. Record extreme temperatures ranges from -18° F in 1950 to 108° F in 1956. Hot afternoons of 90° F and above occur about 17 days per year on the valley floor. Temperatures of 100° F or more are expected about every other year, and minimums of 0° F or lower about one in every 20 years.

2.6 Air Quality and Noise

2.6.1 Air Quality

Air quality in Cornelius is monitored and regulated as part of the entire Portland Air Quality Maintenance Area (AQMA). The results of air quality and Air Quality Index that describes daily air pollution might be obtained from Department of Environmental Quality (DEQ) and is available on their web site (www.deq.state.or.us). The DEQ monitors, Carbon Monoxide, A&B Particulate, Ozone, Oxides of Nitrogen and Hydrocarbons, Light Scattering, Hazardous air pollution, lead and sulfur dioxide. In general air quality in Cornelius is good. There are no major pollution sources in Cornelius or nearby. The only long term concern for air is future high traffic volume and congestion that will likely increase exhaust emission levels.

2.6.2 Noise Sources

Based on information presented in the City of Cornelius Comprehensive Plan, significant noise sources within Cornelius are:

- Tualatin Valley Highway with Baseline and Adair Street,
- The Southern Pacific Railroad,
- The Burlington Northern Railroad,
- The Fire Department fire horn at 13th North Avenue, and
- Several companies in north and south industrial zones.

2.7 Natural Hazards and Soils

As described in the City's Comprehensive Plan, there are no major hazards in Cornelius other than within the 100-year flood plain. There are some hazards relative to earthquakes. Safety standards and regulations are provided by the Uniform Building Code. As there are no major areas with the land slope greater than five percent, landslides are not expected and erosion hazard is very low.

2.8 Land Use

2.8.1 Land Use and Administrative Boundaries

Existing land use zoning and administrative boundaries for the City are shown in Exhibit 2-2. The City has 1,260 acres within its UGB. Current zoning shows over 35% of land use is devoted to single family residential, 6% multi-family residential, 12.5% commercial, 5% industrial, 12% approximately as vacant land, and 20% for public rights-of-ways and about 10% for public institutions and parks and small areas of rural land.

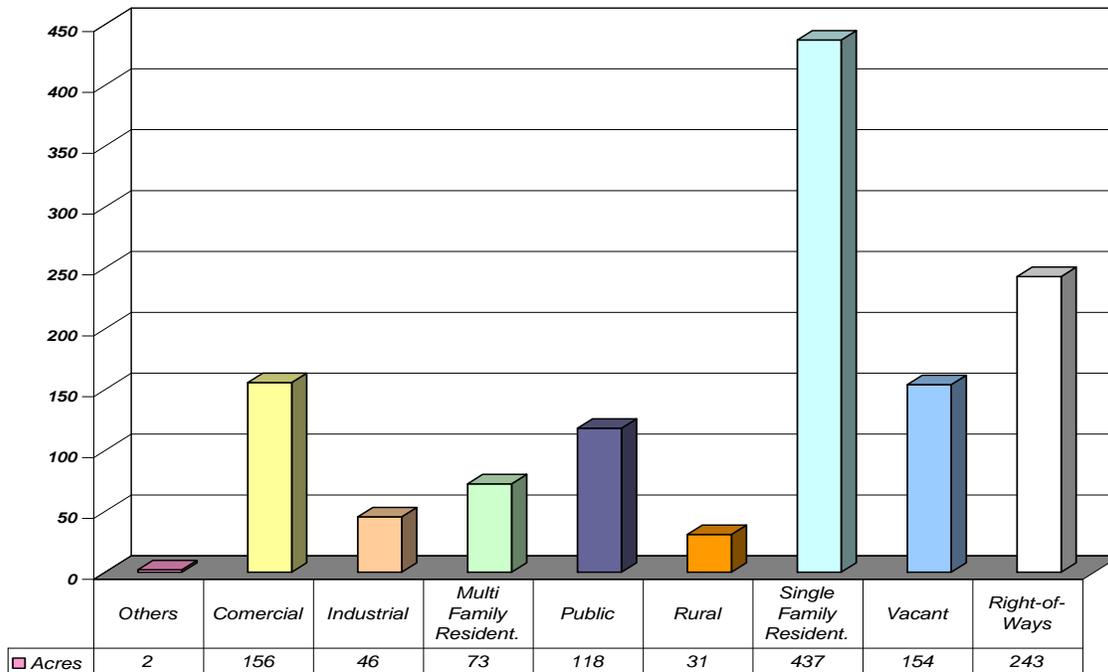


Exhibit 2-4
 City of Cornelius
 Existing Land Use (acres)

2.9 Water Sources

The City of Cornelius owns, operates and maintains its water distribution system. The City receives all of its water from the City of Hillsboro through wholesale water purchase. Water is supplied from the Joint Water Commission (JWC) water treatment plant (WTP), partially owned by the City of Hillsboro, via the 72-inch North Transmission Line completed in 2002.

2.9.1 Numbers of Connections and ERUs

Based on certified census results on July 1, 2000, and the Portland State University 2003 estimate, the City's projected population for 2004 is 10,450 persons through 2,529 connections totaling 2,910 ERUs. The City's customer base is largely residential, with some light commercial and industrial accounts. The City's accounts range in size from 3/4" to 3" meters. Approximately, 96.5% of the City's meters are the standard residential size of 3/4" x 5/8". The next largest percentage are 1" and 2" meters which make up 3%, followed by 1-1/2" and 3" meters that make up 0.5% of the City's inventory. An illustration of the City's meter inventory is shown in Exhibit 2-5.

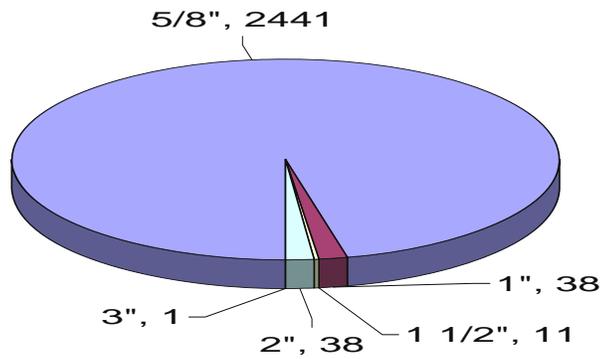


Exhibit 2-5
City of Cornelius
Water Meter Breakdown

2.9.2 Customer Classes Breakdown

In addition to a breakdown by meter size, an examination was also made of the City’s customers by class of use. Nearly 95% of all accounts are classified as residential use. The next largest user class is commercial/industrial, with the remainder comprised of schools and City (public) use and others. A summary of the number of accounts by customer class for these main categories is shown in Exhibit 2-6.

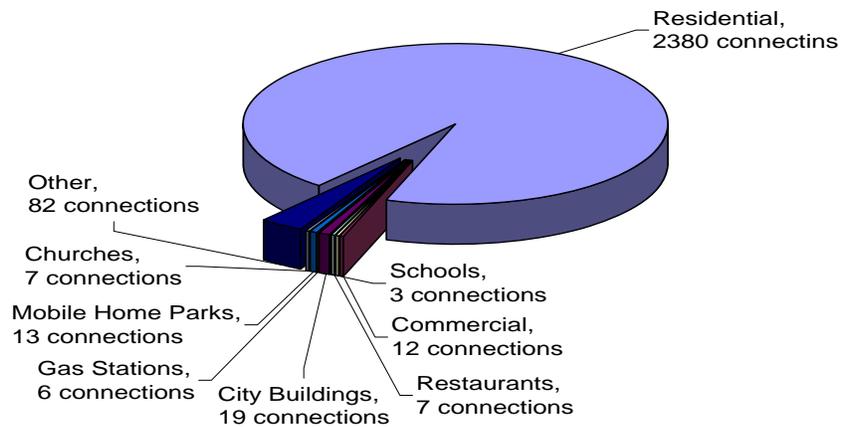


Exhibit 2-6
City of Cornelius
Customers Breakdown

2.9.3 Water Demand

Average annual and peak day water demand for the City of Cornelius is shown on Exhibit 2-7. This demand was adopted from the City's 2004 Water Master Plan and is calculated based on the average water use per ERU of 397 gal/day or approximately 114 gallons/person day multiplied by estimated population from 10,450 in year 2004 to total of 20,000 people in the year 2024. A peaking factor of 2.4 was assumed (PDD: ADD).

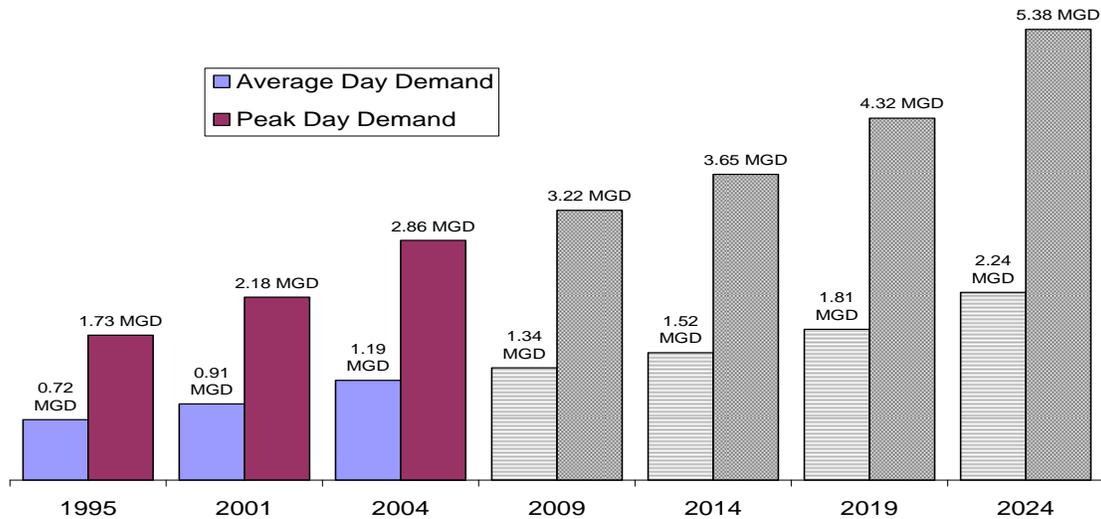


Exhibit 2-7
City of Cornelius
Historic and Future Water Demand

Section 3

Existing Wastewater System

3.1 System Description and History

The City owns and operates a sanitary sewer collection system, which presently serves a population of approximately 10,000 people through nearly 2,600 residential, commercial and industrial connections located within the existing UGB.

The existing sanitary system collects wastewater within two major (north and south) drainage basins. For maintenance and operational purposes, these primary basins are further divided into 18 subdrainage basins or secondary system sections as shown in Exhibit 3-1. The secondary system sections numbered 1, 2, parts of 3 and 4, 6 and 18 are a part of the north drainage basins while remaining system sections are part of the south drainage basin. Wastewater from the south drainage basin is routed to Forest Grove while the north drainage basin is conveyed to Hillsboro Wastewater Treatment Plants respectively. Both plants are owned and operated by CWS of Washington County.

3.1.1 South Drainage Basin

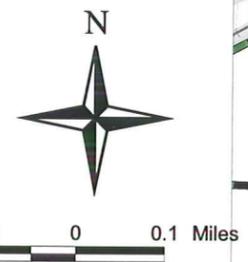
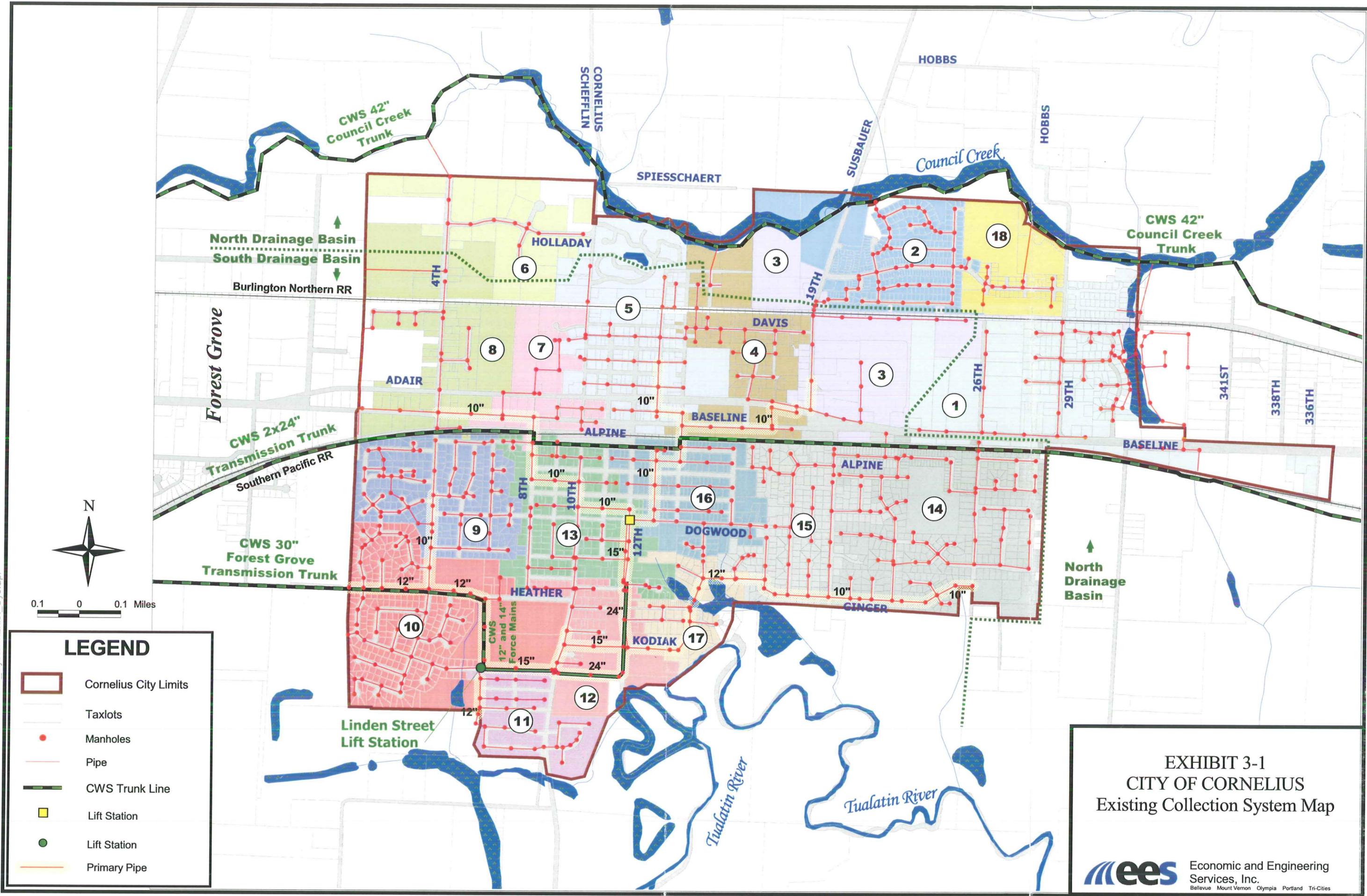
The South drainage basin is served by the City's oldest sewer collection system and encompasses approximately 80% of the City's existing sanitary collection capacity. The drainage area is located between the administrative boundary with the City of Forest Grove on the west side, 28th Avenue on the east side and it slopes mildly from the Burlington Northern Railroad on the north toward the Tualatin River on the south.

The oldest portion of the sanitary sewer collection system in this basin was built in 1959 and is almost 50 years old. It was constructed to serve the Old City center located along Baseline and Adair Streets and a residential area bounded by 4th and 19th Avenue or 19th Place, North Fremont and South Ginger Street. Wastewater was collected and routed via 12th Avenue trunk to the former City of Cornelius treatment plant on the Tualatin River.

The City operated and maintained the plant for almost 26 years. Under increasing operating cost, regulatory constraints and discharge criteria, the City decided to seek an alternate solution for treatment of wastewater flows in terms of a long term agreement with Clean Water Services (formally Unified Sewerage Agency). After finalization of the agreement, the treatment plant was abandoned in 1974 and wastewater from the plant was diverted via a new 15-inch transmission main to a newly constructed (2,300 gpm) lift station on Linden Street.

Wastewater from Linden Street lift station was then pumped via 12-inch force main along South Heather Street to the manhole at the boundary with Forest Grove, and further by gravity, via 30-inch transmission line, to the Forest Grove WWTP.

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LEGEND

- Cornelius City Limits
- Taxlots
- Manholes
- Pipe
- CWS Trunk Line
- Lift Station
- Lift Station
- Primary Pipe

EXHIBIT 3-1
CITY OF CORNELIUS
 Existing Collection System Map



Economic and Engineering Services, Inc.
 Bellevue Mount Vernon Olympia Portland Tri-Cities

Over the next few years, three major sewer collectors were added to this lift station. One of them was a 12-inch trunk, built in 1974, collecting and diverting sewage from 4th Avenue area. A second 12-inch trunk was also constructed in 1974 to provide service to the 20th Avenue area and additional areas further east to be developed in the future. In 1979, a third 10-inch trunk was added to collect wastewater along Linden Street, west of the lift station.

The City of Cornelius routes a small percentage of its wastewater from Subbasin No. 8 to the City of Forest Grove collection system. At the same time the City of Cornelius receives wastewater from Neil Armstrong Middle School and Fernhill Elementary School in the City of Forest Grove High School located at Heather and Mountain View Streets. The school has capacity for approximately 350 students.

CWS has also increased the total transmission capacity from the City of Cornelius south drainage basin to the Forest Grove WWTP (to 4,750 gpm or 7 MGD) by adding a parallel 14-inch force main along South Heather Street in 2002, and upgrading its existing Linden Street lift station in 2004.

3.1.2 North Drainage Basin

The North drainage basin covers approximately 20% of the existing UGB and slopes north from Burlington Northern Railroad tracks toward Council Creek. The sanitary sewer collection system for this area was constructed over the last 20 years and connects to the existing 42-inch CWS Council Creek Trunk at five (5) different locations.

This major trunk has an approximate capacity of 13 MGD. It was constructed by CWS in 1991 and routes wastewater flows from the Cities of North Plains, Banks, and a northern portion of Forest Grove to the Hillsboro WWTP. There is a plan to increase capacity of this trunk. Based on discussions with CWS, the upgrade of the trunk will occur as wastewater flows increase within its drainage area.

CWS expanded both treatment plants in Forest Grove and Hillsboro, in 1997, to meet National Pollutant Discharge Elimination System (NPDES) permit requirements.

3.2 Service Area Policies and Regulatory Overview

3.2.1 Service Area Policies

Operation of the Cornelius Sanitary Sewer System is governed by policies established by the City, an Intergovernmental Agreement (IGA) between the City of Cornelius and Clean Water Services, Washington County, METRO, Oregon Department of Environmental Quality, DLCD and federal agencies (see Appendix B)

3.2.2 Regulatory Overview

The federal regulatory structure provides guidance and compliance direction to the state and local authorities. The state provides an effective role in defining requirements, while the legal ordinances are most typically a local instrument.

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In the City's case, CWS holds the NPDES permit that covers the City of Cornelius because it receives the City's raw sewage discharge. The NPDES permit is administered by Oregon Department of Environmental Quality (DEQ). The City itself does not have its own NPDES permit; however, per the City's intergovernmental agreement with CWS, it must fulfill its responsibilities to satisfy CWS' NPDES requirements. Furthermore, in 1996, DEQ modified its water quality standard for bacteria, which established sewer overflow restrictions in the Oregon Administrative Rules (OAR) that specifically prohibited summer and winter overflows, except during certain defined storm events.

3.2.3 CWS Intergovernmental Agreement (IGA)

Clean Water Services is a wastewater and stormwater public utility that was formed in 1970 as the Unified Sewerage Agency of Washington County to address serious health and pollution problems in the Tualatin River and its tributaries. In 2001 the Unified Sewerage Agency formally changed its name to Clean Water Services to more appropriately reflect its mission objectives. Today CWS works in partnership with 12 member cities—Beaverton, Tigard, Tualatin, Hillsboro, King City, Forest Grove, Sherwood, Cornelius, Banks, Gaston, Durham, and North Plains along with urbanized portions of unincorporated Washington County to improve water quality in local streams, manage flooding, protect fish habitat, manage flow in the Tualatin River and operate and maintain the public sanitary sewer and surface water management system. Over the last 30 years, CWS has unified 26 small local wastewater treatment plants into one coordinated system of four wastewater treatment plants and 41 lift stations. CWS treats more than 64 MGD of wastewater a day to one of the highest standards in the nation before returning the water to the Tualatin River.



Exhibit 3-2
Clean Water Services
Boundary and Major Facilities

Since 1974, the City has maintained an IGA with CWS regarding wastewater treatment, operation and maintenance of sanitary collection and transmission utilities, and other shared responsibilities. The latest IGA was approved by the City on July 6, 2004. The IGA includes two appendices “A” which describe the shared responsibilities between CWS and the City for July 1, 2004 – June 30, 2005 and modifications effective July 1, 2005. The shared responsibilities will form the basis of a future reevaluation of the current rate split between CWS and the City. The current IGA and both Appendices “A” are included as Appendix B of this master plan.

This agreement defines CWS’s responsibility for all construction, maintenance, inspection, repair and replacement, and operation of wastewater treatment plans, lift stations, force mains between lift station and wastewater treatment plants, and all other collection pipelines 24-inch or larger. CWS is also taking full responsibility for non-structural line sealing and point repair, manhole rehabilitation on all sanitary collection and transmission pipelines, as well as developing and performing flow monitoring, industrial waste, fat, oil and grease programs. CWS will also share responsibility with the City regarding Infiltration and Inflow (I/I) abatement and system rehabilitation projects, and several other engineering, inspection and support elements.

The City takes full responsibility regarding maintenance, replacement and upgrade of its collection system consisting of pipelines sizes 21-inch and under, and participates in shared responsibility with CWS, as described above.

3.3 Facilities Inventory

The City's collection system consists of major collector pipes (trunks) 10-inch and larger, collection system pipes 8-inch and smaller, overflow lift station and associated pipelines, siphon pipes, and manholes (see Exhibit 3-1)

Major collector pipelines in the South drainage basin were mostly built as an original part of the system, between 1959 and 1977, and upgraded in 1978 by adding a 15-inch overflow line along South 12th Avenue between Dogwood and Ginger Street (Subbasin No. 17) and 24-inch line along South 12th Avenue and South Flax Plant Road and between Ginger Street and Linden Street Lift Station (Subbasins No. 12 and 17). This 24-inch line now belongs to CWS. There is no major collector lines (10-inch and larger) in North drainage basin. The existing sanitary collection system in this area is mostly made of 8-inch PVC pipes and collect and convey wastewater to the Council Creek trunk.

3.3.1 Collection Pipelines

Pipe Sizes and Pipe Material

The City's sanitary collection system is made up of approximately 27 miles of 18-inch or smaller sewer lines. Exhibit 3-3 shows the distribution by size. The majority of the City's pipes are 8-inch in diameter which makes up approximately 75% of the total.

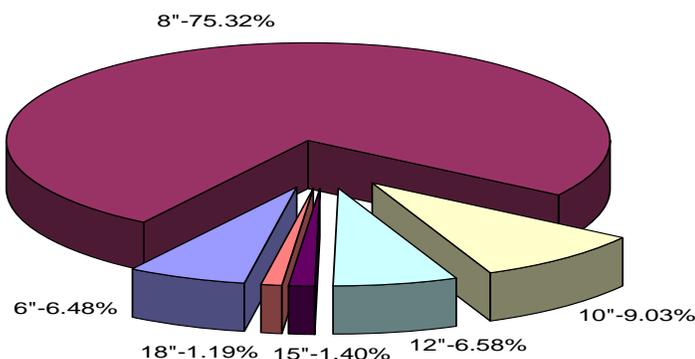


Exhibit 3-3
City of Cornelius
Sewer System Pipe Sizes

Exhibit 3-4 provides a breakdown of the City’s sanitary lines based on material. The majority of the City’s pipelines are made of concrete sewer pipes which make up approximately 59% of the total. Concrete pipes were exclusively used for the construction of original sanitary system since 1959 until the late 80’s, after which City started using PVC pipes to serve new developments. PVC pipe material currently makes up 35% of the total pipes by installed length. A small amount of ductile iron lines are used for shallow applications, local overflow, and siphon lines.

Since the 1980’s CWS has been financing pipeline/manhole rehabilitation projects of the City’s oldest sanitary collection system. Those projects consist mostly of replacing or upgrading the majority of the existing concrete pipes by implementing pipe-bursting and/or slip-lining techniques, using High Density Polyethylene (HDPE) material for pipe and epoxy lining for rehabilitation of manholes. By doing so, CWS is trying to reduce the I/I flow component, delay upgrade of the existing its major treatment and transmission system facilities.

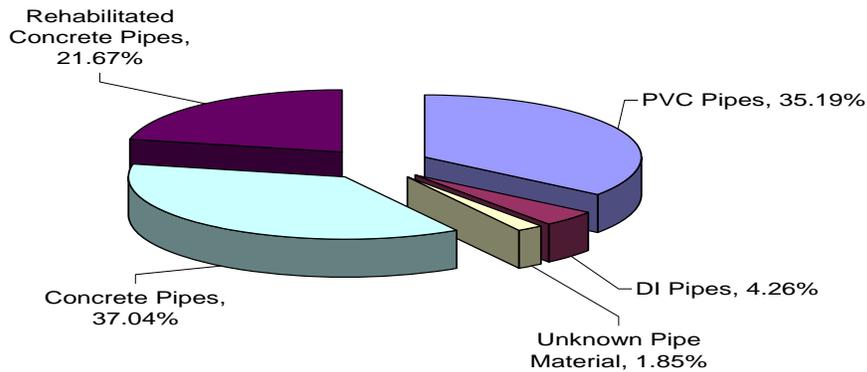


Exhibit 3-4
City of Cornelius
Collection System – Pipe Material

Pipe locations based on age (year of construction) and pipe material, are shown on Exhibits 3-5 and 3-6.

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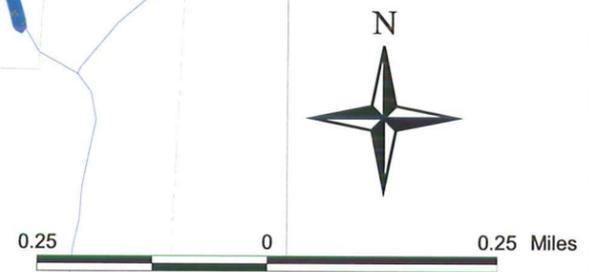
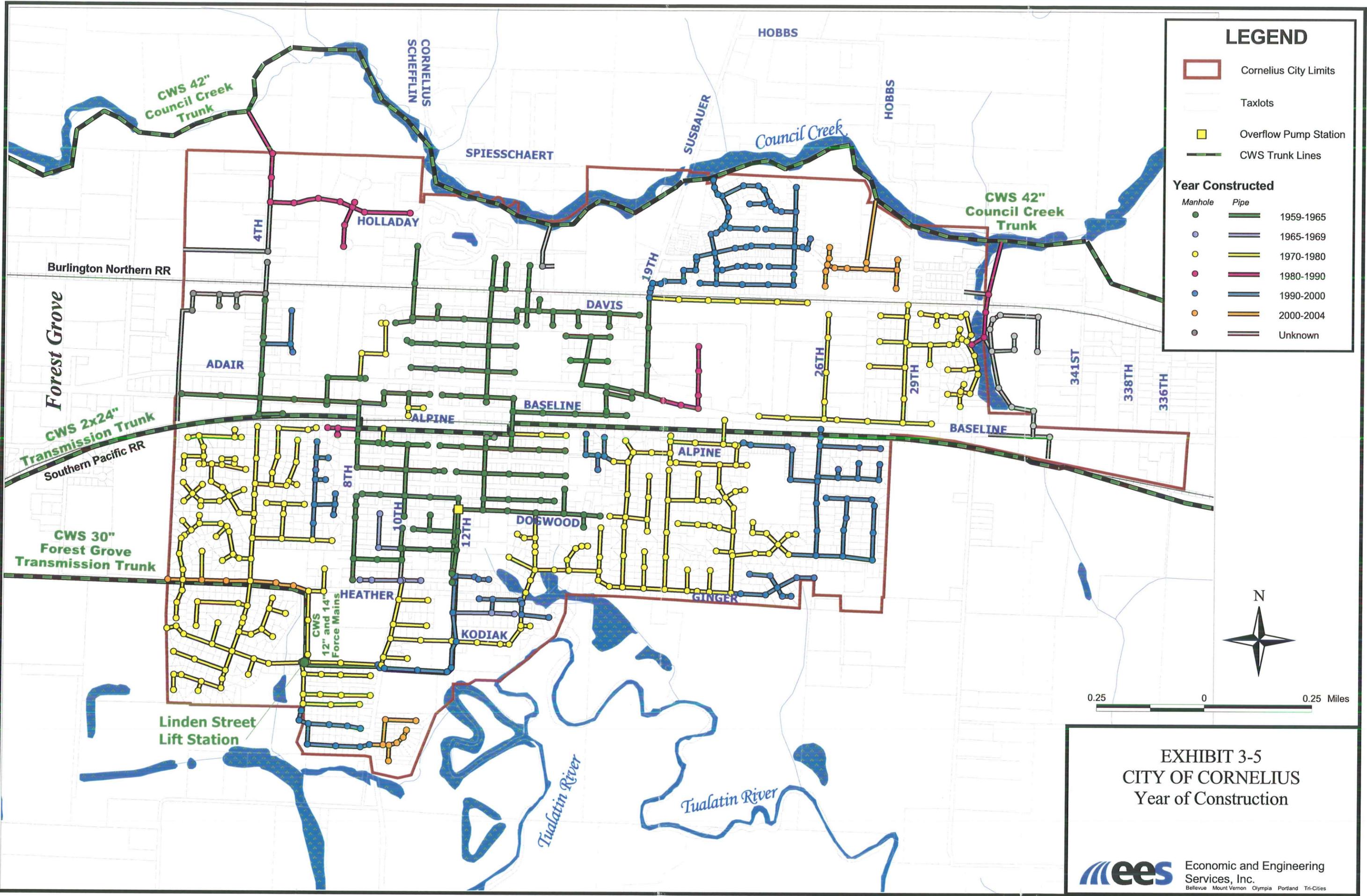
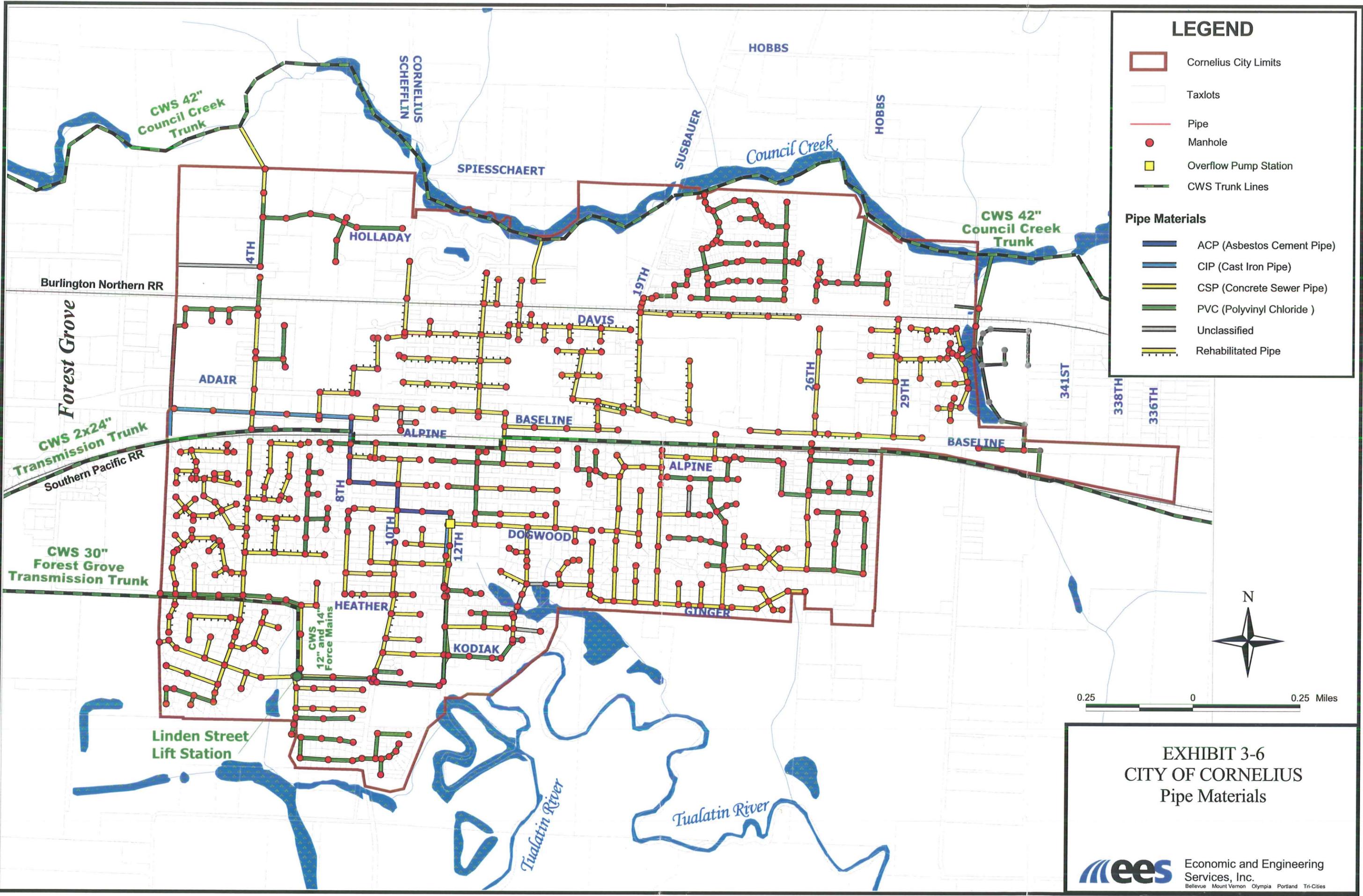


EXHIBIT 3-5
CITY OF CORNELIUS
 Year of Construction

ees Economic and Engineering Services, Inc.
 Bellevue Mount Vernon Olympia Portland Tri-Cities

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LEGEND

- Cornelius City Limits
- Taxlots
- Pipe
- Manhole
- Overflow Pump Station
- CWS Trunk Lines

Pipe Materials

- ACP (Asbestos Cement Pipe)
- CIP (Cast Iron Pipe)
- CSP (Concrete Sewer Pipe)
- PVC (Polyvinyl Chloride)
- Unclassified
- Rehabilitated Pipe



0.25 0 0.25 Miles

EXHIBIT 3-6 CITY OF CORNELIUS Pipe Materials

Pipe Alignments

The majority of the existing collection lines and related manholes are laid inside the southbound lane of the City's streets and eastbound lane of the City's avenues. The streets mostly follow south-north and avenues east-west alignments, respectively. There are some of collection lines laid in narrow, three to four feet wide utility easements, between the tax lots in the old residential areas, located mostly between 8th and 16th Avenue and N. Davis and S. Fawn Street (Subbasins No. 11, 12 and 13). Those easements are slightly narrower between S. Fawn and Heather Street or even disappear as could be noticed between Linden and Nectarine Street. Even though the city has permanent utility easements the sanitary lines and manholes are inaccessible for inspection and maintenance in those areas.

Pipe Cover and Pipe Crossings

The majority of the existing sanitary lines are between five and ten feet deep. Average pipe cover is about eight feet. However, in some locations at the east City's boundary, pipe invert elevation rises to three feet from the surface, mostly due to minimum pipe slope requirements and large distance from Linden Street lift station. There are several sites where sanitary lines cross Burlington Northern and Pacific Railroad, Baseline and Adair Streets. Based on discussion with the City personnel, all of those crossings are fairly deep and were made of concrete pipes as carrier pipes. There is no knowledge if casing pipes were installed at those crossings.

3.3.2 Lift Station

There is only one emergency overflow lift station located at S. 12th Avenue and Dogwood Street (Subbasin No. 13). It operates only during high intensity rainstorms when capacity of the existing 15-inch sanitary line is exceeded due to high I/I flow component. This lift station was built as a manhole structure and is equipped with two submersible sewage pumps type SK 60 (6 Hp, 1,200 gpm) and SPI (10 hp, 2,000 gpm). The lift station pumps to a 15-inch PVC overflow line in an adjacent manhole that gravity drains to the manhole in Ginger Street. Wastewater flows from this manhole are routed by gravity toward CWS's Linden Street lift station, via 24-inch PVC line built by CWS in 1998. Both pumps operate automatically based on manhole water level.

The City plans to remove this pump station in the future if replacement of the dual piping in S. 12th Avenue between Ginger and Dogwood and the new Linden Lift station successfully prevent winter system backups.

3.3.3 Siphons

The City's collection system has two (2) inverted siphons built in 1976. Both are located in the South Drainage zone (Subbasin No.17). The first siphon is located between Emerald Loop and 15th Avenue. The second, located further downstream, is located between 15th Avenue and Heather Street. Both siphons consist of 2 lines made of 6-inch and 10-inch cast iron pipes. The City flushes both siphons regularly, every two months, due to excessive sediment (waste) deposition during low flow conditions.

3.3.4 Manholes

The sanitary sewer collection system consists of 650 prefabricated concrete manholes with cast iron lids and inside steps. There are only a few manholes that have inside or outside pipe drops. All of City's manholes are four (4) feet ID, except several five (5) feet ID manholes built along Heather Street in 2002/2003. As mentioned before, CWS' has been rehabilitating some of those manholes to reduce I/I flows. Those projects include removal and replacement of highly damaged or broken manhole segments, plugging of cracks by grouting, and lining by epoxy or similar manhole lining material. The locations of these rehabilitated pipelines are shown on Exhibit 3-6.

3.4 System Deficiencies Identified by Operation Staff

An interview with the maintenance crew was held to obtain more specific information about existing system deficiencies and operational and maintenance issues. Those are summarized and presented on Exhibit 3-7. The sanitary sewer system O&M team completes video surveillance of the entire system once every 7 years and keeps sewer graphical inspection reports for each of collection lines. Those reports provide date and time of inspection, operator's name, subbasin (system section) number, street name, upstream and downstream manhole number, pipe ID and pipe material, lateral location, and finally station and description or code of identified pipe defect, pipe deficiencies or obstructions. Those reports are often followed with photos and identify localized pipe sags, plugs in sewer laterals, pipe cracks, broken pipe sections, longitudinal or perpendicular pipe fractures, grease accumulation and build up, root intrusion and infiltration locations. All of those reports are discussed and followed with recommended solutions and proposed actions.

Based on discussion with the maintenance crew, the majority of identified deficiencies might be solved under regular system maintenance activities. There are other issues that need additional attention:

- significant build-up of grease along several pipe sections,
- pipe sections that could not be video surveyed or easily accessed due to small pipe or insufficient space at pipe entrance,
- pipe sections that could not be easily maintained due to very narrow easement or no easement at all,
- need for frequent line flushing due to sediment buildup in siphon pipes, and
- need for frequent line flushing due to back up of flows in a sanitary line along Heather Street, west of 4th Avenue (Subbasin No. 10).

This study will further analyze those issues and provide suggestions or recommendations for their solutions.

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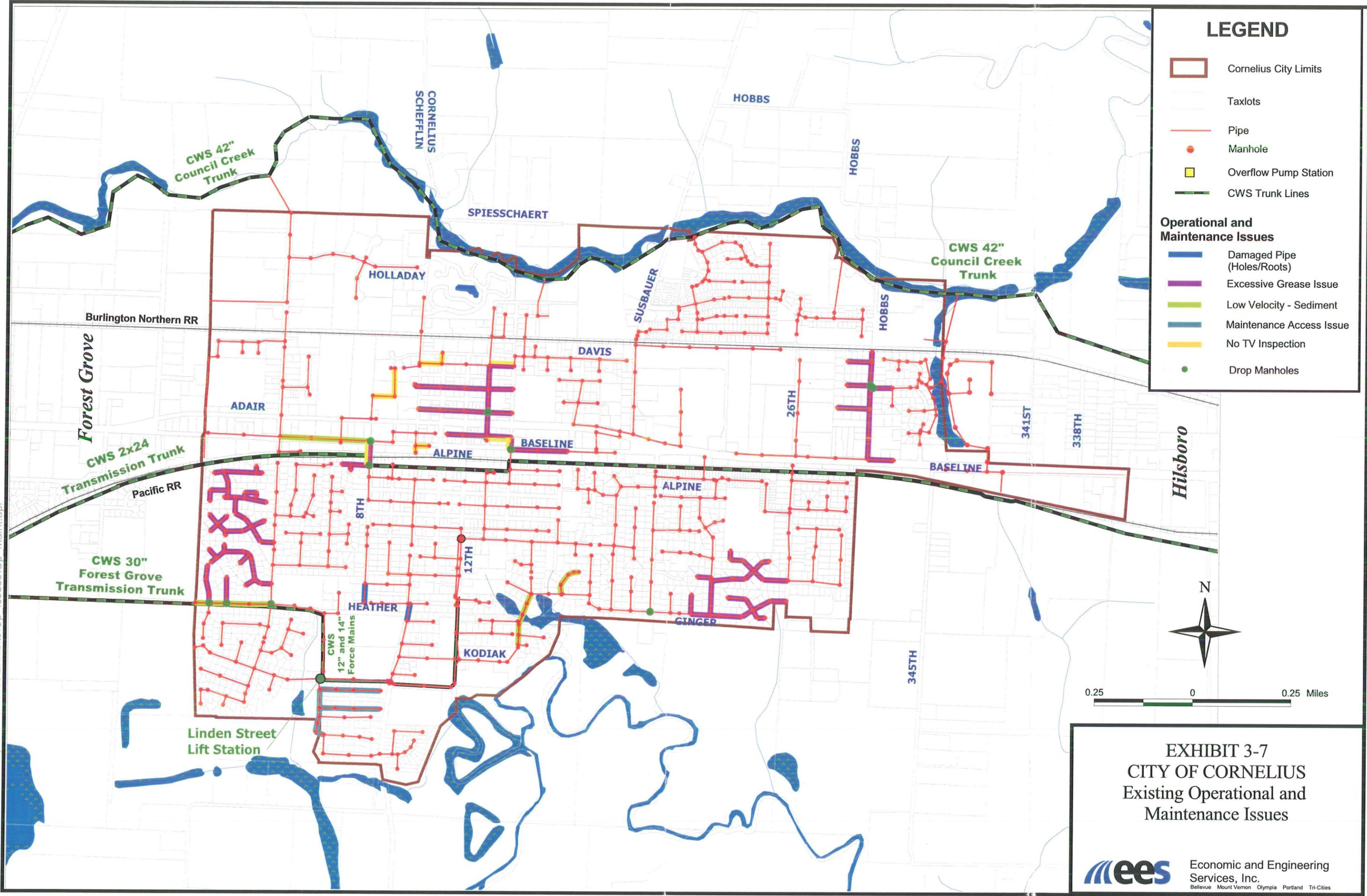


EXHIBIT 3-7
CITY OF CORNELIUS
 Existing Operational and Maintenance Issues



Economic and Engineering Services, Inc.
 Bellevue Mount Vernon Olympia Portland Tri-Cities

Section 4

Planning Data

4.1 Introduction

This section includes the population projections, land use development, wastewater flow components and unit values, design criteria, and cost criteria that will be used for evaluation of the existing and planning of future system components. Based on discussion with the City of Cornelius Operations and Engineering staff and CWS's personnel, the following data and assumptions as well as planning and design criteria, previously adopted by CWS and/or the City, will also be used in this study.

Developments

- 1) Population projections as defined in the latest 2004 City of Cornelius Water Master Plan (Exhibit 4-1) shall be used to estimate future wastewater flows.
- 2) Population density of 3.04 people per dwelling unit for all new residential areas per 2000 Cornelius Amended Comprehensive Plan.
- 3) Estimated population growth will be distributed within proposed UGB based on zoning maps and expected land use, as provided by the City's Planning Department. This will also be the extended study area for the 2004 Sanitary Sewer System Master Plan.
- 4) The City of Cornelius will provide sewer service to the total projected population within the proposed study area by 2024.
- 5) Wastewater flow definitions and unit flows are as defined by the Year 2000 CWS's Sanitary System Sewer Master Plan Update. Those flows are divided on dry weather flows (or sanitary flows), wet weather flows, and I/I flows and described further in the text.

Existing City Limits and UGB

- 6) Population density for single residential and multi-residential areas, within the existing City limits and existing UGB will be estimated based on the 2004 population of 10,450 people and a total number of tax lots or dwelling units within each of those areas.
- 7) Existing residential, commercial and industrial dry weather unit flows (or sanitary unit flows) will be estimated from existing cumulative dry weather flows. Those existing cumulative dry weather flows are anticipated to be approximately at 85% of the current, year 2004, average potable water use (demand). For more detailed unit flow estimates see Section 6, Subsection 6.3.1 Base Sanitary Flows of this report.

- 8) Wastewater flow definitions and unit wet weather and I/I flow values will be as defined by the Year 2000 CWS's Sanitary System Sewer Master Plan Update

Both, Existing City Limits and new Developments

- 9) Design Criteria for evaluation of existing and planning and construction of new wastewater facilities, are as defined by Design and Construction Standards for Sanitary Sewer and Surface Water Management, Clean Water Services, March 2004.
- 10) The unit cost criteria, as presented in this section, outlines the level of detail of the cost estimates.

4.2 Population Projections

The purpose of population projections is to distribute the population based on land use data throughout the UGB and AIs, and apply wastewater unit flow factors to determine future wastewater quantities. Those quantities will be calculated for the entire City's collection system and for individual or group of drainage basins to define maximum discharge rates and connection locations to the existing CWS's transmission or pumping facilities. Those flow projections will also be used to evaluate capacity of the existing collection system and adequately size future improvements within the proposed City's UGB.

The population projection presented in the Year 2004 Water Master Plan is based on certified census results on July 1, 2000, and the Portland State University Population Research Center 2003 estimates, and provides population projections up to year 2024. For the purposes of this study the year 2024 will be used as the end of the planning period.

Assuming slow to moderate growth rate it is estimated that by the year 2024 the City's population will reach about 20,000 people. However, to accommodate that growth, the UGB will need to be expanded beyond its current boundaries.

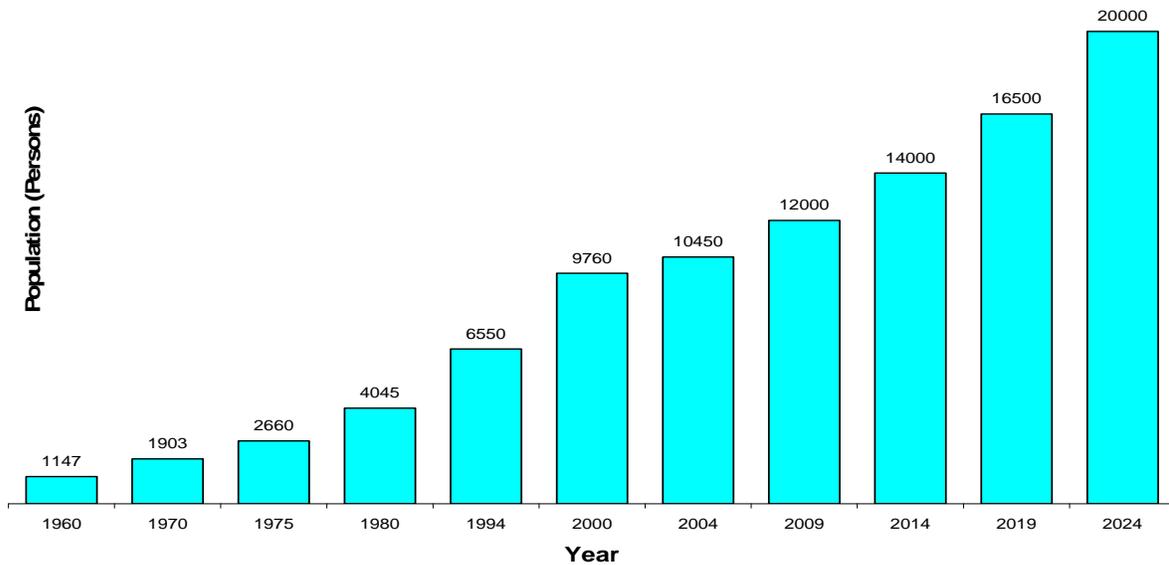


Exhibit 4-1
City of Cornelius
Historic and Projected Population

4.3 Urban Growth Area Expansion

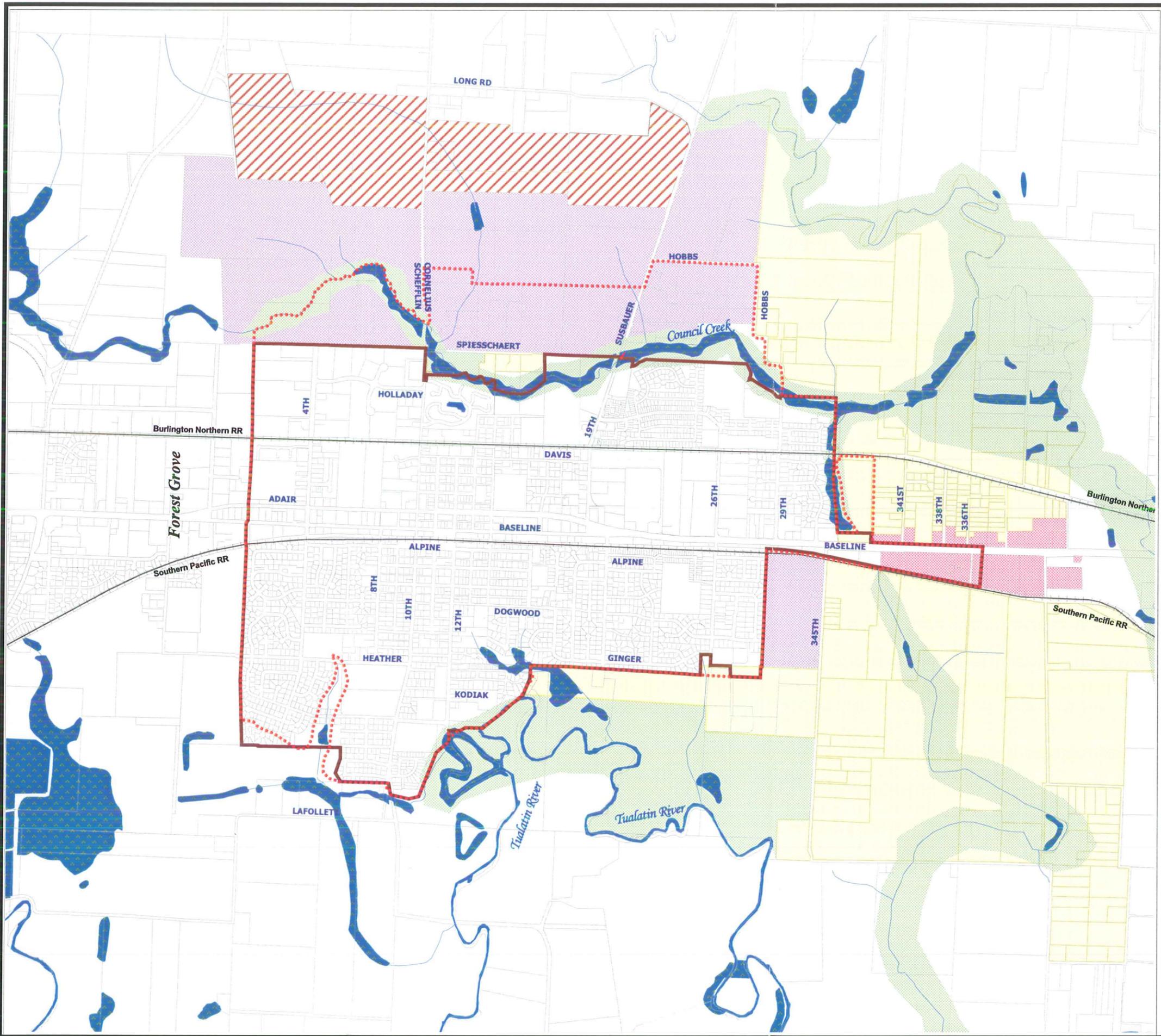
The City expects expansion of the existing UGB within the 20-year planning period. When approved by METRO, the boundary expansion may add up to a total of 1,670 acres of new land to the UGB. It is anticipated that approximately 1,400 acres will be added by year 2014 and additional 270 acres between 2014 and 2024.

Based on a zoning map provided by the City’s Planning department, the proposed AIs might consists of approximately 815 acres of single family residential zone (R-7), 700 acres of industrial/institutional zone, and 55 acres of commercial area. Possible land use and locations of AIs are shown on Exhibit 4-2.

4.4 Distribution of Total Population throughout possible UGB including AIs

Single family residential zone is expected to have a maximum density of not more than five (5) dwelling units per net acre having a tax lot of not less than 6,000 square feet. A net acre is equal to 32,670 square feet, and excludes roads, common open space, flood plains, riparian, setbacks and slopes over twenty-five (25) percent. Based on these assumptions it is assumed that 4,075 dwelling units will be added by the year 2024.

Those low density residential areas are expected to consist of: (1) 200 acres or 1,000 dwelling units located north of Council Creek and east and south of the proposed industrial zone, (2) 110 acres or approximately 550 dwelling units located east of Council Creek and north of TV Highway, (3) 80



LEGEND

- City Limits
- Urban Growth Boundary
- Railroad
- Rivers and Streams
- Wetlands
- City of Cornelius
- Taxlots

Proposed Land Use

- 2014 Greenspace and Parks Overlay
- 2014 Commercial
- 2014 Industrial
- 2014 Low Density Residential
- 2024 Industrial Growth Area



0 0.5 Miles

EXHIBIT 4-2
CITY OF CORNELIUS
 Proposed Land Use Map
 (Areas of Interest)

Economic and Engineering Services, Inc.
 Bellevue Mount Vernon Olympia Portland Tri-Cities

acres or 400 dwelling units located south of the existing city limits, and (4) 425 acres or 2,125 dwelling units located east and southeast of the existing city boundaries and south of TV Highway.

Possible industrial zones may occur in AIs on the north side of the city between Council Creek and Long Road, and along Baseline Street, southeast of the current city limits. Development of a commercial zone is anticipated along Baseline Street, east toward the City of Hillsboro (Exhibit 4-2).

4.5 Wastewater Flow Components and Projections

The wastewater flows for the City of Cornelius will be calculated for each sewer basin and subbasin to determine total system flows. Those flows will be further divided into two groups, sanitary and I/I. The sanitary group includes residential, commercial, and industrial flow components. I/I flows include infiltration and inflow components. Typical values of unit flows, as described in CWS's master planning documents were used to estimate existing and future flow scenarios for years 2014 and 2024

4.5.1 Wastewater Flow Components

The latest CWS's Sewer System Master Plan has defined basic wastewater flow components as described below. Those CWS's definitions will be used throughout this study.

Dry Weather Flow (DWF)

Dry Weather Flow is the collection's system base flow or sanitary flow component. Typically this component is predictable as it has direct correlation with potable water hourly, daily, weekly and monthly usage pattern and values. Those dry weather flow values could be further estimated as a percentage of a corresponding water usage as is done for the evaluation of the existing collection system (Subsection 6.1.3)

Average Wet Season Infiltration Flow (WWI)

Average Wet Season Infiltration Flow is assumed to be a constant flow during the wet weather season. WWI is site specific and depends mostly on ground water level and physical condition of the collection system. Infiltration into collection system is only possible in sewer lines, sewer laterals and manholes through defects, cracks, pipe joints and at the pipe manhole connections. The ground water level during the wet season in Cornelius is estimated to be very high, generally three to four feet below the surface in all areas of the City, suggesting that this flow component will stay constant throughout the system.

Storm Responsive Infiltration Flow (SRI)

Storm Responsive Infiltration Flow is related to significant increase in inflows and infiltration rates through manholes and pipe defects, caused by specific storm event, street flooding and temporary rapid change in ground water level. Experience shows that often roof drains and/or

area drains are often connected to the sanitary lines, instead of to stormwater system, causing such an increase in I/I flow component during storm events.

4.5.2 Unit Flows

Dry Weather Unit Flows

Based on the existing zoning and possible land use within new AIs, the following unit flows were adapted from the CWS' Sewer Master Plan and slightly modified to meet City's specific water demand/sanitary flow conditions. Those unit flows, as shown in Table 4-1 will be used to generate average daily dry weather flows for the proposed developments.

Table 4-1 City of Cornelius Dry Weather Flows Residential and Commercial / Industrial Unit Flow Rate				
Land Use	Description	Dwelling Unit (du) Density (pop/du)	Residential Unit Rate (gpcd)	Commercial/Industrial Unit Rate (gpd/1000sq. ft.)
CG	General Commercial			84
LI	Light Industrial			84
SFR	Single Family Residential	3.04	67	
MFR	Multi- Family Residential	3.04	87	
POS	Parks and Open Spaces			0

Average Wet Season Unit Flows

As suggested by CWS's Master Plan Update, average wet season unit flows of 200 gallons per acre per day (gpad) will be applied in this study to all new and already developed city areas.

Storm Responsive Infiltration Unit Flows

The 1969 CWS Master Plan used rate of 900 gpad for I/I allowance. In 1981 this allowance was increased to 1,500 gpad for new development. At the same time, it was estimated that actual I/I rates for the existing collection system exceeded 1,500 gpad. In 1979 Cornelius-Forest Grove Sewer Master Plan it was estimated that I/I flows in developed areas were in excess of 2,000 gpad. Measurement taken on South 12th Avenue during storm event in January of 1980, indicated I/I of approximately 2,400 gpad.

Since its 1985 Master Plan, CWS has required that new facilities within the sanitary sewer system convey rate of 4,000 gpad from upstream of new developed areas. The 1995 CWS Sewer Master Plan suggested rate of 1,850 gpad for new development based on statistical analysis of flow monitoring data and used that rate in modeling and evaluating future system improvements. The 2000 CWS Sewer Master Plan Update suggested that those I/I rates for new development shall be reduced to 1,650 gpad. That master plan found that typical I/I rates from developed portions of Rock Creek and Durham were approximately 2,000 gpad.

Even though the existing system was producing average I/I rates of 2,000 gpad, CWS has decided to use an I/I flow rate of 4,000 gpad throughout the new system to ensure that all facilities would be adequately sized. This rate will also be used in this study for future system upgrades. For the existing system evaluation, a rate of 2,000 gpad is assumed to determine I/I storm responsive flows.

4.6 Hydraulic Criteria

4.6.1 Hydraulic Evaluation Criteria

As mentioned earlier, estimated flows in the collection system include sanitary flows derived from unit flow rates based on population (DWF), wet flows (WWI), and storm event response I/I contributions (SRI) from each sanitary basin at a constant rate. It is anticipated that this combination of flows would provide for sufficiently conservative results. It is assumed, that for the purposes of evaluating both the existing collection system and future system improvements, no other safety factors will be applied.

4.6.2 HGL Analysis and Improvement Ranking System

This study will use CWS's adopted ranking system to determine the severity of surcharging problems within the gravity sewer pipes. The ranking system was developed as part of the 1995 Collection System Needs Analysis and summarized in Table 4-2, and illustrated in Exhibit 4-2. Sewer system improvements and the phasing of those improvements were defined based on analysis of the peak hydraulic grade line (HGL) within the system. The HGL freeboard is the difference between the HGL elevation and the ground elevation. There are three ranges of HGL established:

- Shallow HGL < 3.0 feet below ground
- Intermediate HGL Range 3 feet < HGL < 10 feet below ground
- Deep HGL > 10.0 feet below ground

A significance test is used to determine if the difference between the slope of the HGL and the slope of the pipe is excessive.

Table 4-2
City of Cornelius
Definition and Description of
Hydraulic Grade Line Ranking

Rank	Description	Improve	HGL Freeboard
LS	HGL daylight with significant HGL Slope increase (HGL elevation > ground elevation)	Yes	Less than zero feet
LH	HGL daylight (HGL elevation > ground elevation)	Yes	Less than zero feet
HS	High HGL with significant HGL Slope Increase	Yes	Between 0 and 3 feet
HH	High HGL	Yes	Between 0 and 3 feet
IS	Intermediate HGL	Yes	Between 0 and 3 feet
IH	Intermediate HGL With Significant HGL Slope Increase	Yes	Between 3 and 10 feet
DS	Deep HGL with Significant HGL Slope Increase	No	Greater than 10 feet
DH	Deep HGL	No	Greater than 10 feet
OK	No surcharging	No	HGL is within pipe crown

For each planning scenario model run, the HGL ranking will be computed. However, the pipe will only be improved if two conditions occur: 1) the HGL rank is one of the six improvement conditions identified in Table 4-2; and 2) the peak flow exceeds the maximum allowable capacity of the pipe (i.e., no pressure flow in pipe is allowed).

A schematic illustration of the hydraulic grade line categories is shown on Exhibit 4-3.

4.7 Design Criteria

Recommended projects are based on the City's standards and development guidelines, and the Design and Construction Standards for Sanitary Sewer and Surface Water Management, Clean Water Services, February 2002.

Pipe sizes for replacement projects are the same as existing, except where required to accommodate growth. Pipeline sizing for the existing system is calculated by the computer model, SewerCad (described in Appendix A). General design standards for gravity sewers, force mains, and pump stations are described below.

- Existing and proposed gravity sewers are evaluated and/or designed with capacity for the peak day flow rate and maximum d/D (depth of flow/pipe inside diameter) ratio of 0.8. This ratio of 0.8, instead of proper ratio of 0.95, will be used to provide the City with enough time for planning and design activities, prior to the pipe reaching its full capacity. Pipes are concrete or PVC with a Manning's pipe roughness coefficient of 0.013 laid on minimum slope as defined by CWS design criteria to ensure a minimum flow velocity of 2 fps when flowing full. This criteria is summarized in Table 4-3. Minimum depth of cover is established at 3 feet with a maximum depth of 12 feet approximately.

Table 4-3
 City of Cornelius
 Pipe Capacity Based on Pipe Diameter
 and Minimum Pipe Slope

Pipe ID (in)	Minimum Pipe Slope ft/100 ft	Maximum Capacity Pipe Gravity Flow		
		cfs	gpm	mgd
6	0.6	0.44	197.5	0.28
8	0.4	0.77	345.6	0.50
10	0.28	1.16	520.6	0.75
12	0.22	1.68	754.0	1.09
15	0.15	2.51	1126.6	1.62
18	0.12	3.65	1638.2	2.36
21	0.1	5.02	2253.1	3.24
24	0.08	6.42	2881.5	4.15

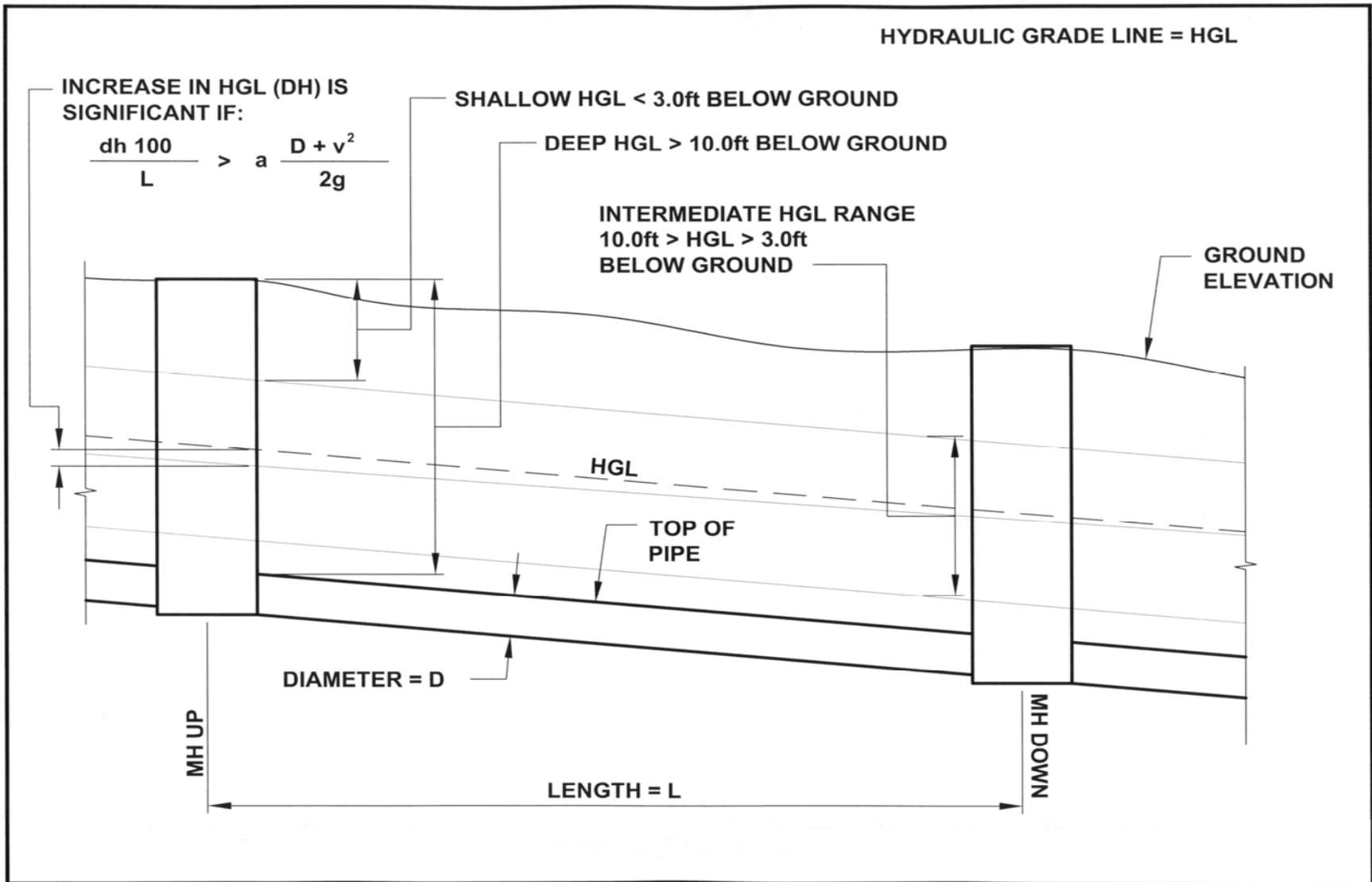


Exhibit 4-3
Schematic Illustration of HGL Categories

- Manholes are precast concrete and located approximately every 300 linear feet at an average depth of 8 feet. Replacement of existing pipes includes replacement of existing service connections from the new pipe to the existing building, consistent with City policy.
- Force mains are designed with capacity for the peak daily flow rate with flow velocities ranging from 2 to 6 fps. Pipes are ductile iron with Manning's roughness coefficient of 0.013, and minimum cover of four feet. Friction loss was calculated based on a variation of the Manning's equation for the projected flows. Minor losses were estimated at five percent of the pipeline friction loss.
- Pump stations include a duplex wet well with two submersible pumps, each capable of pumping the peak day flow rate (equivalent to the pump station pumping peak day flow with one pump out of service). The pump stations include odor control components, a building to house controls, and an emergency generator. Pump stations are assumed to be located within the right-of-way if a generator is not included, and located on adjacent property where a generator building is required. No land acquisition or right-of-way analysis was conducted for this project.

4.8 Cost Criteria

The costs estimated in this study are comprehensive planning level estimates, and are considered to be accurate to ± 50 percent. The estimates are based on costs per unit for each item. Pipelines are estimated based on dollars per lineal foot and include material, installation, and restoration. Pump station estimates are based on dollars per horsepower of total pumping capacity, which takes into consideration the flow rate and head added by the pump, and a cost per each for the pump station facility. Additional cost for a generator and control building is estimated per each. The estimated capital costs include two components: construction costs and indirect costs.

4.8.1 Construction Costs

Construction costs include the base cost plus construction contingency. The base cost is the unit cost multiplied by the number of units estimated for the facility. The construction contingency is estimated at 50 percent of the base cost. Total construction cost is the sum of the base cost, plus 50 percent for construction contingency.

4.8.2 Indirect Costs

Indirect costs include engineering, (design and construction) administration, legal, surveying, geotechnical, and financial costs. Engineering design costs are estimated to be 30 percent of the construction cost, administration costs are estimated to be 15 percent, and legal and financial costs are estimated to be five percent. Total indirect costs are 50 percent of the construction cost.

4.8.3 Total Capital Cost

The total capital cost is the sum of construction and indirect costs.

4.9 Alternative Evaluation for New Development Areas

Alternative analyses for gravity sewers, force mains, and pump stations were developed and evaluated prior to selection of recommended projects. The criteria used to evaluate the alternatives are described below.

- Total Capital Cost
- Economic Opportunity
- Environmental Impacts
- Public Acceptability
- Ease of Maintenance

Section 5

Selection of Alternatives

5.1 Potential Alternatives

Exhibit 7-1 shows Areas of Interest (AIs) divided into fifteen subdrainage basins. Those basins were delineated based on local topography and site specific natural and manmade features that influence drainage patterns within the proposed urban growth boundaries. Those features include Council Creek, Dairy Creek, and Job's Ditch water courses, smaller ditches and drainage valleys, state highways, railroads, and local roads.

EES has analyzed potential alternatives to collect and route wastewater flows from those subbasins toward the two major CWS's transmission utilities, a 42-inch Council Creek trunk and Linden Street Lift Station.

Those alternatives include:

- **Alternative 1:** Increase capacity or upsize the existing major collection system lines to carry additional flows from the AIs.
- **Alternative 2:** Wastewater flows from the AIs would be routed through new sewer system components to the existing or future CWS transmission facilities.
- **Alternative 3:** Combination of Alternatives 1 and 2, wastewater flows will be collected and routed via existing and new system components.

5.2 Selection of Alternatives

One, or a combination of alternatives was then assigned to each of the subbasins. Those alternative allocations are based on unrefined and insufficient topography and planning data and such must be used for preliminary planning only. Potential solutions for collection and diversion of wastewater flows, as described below, must be revisited and refined prior to any development in those areas.

Acknowledging previously mentioned assumptions, it is suggested that:

- New sewer system components within all subdrainage basins located north of Council Creek (subbasins 19 to 23) and Subbasin 24 will be developed under Alternative 2. Each of those subbasins will require construction of separate collection systems possibly consisting of 10 to 12-inch collection lines and 12 to 18-inch major collectors connected to the existing 42-inch or a CWS proposed 33-inch Council Creek trunk at several locations. (see Exhibit 7-1)

- Sewer system within Subbasin 27 will be developed under Alternative 1 assumptions. Based on capacity and topography of the existing system and surface elevation in the area, this subdrainage basin with might be connected to the existing 8-inch sanitary line along S. Ginger Street.
- New collection system within Subbasin 26 and southern portion of Subbasin 28 might be developed under Alternative 3 assumptions. Those areas might be served partially by gravity and partially by temporary lift station pumping (routing) wastewater to the existing sewer manhole located in the south drainage basin (Subbasin No.14) at S. 28th Avenue and S. Dogwood Street. The northern portion of subbasin 28 might be served by the existing collection system that for the City's new east commercial zone along Tualatin Valley Highway. This system is made of 8-inch lines and diverts flow north toward Council Creek trunk.
- Sewer system for drainage areas 25, 29, 30, 31, 32 would be built under Alternative 3 assumptions. Most wastewater from those areas will be diverted via new collection system and major collectors (trunks) toward the existing or proposed Council Creek trunks. Subdrainage area 31 might be served by the existing east commercial zone collection system, as mentioned previously.

Section 6

Collection System Evaluation

6.1 Introduction

The existing collection system was evaluated through the development of a collection system model to determine and quantify the location of areas with deficient or excess capacity. The model's loading conditions included a calculation of base sanitary flows consistent with current water use as well as estimates of inflow/infiltration flows that occur due to groundwater levels and storm events. Anticipated impacts of proposed development were also considered. The City provided guidance on the areas marked for development, Areas of Interest (AIs) and the proposed land uses of these areas. Under this guidance and consistent with CWS' assumptions for residential, commercial/industrial base sanitary flows with weather related I/I, a calculation of future flows to the system was also conducted. Finally, a proposed plan for collection of these future flows was developed for ultimate inclusion in a capital improvement program.

6.2 Hydraulic Modeling Approach

A model of the system was developed to provide the ability to simulate the collection system's response to specific loading conditions. The software package used in this task was Haestad Methods'© SewerCAD Sanitary Modeling software. SewerCAD provides the ability to build a computational model through the Autodesk Map interface and allows for easy transferal of data between various other GIS and database applications.

The model classifies loads as sanitary (dry weather) loads, wet weather loads, and known loads. Sanitary base flows are not weather dependent and are a function of residential, commercial, and industrial activities. Wet weather loads are related to rainfall activity and are normally categorized as inflow or infiltration.

The sanitary (dry weather) base flows were calculated as a function of residential population and commercial/industrial activities. The residential portion of flow was calculated from an estimate of the volume of flow per capita per day. The commercial/industrial loads were calculated based on an estimate of volume of flow per acre per day.

Wet weather flows were considered as two components, wet season infiltration/inflow and storm response infiltration/inflow. The flow-monitoring data collected by CWS' as part of their most recent master plan update formed the basis for these estimates of weather-driven flow conditions.

6.2.1 Data Collection

The model was created by combining data from multiple resources in an effort to create the most accurate picture of the existing system. The key sources of data include a GIS shapefile of

sanitary sewer lines and manholes developed by CWS staff. This data was matched against the City's Autocad sanitary sewer basemaps and discrepancies between the two data sources were noted. The City's basemap was assumed to have precedence over the CWS data. Areas of the system without invert elevations were calculated based on a known downstream elevation and a minimum slope of 0.004 ft/ft.

6.2.2 Scenario Development

The collection system model was used to simulate base sanitary flows and a combination of base and inflow/infiltration flows. The scenarios modeled include base sanitary flow, base plus wet season I/I flows, and base plus wet season and storm response I/I flows. In addition to these three scenarios, the model was run with storm response I/I flows ranging from 2,000 gpad to 10,000 gpad to summarize the excess capacity within the existing collection system. These results were categorized by drainage basin within the existing city limits. A taxlot map was used to allocate loads to the model. Taxlots were assigned to manholes based on proximity. Then, loads for each taxlot were calculated based on existing land use (i.e. single family residential, multi-family residential, or commercial/industrial) and, in the case of wet weather and storm responsive infiltration flows, total area. Each load was then assigned to the appropriate manhole and imported to the hydraulic model.

The future development was evaluated by comparing the additional flow requirements and excess capacity, as determined by the hydraulic model output, within the existing collection system. A large portion of the AIs lies north of the 42-inch Council Creek trunk and, due to natural drainage patterns, would most likely have little or no impact on the City's existing collection system. These areas were considered separately and the flow requirements were summarized to quantify the anticipated impacts to the Council Creek trunk.

6.3 Existing Collection System Evaluation

6.3.1 Base Sanitary Flows

Residential Base Flow

The most recent taxlot information as published by Metro's Regional Land Information System (RLIS) was used to estimate the total number of developed residential lots. The City estimates a current population within the city limits of 10,450 people. The taxlot database showed a total of 2,220 single family and 33 multi-family residential lots within the city limits. Based on this information, it was assumed that the City has a current population density of approximately 4.6 people per single family lot and seven people per multi-family lot. Although higher than typical for other urban settings, the population density assumptions combined with current taxlot data are consistent with the current population estimate of 10,450 people.

Commercial/Industrial Base Flow

Due to the lack of industrial/commercial flow data, a commercial/industrial unit flow was estimated to be consistent with the City's average annual water demands and anticipated base sanitary flows. Approximately 60% to 85% of water consumption is generally converted to wastewater (Metcalf and Eddy 1991). The City's most current water master plan reports an average annual consumption of approximately 1.3 mgd. Therefore, the city's average base sanitary flow should be on the order of 0.8 mgd and 1.1 mgd. In an effort to remain conservative, the higher estimate was assumed for total base flow.

The RLIS taxlot database contains a total commercial/industrial area within the city limits of 8.77 million sq. ft. This area multiplied by a unit flow of 45 gpd/1,000 sq. ft. resulted in a commercial/industrial base flow of 0.39 mgd. Adding the residential base flows (0.71) results in a total base flow of 1.1 mgd. This commercial/industrial unit flow of 45 gpd/1,000 sq. ft. is approximately 54% of that used in CWS's 2000 Master Plan Update (84 gpd/1,000 sq. ft). This discrepancy may be explained by the different nature of industrial/commercial activity within the City of Cornelius as compared to the surrounding communities served by Clean Water Services, most significantly Beaverton, Hillsboro, and Forest Grove.

A summary of base flows grouped by major drainage basins are provided in Table 6-1. A map showing the 19 drainage basins is provided in Exhibit 3-1.

Table 6-1
City of Cornelius
Base Sanitary Flow Estimates

Drainage Basin	Commercial/ Industrial Area (sf)	Multi-Family Residential Population	Single Family Residential Population	MFR Load ¹ (gpd)	SFR Load ¹ (gpd)	Com/Ind Load ¹ (gpd)	Total (gpd)
1	1,548,428	14	453	1,218	30,351	69,679	101,248
2	456,443		1,241	0	83,147	20,540	103,687
3	1,722,660	21	55	1,827	3,685	77,520	83,032
4	514,488	29	336	2,523	22,512	23,152	48,187
5	432,674	43	361	3,741	24,187	19,470	47,398
6	1,616,166			0	0	72,727	72,727
7	357,051	14	19	1,218	1,273	16,067	18,558
8	1,147,579	78	103	6,786	6,901	51,641	65,328
9			1,004	0	67,268	0	67,268
10			1,055	0	70,685	0	70,685
11			604	0	40,468	0	40,468
12	710,550	14	303	1,218	20,301	31,975	53,494
13			863	0	57,821	0	57,821
14	18,581		1,669	0	111,823	836	112,659
15	35,694		1,086	0	72,762	1,606	74,368
16	31,440		655	0	43,885	1,415	45,300
17	181,466	22	298	1,914	19,966	8,166	30,046
18			116	0	7,772	0	7,772
Totals	8,773,220	235	10,221	20,445	684,807	394,795	1,100,047
Total Population			10,456		Total Base Flow		1,100,047

¹ Unit loading factor assumptions include: MFR – 87 gpcd, SFR – 67 gpcd, and Com/Ind – 45 gpcd.

Discussion of Model Results

Under an average base flow loading of approximately 1.1 mgd, there were no pipes in the existing system deficient in capacity. In addition, there were no pipes operating at more than 80% capacity.

6.3.2 Wet Weather and Storm Response Infiltration Flows

Clean Water Services' 2000 Sanitary Sewer Master Plan Update includes an extensive analysis of wet season and storm response infiltration flows based on a comprehensive review of flow monitoring throughout the system. Due to a lack of flow monitoring data within the City and the level of comprehensiveness of Clean Water Services analysis, this data was used as the basis for estimating wet season and storm-driven infiltration flows for the City's collection system. Exhibit 6-1 provides wet weather unit flows (gpad) as calculated from CWS' flow monitoring data. Of approximately 116 monitoring locations, 63% had wet weather unit flows of 400 gpad or less, with 41% having flows less than 200 gpad. From this review, a 200 gpad wet season unit flow was selected for application within the City's collection system model.

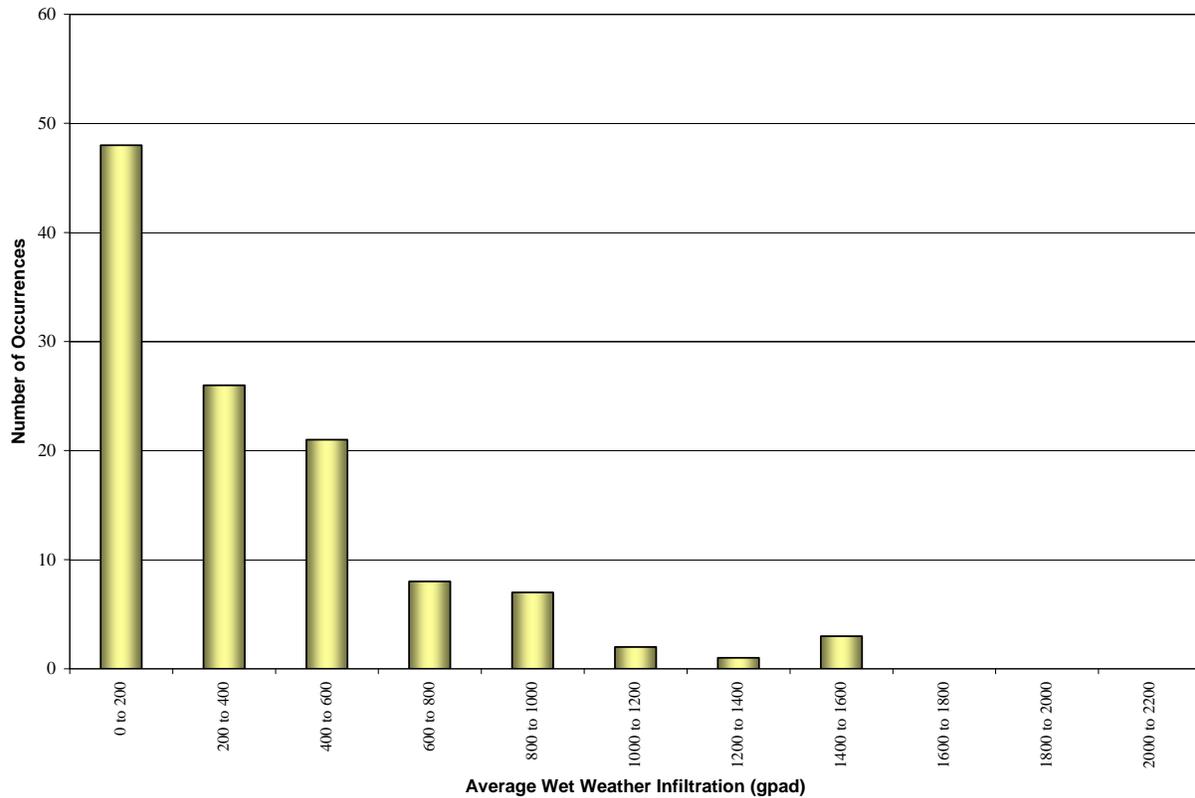


Exhibit 6-1
Histogram – Wet Weather Unit Flows (gp/d)

Table 6-2 provides a summary of the loads input to the model under this scenario. Under an assumption of 200 gp/d, the total wet weather load to the system was 0.2 mgd. The combination of base sanitary flows and wet weather flows produced a total system flow of approximately 1.3 mgd.

Discussion of Model Results

Under a loading condition of base flow with wet weather flows of approximately 1.3 mgd, there were no pipes in the existing system deficient in capacity. In addition, there were no pipes operating at more than 80% capacity.

Storm Response Infiltration Flows

Storm response infiltration flows (SRI) are those flows that result from precipitation events and the associated infiltration of water through the soil or inflow through other likely pathways. Much like the wet season unit flows shown above, a similar analysis is presented for storm response infiltration flows. Exhibit 6-2 shows a similar chart presenting the number of occurrences for eleven different flow ranges. The flow ranges presented are in increments of 100 gp/d and represent the 80th percentile peak flow rates resulting from various precipitation events. Approximately 54% of the sites had SRI flows ranging from 0 to 1,000 gp/d and 24% ranging

from 1,000 to 2,000 gpad. After reviewing this data an SRI flow of 2,000 gpad was assumed for application within the City’s collection system model.

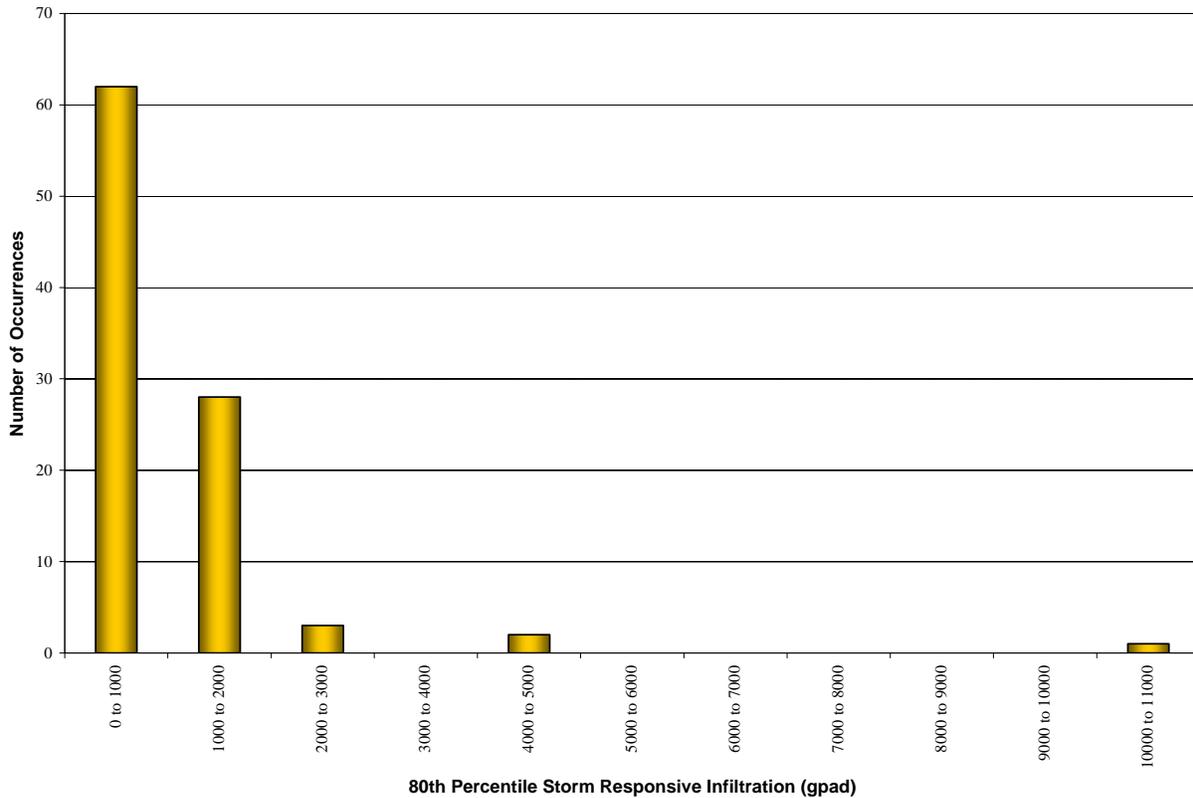


Exhibit 6-2
Histogram – 80th Percentile Storm Responsive Infiltration (gpad)

Under an additional SRI flow of 2,000 gpad, the total SRI load to the system was 2.0 mgd. The combination of base sanitary flows and wet weather flows produced a total system flow of approximately 3.3 mgd. A summary of flows by drainage basin for base, wet weather, and SRI flows is provided in Table 6-2.

Table 6-2
City of Cornelius
Summary of Modeled Sanitary Loads

Drainage Basin	Base Load (gpd)	Wet Weather Load (gpd)	SRI Load (gpd)	Total (gpd)
1	101,248	19,599	195,992	316,839
2	103,687	12,026	120,260	235,973
3	83,032	14,971	149,713	247,716
4	48,187	9,732	97,320	155,239
5	47,398	13,027	130,265	190,690
6	72,727	11,914	119,136	203,777
7	18,558	7,470	74,702	100,730
8	65,328	17,517	175,168	258,013
9	67,268	9,109	91,092	167,470
10	70,685	13,635	136,345	220,665
11	40,468	6,873	68,730	116,071
12	53,494	6,294	62,935	122,723
13	57,821	11,524	115,242	184,587
14	112,659	18,184	181,842	312,685
15	74,368	9,601	96,006	179,975
16	45,300	7,497	74,971	127,768
17	30,046	6,016	60,161	96,223
18	7,772	8,396	83,956	100,123
				3,337,199
Total (Base Flow)				1,099,980
Total (Base + Wet Flow)				1,303,363
Total (Base + Wet Flow + SRI)				3,337,199

Discussion of Model Results

The collection system model was run under with a loading of 3.3 mgd which includes wet weather infiltration (200 gpad), storm response infiltration (2,000 gpad), and base sanitary flows. One pipeline did not meet the evaluation criteria discussed in previous sections. This pipeline had a flow which exceeded 80% of pipe capacity (see Table 6-3). However, it should be noted that due to a lack of field verified data, the invert elevations should be verified before a decision is made as to appropriate actions regarding this section of pipe.

Table 6-3 City of Cornelius Gravity Pipe Deficiencies Wet Weather and Storm Response Infiltration + Base Flow Scenario								
Label	Constructed Slope (ft/ft)	HGL Slope (ft/ft)	HGL Ranking	Velocity In (fps)	Velocity Out (fps)	Percent Capacity (%)	Drainage Basin	Notes
50399	0.0002	0.0013	IS	1.30	2.46	131%	2	

6.3.3 Existing System Capacity Analysis

In addition to the three scenarios (base flow, wet season + base flow, SRI + wet season + base flow), the model was also used to evaluate total system capacity. The purpose of which was to provide an understanding of the available capacity by drainage basin. This capacity analysis will help the City to target future rehabilitation efforts based on those areas that have less of an ability to carry I/I flows. The Storm Response Infiltration flows were increased in increments of 1,000 gpad. The pipes that were in excess of 80% of their constructed capacity were identified under each of the different loading conditions. Table 6-4 provides a summary table of the number of pipes in excess of 80% capacity for each SRI loading condition.

Table 6-4 City of Cornelius Number of Pipes >80% Capacity								
Drainage Basin	Storm Response Infiltration Flow (gpad)							
	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
1	1	3	4	4	4	4	5	7
2					1	2	4	4
3				1	3	3	3	4
4		1	4	6	6	6	6	6
5								2
7					2	2	2	2
8					1	3	3	3
10	2	2	2	3	3	3	3	3
12			3	3	3	3	3	3
13	2	4	5	8	9	10	10	10
14					2	5	8	9
15					1	2	4	6
16		6	6	6	6	6	6	6
17	5	5	6	6	8	9	9	9

Note: Drainage Basins 6, 9, and 11 did not have pipes > 80% capacity at an SRI unit flow of 10,000 gpad.

From this table and based on assumptions stated earlier, drainage basins 1, 10, 13, and 17 currently have little excess capacity using the assumptions stated earlier and should be prioritized

for rehabilitation and other maintenance activities to guard against increasing I/I flows and to maintain the maximum flows allowable based on pipe size and constructed slope.

6.4 Future Collection System Evaluation

Development of a capital improvement program requires an analysis of the impacts of future development on existing infrastructure as well as identification of new infrastructure. The City is planning that future development will occur in those areas outside the City limits and within the UGB. In addition, there are portions of land, AIs, that are considered for possible expansion of the UGB and, based on the City’s guidance, have been generally addressed in this report. Also, the City has identified possible land uses for AIs. These land uses consist of low-density residential, commercial, and industrial land use types. The type of land use, total area, and anticipated growth in population will be the major factors driving the capital improvement needs. The analysis of future development was separated into two categories based on the natural drainage patterns of the surrounding area and the location of a 42-inch sanitary sewer trunk owned by CWS. In general, the areas of the City north of the Council Creek would drain south towards the Council Creek trunk. The areas south of Council Creek could drain to the north and west towards the City’s existing collection system or directly north, terminating at the Council Creek Trunk. Analysis of these areas north and south of Council Creek is considered in more detail in sections 6.4.1 and 6.4.2.

6.4.1 Future Flow Estimates

The City projects a 2024 population of 20,000. To accommodate this growth the City anticipates that the existing UGB will have to extend beyond its current boundary (See Exhibit 4-2). The City’s most recent water system master plan states that the current reserve of R-7 zoned land will be exhausted by 2006. Assuming these constraints, it is anticipated that the majority of growth in base sanitary flow will be experienced outside of the existing city limits and there will be little increase in flow resulting from infill and population growth within the current City limits.

Estimates of future flow were based on the AIs identified by the City for possible growth. The unit flows used to calculate the base sanitary flow are shown in Table 6-5. The unit flow estimates of base sanitary flow are consistent with CWS’ master plan update completed in year 2000. The unit flow estimates for I/I are consistent with previously defined estimates discussed previously (Section 6.3.2).

Table 6-5 City of Cornelius Unit Flow Assumptions for Future Areas		
Unit Flow Type	Units	Value
Commercial/Industrial	gpd/1,000 sq ft	84
Low Density Residential	gpcd	67
Wet Season I/I	gpad	200
Storm Response I/I	gpad	2,000

6.4.2 Possible AI Development North of Council Creek Trunk

The majority of the area north of Council Creek has been identified for industrial land use (See Exhibit 4-2). The areas north of the City include approximately 490 acres of industrial land and 200 acres of low-density residential areas identified for development within the next 10 years. Past 2014, there are an additional 265 acres of commercial/industrial area marked for development between 2014 to 2024. Table 6-6 provides a summary of the six main drainage areas north of Council Creek.

Table 6-6 City of Cornelius Future Areas – North of Council Creek			
Area	Year 2004 - 2014		Year 2014 - 2024
	Commercial/Industrial (acres)	Low Density Residential (acres)	Commercial/Industrial (acres)
19	129.9	0.0	84.4
20	150.5	6.8	111.4
21	87.5	0.0	69.2
22	124.2	47.9	0.0
23	0.0	143.2	0.0
24	0.0	1.4	0.0
Total	492.1	199.2	265.0

From these areas, base sanitary flows, wet season flows, and storm response infiltration flows were calculated consistent with the unit flow assumptions. A summary of the estimated base sanitary flows for each drainage area are shown in Table 6-7.

Table 6-7 City of Cornelius Future Base Sanitary Flows – North of Council Creek			
Area	Industrial (gpd)	Low Density Residential (gpd)	Total Sanitary Base (gpd)
19	784,143	0	784,143
20	958,412	5,437	963,849
21	573,244	0	573,244
22	454,409	38,528	492,937
23	0	115,291	115,291
24	0	1,106	1,106
Total	2,770,208	160,362	2,930,570

A summary of base, wet season I/I and storm response I/I flows is provided in Table 6-8.

Table 6-8 City of Cornelius Year 2024 Flow Summary – North of Council Creek				
Area	Base (gpd)	Wet Season (gpd)	SRI (gpd)	Total (gpd)
19	784,143	42,861	428,606	1,255,610
20	963,849	53,737	537,366	1,554,952
21	573,244	31,333	313,330	917,907
22	492,937	34,409	344,086	871,432
23	115,291	28,640	286,398	430,329
24	1,106	275	2,748	4,129
Total	2,930,570	191,253	1,912,534	5,034,358

It is assumed that these flows would drain to the 42-inch Council Creek Trunk. The general locations of connection points are shown in Exhibit 7-1. In summary, it is anticipated that the future development would require a capacity of 5.03 mgd, of which 2.93 mgd is base sanitary flow. The level of impact these flows will have on future infrastructure needs is dependent on the available capacity in the Council Creek Trunk.

6.4.3 Possible AIs Development South of Council Creek Trunk

The areas south of the Council Creek have the potential to drain to the existing collection system or to the north towards the Council Creek Trunk. A summary of the areas south of Council Creek are shown in Table 6-9.

Flow Estimates

Table 6-9 City of Cornelius Future Areas – South of Council Creek (2004 – 2024)			
Drainage Area	Commercial/Industrial (acres)	Low Density Residential (acres)	Total (acres)
25	17.80	110.42	128.21
26	0.52	44.56	45.08
27	0.00	33.39	33.39
28	41.21	0.24	41.45
29	0.00	98.35	98.35
30	0.00	50.36	50.36
31	31.68	0.00	31.68
32	5.28	215.17	220.44
33	0.00	63.45	63.45
Total	96.48	615.92	712.41

From these areas, base sanitary flows, wet season flows, and storm response infiltration flows were calculated consistent with the unit flow assumptions. A summary of the estimated base sanitary flows for each drainage area are shown in Table 6-10.

Table 6-10 City of Cornelius Future Base Sanitary Flows – South of Council Creek			
Area	Commercial/Industrial (gpd)	Low Density Residential (gpd)	Total Sanitary Base (gpd)
25	65,113	88,897	154,010
26	1,917	35,873	37,791
27	0	26,885	26,885
28	150,789	190	150,979
29	0	79,179	79,179
30	0	40,542	40,542
31	115,911	0	115,911
32	19,305	173,233	192,538
33	0	51,087	51,087
Total	353,035	495,886	848,921

A summary of base, wet season I/I and storm response I/I flows is provided in Table 6-11.

Table 6-11 City of Cornelius Year 2024 Flow Summary by Area – South of Council Creek				
Area	Base (gpd)	Wet Season (gpd)	SRI (gpd)	Total (gpd)
25	154,010	25,642	256,422	436,074
26	37,791	9,016	90,162	136,969
27	26,885	6,679	66,786	100,350
28	150,979	8,289	82,892	242,160
29	79,179	19,669	196,692	295,540
30	40,542	10,071	100,712	151,325
31	115,911	6,336	63,356	185,603
32	192,538	44,089	440,886	677,513
33	51,087	12,691	126,906	190,683
Total	848,921	142,481	1,424,814	2,416,216

Proposed Collection Plan

Based on the natural drainage patterns south of Council Creek, the drainage areas proposed to impact the existing collection system include areas 26, 27, 28, 29, and 30. Drainage area 27 has an estimated flow of 100,350 gpd. This flow is proposed to drain to the sanitary sewer along Ginger Street on the southern side of the City. The model output, under a loading condition of base flow, wet and storm response I/I showed that the sewer lines along Ginger Street had excess

capacity of more than 300,000 gpd. However, there are capacity problems with the sewer lines in the vicinity of the siphon lines near 15th street (labeled in the model as P-580, P-581, P-582, and P-583).

In addition, considering that portions of drainage area 26, 28, and 29 will be developed in the near future, a proposed collection system for the near term has been identified. Due to the natural topography, these areas will either need to be pumped to the existing collection system along Ginger Street or a new sewer trunk should be built to drain to the north towards the 42-inch Council Creek Trunk. A new sewer trunk draining this system would have a length of slightly less than 2 miles. Due to the anticipated construction expense, in the near term, it is proposed to pump this flow until the capacity of the sewer line along Ginger Street has been reached, a flow of approximately 200,000 gpd.

Considering longer term development and the incorporation of the other areas south of Council Creek, it is proposed to construct a collection system draining to the north and terminating at the 42-inch Council Creek trunk. The anticipated flows and preliminary sizing of the main trunks involved in the system are presented in Table 6-12. Preliminary alignments are presented in Exhibit 7-1.

Table 6-12 City of Cornelius Preliminary Sizing of Proposed Sewer Lines				
Pipe Section	Required Capacity (gpd)	Length (ft)	Pipe Size Based on Minimum Slope (in)	% Capacity at Minimum Slope (%)
P-5	1,255,610	1,684	18	41.0%
P-6	1,554,952	1,061	18	50.8%
P-7	917,907	1,655	15	43.7%
P-8	871,432	1,299	15	41.5%
P-9	430,329	1,764	12	30.7%
P-10	4,129	850	8	0.6%
P-11	122,254	1,194	8	19.1%
P-12	151,325	1,739	8	23.6%
P-13	825,995	1,656	15	39.3%
P-14	825,995	905	15	39.3%
P-15	2,315,867	1,695	21	43.0%
P-16	960,997	636	15	45.8%
P-17	868,196	3,951	15	41.3%
P-18	151,325	1,658	8	23.6%
P-19	190,683	4,092	8	29.8%
P-20	436,074	2,259	12	31.1%
P-21	918,796	2,094	15	43.8%
P-27	185,603	1,668	8	29.0%
F-1 to F-2	1,255,610		n/a	Council Creek Trunk
F-2 to F-3	2,810,562		n/a	Council Creek Trunk
F-3 to F-4	3,728,468		n/a	Council Creek Trunk
F-4 to F-5	5,030,229		n/a	Council Creek Trunk
F-5 to F-6	7,350,225		n/a	Council Creek Trunk

Lift Stations

Drainage areas 30 and 33 will require a pump station to lift wastewater to an elevation where it can flow by gravity through the proposed collection system. Based on the calculated flow estimates the approximate capacities of these possible lift stations are presented in Table 6-13.

Facility	Area	% Contributing	Flow
Temporary Lift Station	26	50%	68,484
	29	10%	29,554
	28	10%	24,216
Total			122,254
Lift Station 1	30	100%	151,325
Lift Station 2	33	100%	190,683

The drainage areas incorporated in this analysis are presented in Exhibit 7-1.

Section 7

Capital Improvement Program

7.1 Capital Improvement Program

This section provides a detailed description of the Capital Improvement Program (CIP) that has been developed using the hydraulic model and evaluation described in Section 6 and the planning data/criteria from Section 4. A series of capital improvements have been identified to address current and future sanitary flows and to sustain system reliability. The capital improvement projects have been separated into the following categories:

- Pipelines
- Manholes
- Recommended Studies

The recommended capital improvements included in this master plan report focus on the needs of the City of Cornelius' (City) sanitary sewer system. The City relies on CWS to treat its sanitary flows and, as a result, a majority of the flow leaves the City's system by a lift station located on the southwest side of the City. The other major portion of flow leaves the City's system to the north and drains to the existing 42-inch or the proposed 33-inch CWS Council Creek trunks. This capital improvement program includes major infrastructure needs of the City's collection system to the point of connection to CWS' system.

A summary of the sanitary sewer system CIP is developed and presented in Table 7-1. This tabular summary provides total probable project cost, a brief description of each project, as well as prioritizes each capital improvement based on recommended year of implementation. Project priorities should be considered flexible in order to accommodate concurrent construction during other street opening projects, budgetary constraints, specific development projects, and other factors that may affect project implementation. A location map of the various projects is included in Exhibit 7-1.

**Table 7-1
City of Cornelius Sanitary Sewer System
Capital Improvement Program**

CIP No.	Project	Length (feet)	Diameter (inches)	Project Need	Est.Total Cost in 2004 \$	O&M Costs	SDC Eligible Costs	Anticipated Implementation Period			
								2004	2005-2009	2010-2014	2015-2024
Operations / Maintenance											
Collection System Pipelines											
P-1	8-inch PVC sewer pipeline along Magnolia St	905	8	O&M	\$128,655	\$128,655		\$128,655			
P-2	8-inch PVC sewer pipeline along Heather St	590	8	O&M	\$83,875	\$83,875		\$83,875			
P-3	8-inch PVC sewer pipeline along Ginger St	588	8	O&M	\$83,591	\$83,591		\$83,591			
P-4	8-inch PVC sewer pipeline along Fawn St	306	8	O&M	\$43,501	\$43,501		\$43,501			
P-8	18-inch PVC sewer pipeline along S 12th Avenue	896	18	O&M	\$143,990	\$143,990	\$143,990				
P-9	10-inch sewer pipeline rehabilitation, S 13th Avenue	1,054	10	O&M	\$104,235	\$104,235			\$104,235		
P-10	10-inch sewer pipeline rehabilitation, S/N 14th Avenue	770	10	O&M	\$76,149	\$76,149				\$76,149	
P-11	Repair/Modify existing sewer siphon lines	165	6	O&M/Capacity	\$23,457	\$18,766	\$4,691	\$23,457			
P-12	Repair/Modify existing sewer siphon lines	235	10	O&M/Capacity	\$33,408	\$26,726	\$6,682	\$33,408			
P-13	8-inch PVC sewer line in Drainage Area 31	1,668	8	New Development	\$237,124		\$237,124	\$237,124			
Subtotal		7,177			\$957,985	\$709,488	\$248,497	\$143,990	\$633,611	\$104,235	\$76,149
Major Collector Pipelines											
P-5	18-inch PVC sewer pipeline, Future Drainage Area 20	1,250	18	New Development	\$146,796		\$146,796	\$146,796			
P-6	15-inch PVC sewer pipeline, Future Drainage Area 21	1,400	15	New Development	\$147,105		\$147,105	\$147,105			
P-7	15-inch PVC sewer pipeline, Future Drainage Area 22	1,320	15	New Development	\$138,700		\$138,700	\$138,700			
Subtotal		3,970			\$432,601		\$432,601	\$432,601			
Total Pipelines		11,147									
Manholes											
MH-1	Selected Manhole Rehabilitation	10 manholes	60	O&M	\$20,000	\$20,000		\$20,000			
Subtotal					\$20,000	\$20,000		\$20,000			
Recommended Studies											
R-1	Sanitary Master Plan 2009			Regulatory	\$35,000	\$17,500	\$17,500	\$35,000			
R-2	Sanitary Master Plan 2014			Regulatory	\$35,000	\$17,500	\$17,500		\$35,000		
R-3	Sanitary Master Plan 2019			Regulatory	\$35,000	\$17,500	\$17,500			\$35,000	
R-4	Pipe Alignment Study and Final Design for South Part of Areas 20, 21 and 22, N.West of City			New Development	\$60,000		\$60,000	\$60,000			
Subtotal					\$165,000	\$52,500	\$112,500	\$95,000	\$35,000	\$35,000	
Total					\$1,575,586	\$781,988	\$793,598	\$143,990	\$1,181,212	\$139,235	\$111,149

7.2 Pipelines

Several pipelines have been identified for replacement, rehabilitation, or new construction. These segments have been identified through discussions with City staff, results of hydraulic modeling, and evaluation of proposed areas of development.

Project ID	Model ID	Length (ft)	Description	Construction Year	Cost
P-1	n/a	905	8-inch PVC sewer pipeline along Magnolia St	2005	\$128,655
P-2	n/a	590	8-inch PVC sewer pipeline along Heather St	2006	\$ 83,875
P-3	n/a	588	8-inch PVC sewer pipeline along Ginger St	2006	\$ 83,591
P-4	n/a	306	8-inch PVC sewer pipeline along Fawn St	2005	\$ 43,501
P-5	n/a	1,250	18-inch PVC sewer pipeline, Future Drainage Area 20	2007	\$146,796
P-6	n/a	1,400	15-inch PVC sewer pipeline, Future Drainage Area 21	2008	\$147,105
P-7	n/a	1,320	15-inch PVC sewer pipeline, Future Drainage Area 22	2009	\$138,700
P-8	36553, 36555, 50541	896	18-inch PVC sewer pipeline along S 12 th Avenue	2004	\$143,990
P-9	36546, 36545, 36544, P-676	1,054	10-inch sewer pipeline rehabilitation, S 13 th Avenue	2014	\$104,235
P-10	36527, 36526, 36525	770	10-inch sewer pipeline rehabilitation, S/N14 th Avenue	2019	\$ 76,149
P-11	36518	165	Repair/Modify existing sewer siphon lines	2007	\$ 23,457
P-12	36509	235	Repair/Modify existing sewer siphon lines	2007	\$ 33,408
P-13	n/a	1668	8-inch PVC sewer pipeline, New development, Area 31	2006	\$237,124

7.3 Manholes

From discussions with City staff, 10 manholes were identified for rehabilitation. Those manholes are located within the primary (oldest) sewer system, made of concrete pipes. Existing pipe penetrations at those manholes are embedded in thick layers of concrete which do not provide enough space for video camera access. Those excessive concrete layers should be removed and pipe penetration repaired to allow for inspection of adjacent sewer lines. It is estimated that a rehabilitation work will cost about \$20,000.

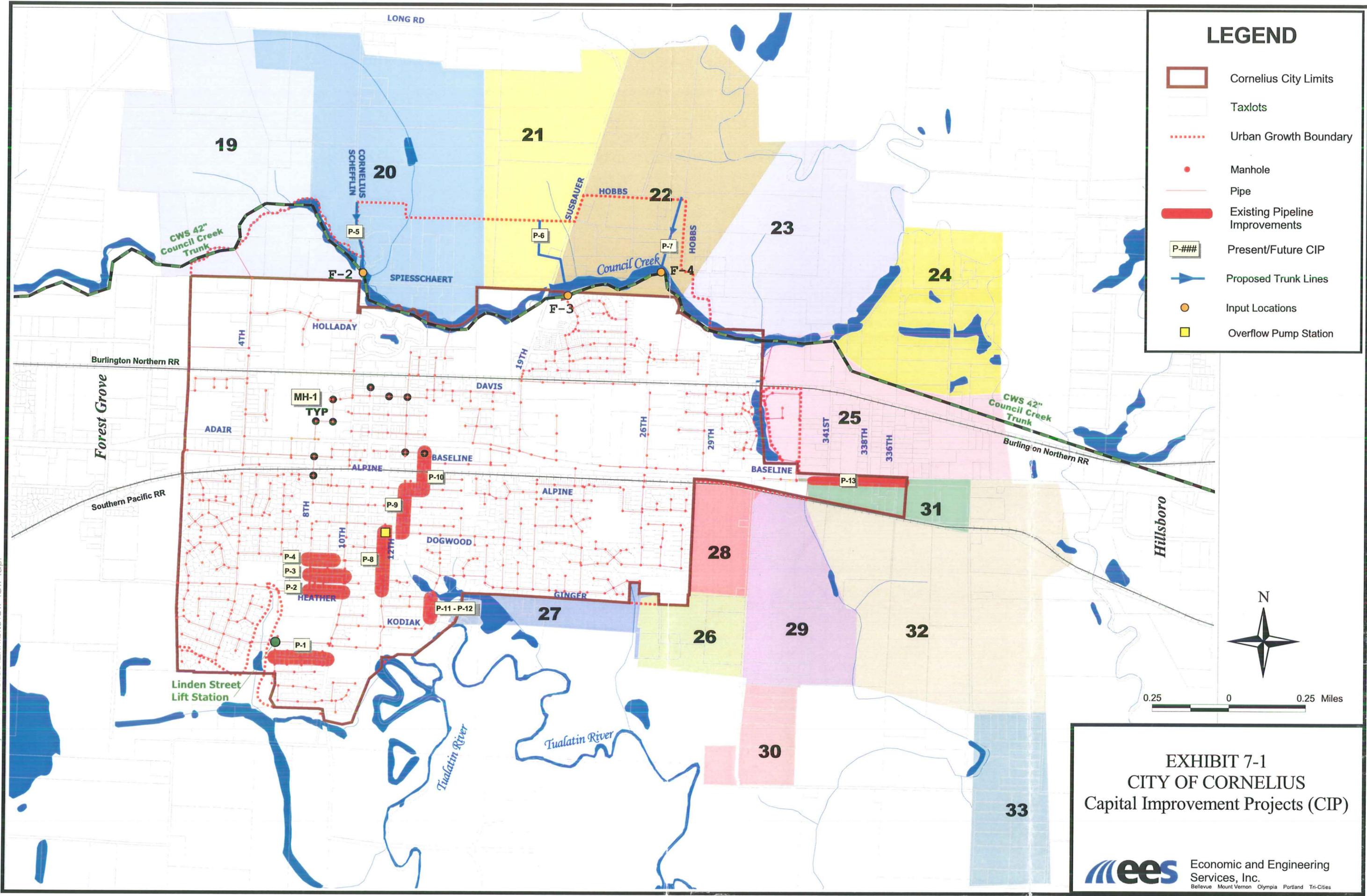
7.4 Recommended Studies

It is estimated that this Sewer Master Plan will need to be updated within a 5 year period to address expected changes in planning criteria, land use, and possible development of the AIs. It is also recommended, prior to any development in the proposed AIs, to further analyze potential

alignments and optimize sizing major new sewer system components based on more specific land use and planning information and refined topography.

Table 7-4 City of Cornelius Recommended Studies		
Project ID	Description	Cost
R-1	Sanitary Master Plan Update (2009)	\$35,000
R-2	Sanitary Master Plan Update (2014)	\$35,000
R-3	Sanitary Master Plan Update (2019)	\$35,000
R-4	Pipe Alignment Study and Final Design for Areas 20, 21, and 22, N.West of City	\$60,000

8/30/2004 C:\GIS\Projects\Cornelius\Exhibits\CIP\CIP.apr



LEGEND

- Cornelius City Limits
- Taxlots
- Urban Growth Boundary
- Manhole
- Pipe
- Existing Pipeline Improvements
- Present/Future CIP
- Proposed Trunk Lines
- Input Locations
- Overflow Pump Station

EXHIBIT 7-1
CITY OF CORNELIUS
Capital Improvement Projects (CIP)

Economic and Engineering Services, Inc.
 Bellevue Mount Vernon Olympia Portland Tri-Cities

Section 8

Financial Review

8.1 Current Rates and Charges

This section presents an overview of the financial responsibilities and resource alternatives for the operation, maintenance, and expansion of the City's sanitary sewer system.

The City currently maintains a sanitary sewer operations fund #06 and a sanitary sewer fixed-assets reserve fund #14 for its sanitary sewer system. The operations fund #06 is the City's main account for tracking the revenue and costs for routine operations and maintenance of its sanitary system. Revenue sources for this fund are derived entirely from monthly customer rate payments, the CWS system development charge (SDC) that is passed directly through to CWS, and net working capital. Personal services, and materials and services outlays are expenditures accounted for in this fund. The capital investment portion of the maintenance and operations budget is in the form of a transfer to the fixed-asset fund #14 where operation funds will be combined with Cornelius SDC reserves to construct system improvements.

The City also maintains a sanitary sewer fixed-assets reserve fund #14. The source of funding for this account is from the collection of SDC fees and transfers from the operations fund #06. This fund is used for tracking and accounting for fixed assets under GASB 34. Depreciation for building and equipment maintenance, and replacement costs must be funded by the sanitary sewer operations fund #06, while expansion of lines and facilities must be funded from Cornelius SDC monies from new development. This fund will receive Cornelius SDC revenues for sanitary sewer and transfers from the operations fund #06 to fund major capital projects and the purchase of equipment. Because of the cost of these projects, large reserves may result as fiscal year carryovers until the projects are completed.

The effective implementation of the CIP is dependent upon accurately developing a program that can be financially supported by the utility, will meet state and local regulatory requirements, and provides the flexibility needed to deal with unforeseen changes. The following subsections present an overview of the elements available to address each of these issues.

8.2 Recommended CIP

The CIP is described in detail in Section 7 of this report. Many needed improvements were defined in the CIP. The capital improvements have been separated between those that are renewal and replacement and hence are paid for through monthly user rates and those, which are growth-related, which can be funded by system development charges. A summary of the cost for the CIP for financial planning purposes is provided in Table 8-1.

Table 8-1
City of Cornelius
Capital Improvements Program Summary
(For Financial Planning Purposes)

Project Type	2004	2005-2009	2010-2014	2015-2024
Operations-Related Costs				
Manholes	\$0	\$20,000	\$0	\$0
Collection	\$143,990	\$385,114	\$104,235	\$76,149
Recommended Studies	\$0	\$17,500	\$17,500	\$17,500
Total Operations-Related	\$143,990	\$422,614	\$121,735	\$93,649
Growth-Related Costs				
Manholes	\$0	\$0	\$0	\$0
Collection	\$0	\$681,098	\$0	\$0
Recommended Studies	\$0	\$77,500	\$17,500	\$17,500
Total Growth-Related	\$0	\$758,598	\$17,500	\$17,500
Total CIP	\$143,990	\$1,181,212	\$139,235	\$111,149

The complete recommended CIP recommends \$143,990 for fiscal year ending (FYE) 2005, and an annual average of \$295,303 for FYE 2006-2009. For FYE 2010-2014, the annual average is \$27,847. It is important to note that these CIP annual averages are split between rates funded (O&M) and growth funded (SDCs). Both monthly sewer rates and sewer SDC fees will need to be reviewed to ensure adequate funding of the recommended sanitary system CIP.

8.3 Funding Sources

8.3.1 Monthly Users

Monthly user charges for municipal utilities are generally structured to satisfy revenue requirements related to O&M expenses, taxes, debt service obligations from bond sales, and those capital construction items funded directly from rates. These revenue requirements are distributed to different classes of customers using cost of service techniques to develop equitable monthly rates.

The level of these rates is impacted by several important items, including the level of exterior grant funding, debt service requirements related to bond sales and other loan issuances, and additional debt service coverage required in the bond covenants to ensure satisfactory maintenance of existing facilities. Debt service coverage frequently consists of 20 to 50 percent of the total debt service. This extra debt service coverage must be collected annually from rates,

but can be completely expended each year in the performance of routine system maintenance and repairs or capital improvements.

8.3.2 System Development Charges

This source of funding is a one-time charge, paid at the time a user makes a connection to the municipal sewer system. It is frequently called a SDC, a general facility charge, a connection charge, a main capacity reserve charge, and a variety of other phrases. In essence, the SDC is for the right to use capacity in the major facilities of the system. Municipalities charge the fee as a way for a new property to pay an equitable share in the cost of the existing, as well as new, facilities. The basis of the charge may be upon the historical value of the existing facilities, the projected new facilities required to meet projected growth, or combinations thereof.

8.3.3 Developer Participation

Developer extension policies frequently dictate the extension of sewer service be installed in accordance with improvements recommend in the sanitary system plan. This is commonly done by the developer and turned over to the City for ownership and O&M. Assets acquired in this way are generally classified as contributed capital or contributed assets.

8.3.4 External Sources of Funds in Oregon

The typical external funding alternatives for municipal wastewater capital improvement programs include state and federal grant/loan programs and municipal bonds financed through either rate revenue or by property assessments. Internal sources of capital funding available to the City include a combination of monthly user rates, SDCs, and contributions in aid of construction received from work done at customer request. Listed below is a general description of these potential sources of revenue.

Oregon's cities and public wastewater utility districts often need financial help in the form of grants and loans to upgrade and maintain services. Publicly owned wastewater utilities in Oregon have four sources of public funds for grants and loans available to them for the planning, design and construction of wastewater systems. The funding agencies are the Oregon Department of Environmental Quality (ODEQ), the Oregon Economic and Community Development Department (OECDD), the United States Department of Agriculture - Rural Utilities Service (USDA-RUS), and the Rural Community Assistance Corporation (RCAC).

- The DEQ administers the Clean Water State Revolving Fund (CWSRF) providing low interest loans to public agencies for planning and environmental studies, design and construction of wastewater facilities; and for non-point source and estuary water pollution control projects.
- The OECDD administers both the Federal Housing and Urban Development Community Development Block Grant program (grant) and the Oregon Lottery funded Water/Wastewater Financing and Special Public Works Fund programs (grant/loan). These programs can

finance planning and environmental studies, design and construction of public wastewater systems.

- The RUS administers several loan and grant programs focused on constructing and upgrading needed public and private non-profit utility systems, including wastewater systems in small rural communities of less than 10,000 in population.
- The RCAC is a Community Development Financial Institution (CDFI) designated by the U.S. Department of Treasury to provide low interest loan for projects, and provides technical assistance with USDA Rural Utilities Services and US Environmental Protection Agency (EPA).

Other federal and state funding programs with a focus on wastewater include:

- Clean Water Act Water Quality Cooperative Agreements
- Oregon 319 Nonpoint Source Grant Program

8.3.5 Revenue Bonds

Cities and utilities also have the authority to issue public debt that is not secured by property tax authority but rather by the ability of the improvements to generate revenue collected in the form of fees, tolls, and development charges. Voter approval is not needed to issue revenue bonds. Some Oregon cities place revenue measures on the ballot anyway as a litmus test of public approval for planned capital projects that are financed with user fees.

While it is easier for municipalities to issue revenue bonds, this convenience generally comes at a cost in the form of higher interest rates. Furthermore, revenue bond issues sometimes have higher reserve and debt coverage requirements as added insurance to bond holders that the community will be able to meet its debt service obligation.

8.4 Funding Comprehensive Utility Rate Study

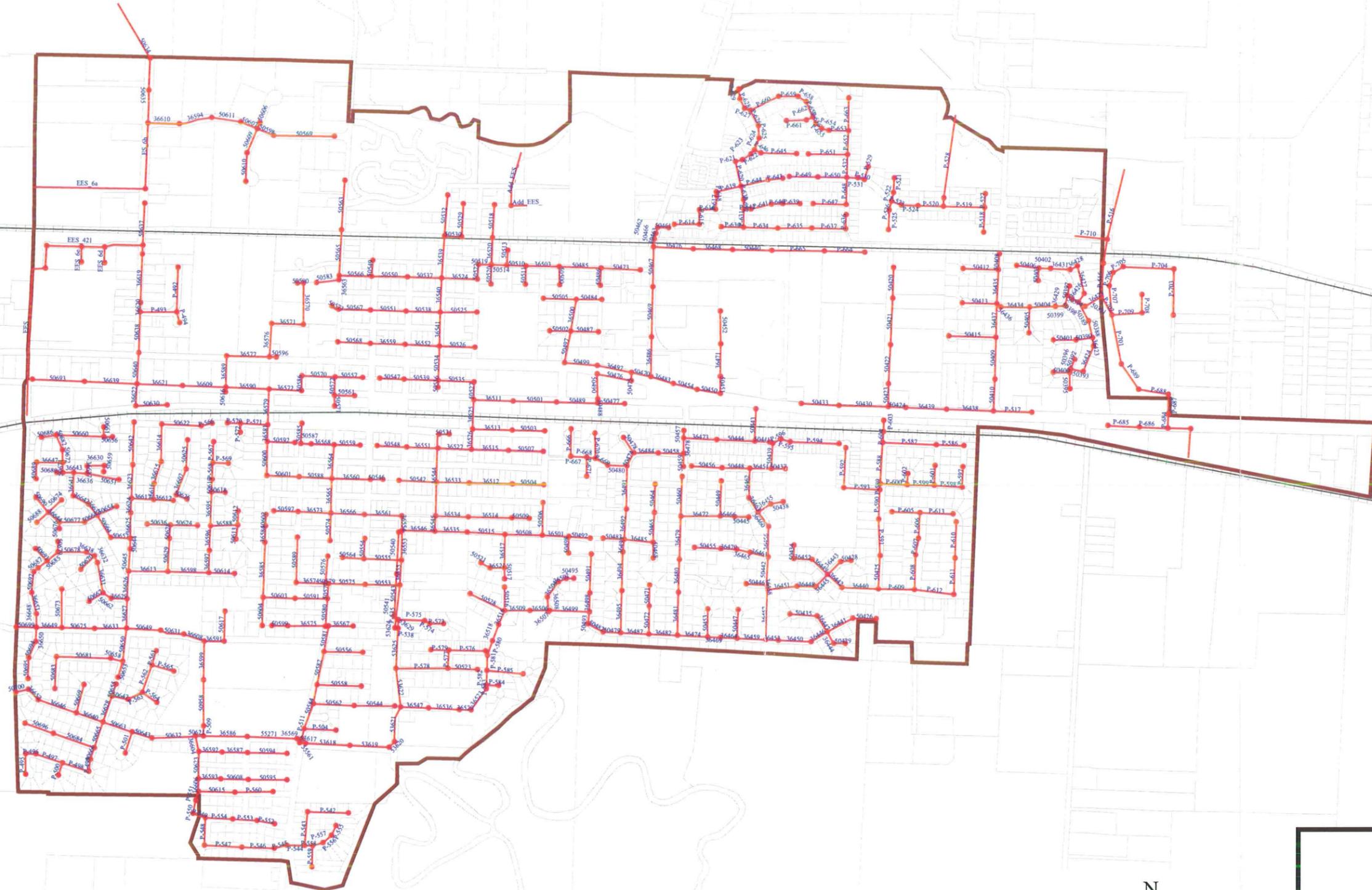
To determine the best options to fund the recommended water system CIP, a comprehensive sanitary rate study is scheduled for late summer 2004. This comprehensive study will evaluate utility system Master Plans, utility operational plans, and the ability to fund these plans at current monthly user rates and SDC rates. Where rates need to be adjusted to be consistent with the CIP, the study will recommend various financial alternatives for the City's consideration.

Appendix A

Hydraulic Evaluation/Calculation Data

LEGEND

-  Cornelius City Limits
-  Taxlots
-  Pipe
-  Manhole



0  0.25 Miles

EXHIBIT A-1 CITY OF CORNELIUS Sanitary Sewer Pipe Index

Exhibit A-2
Scenario: Base Sanitary Flow

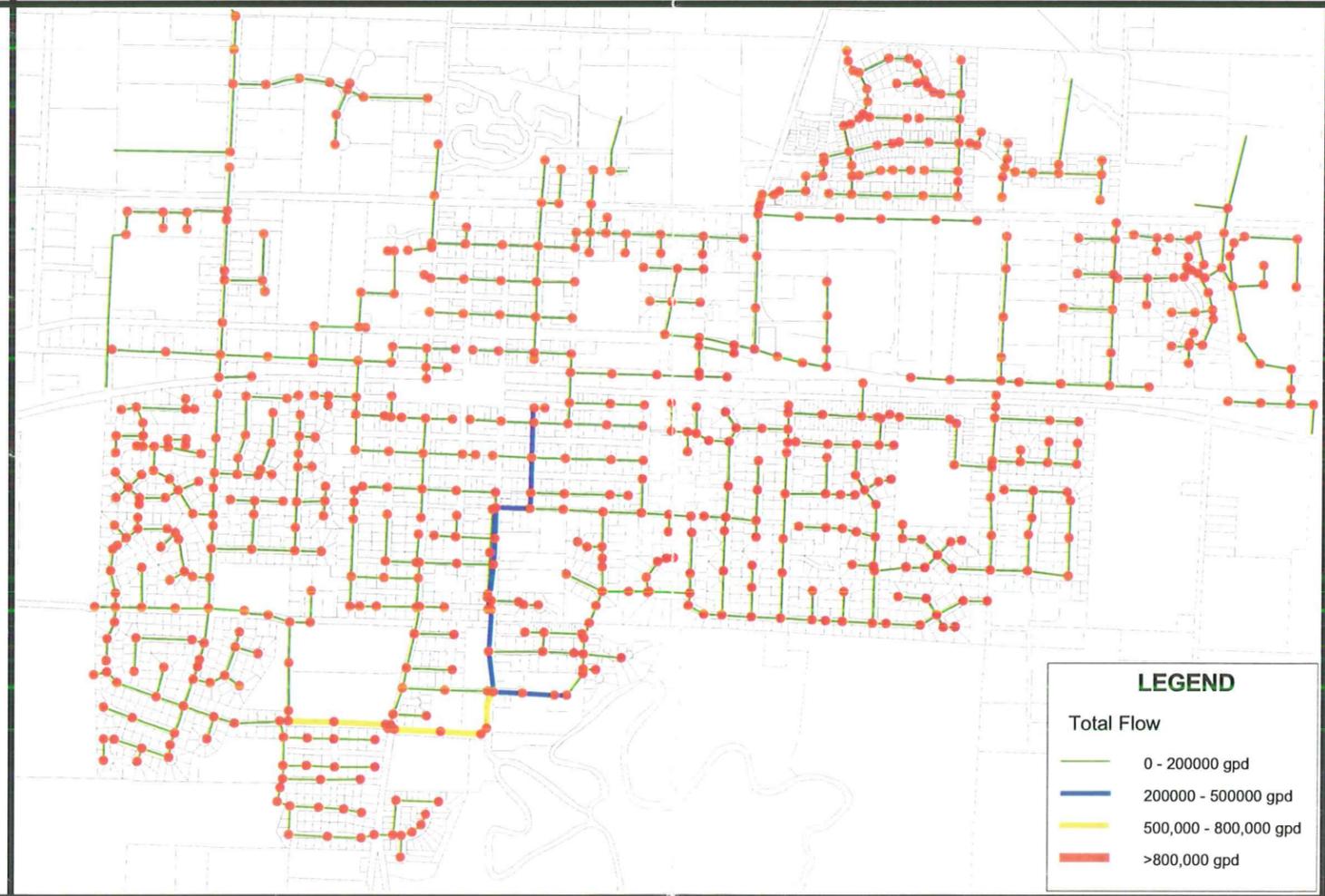
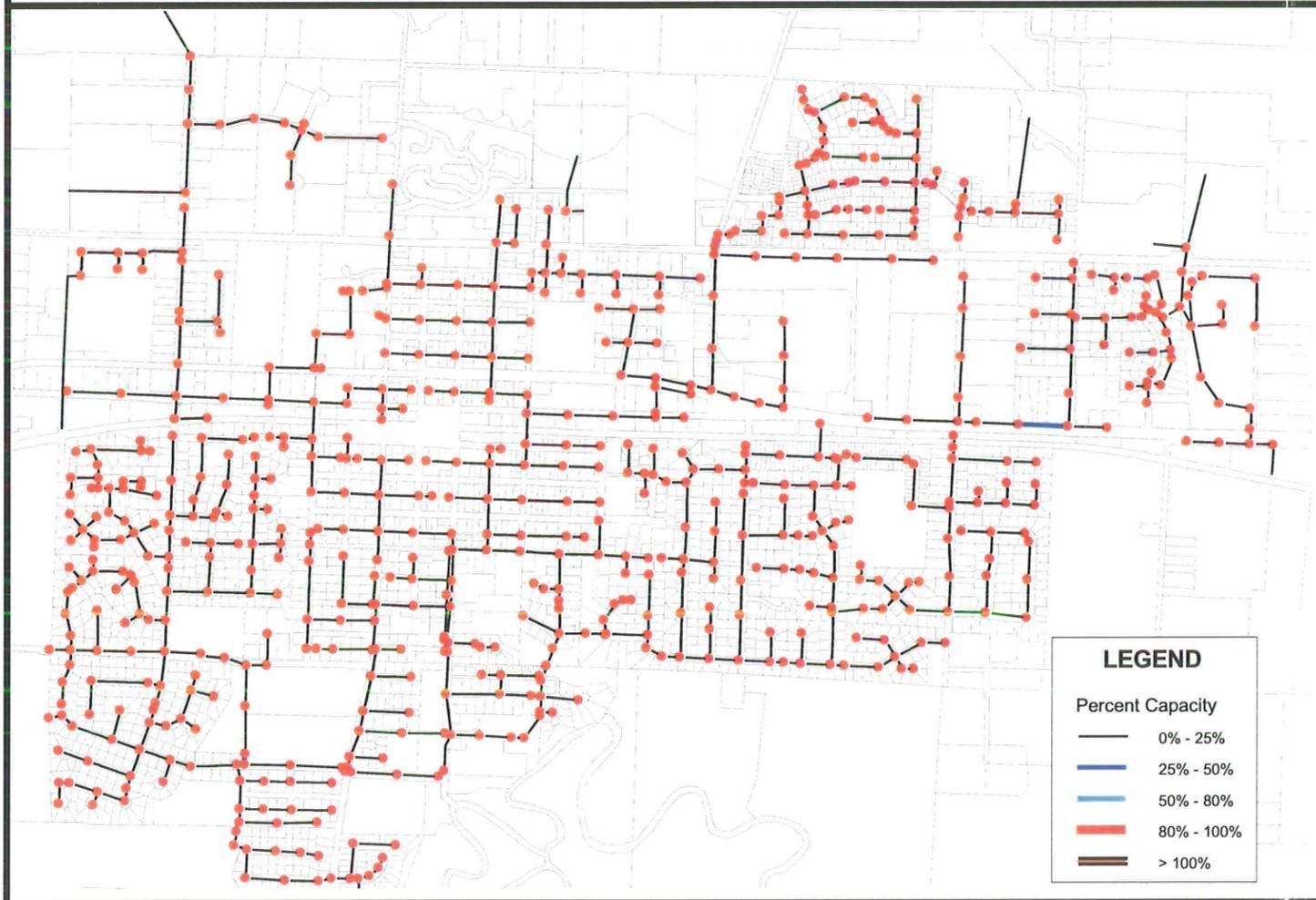
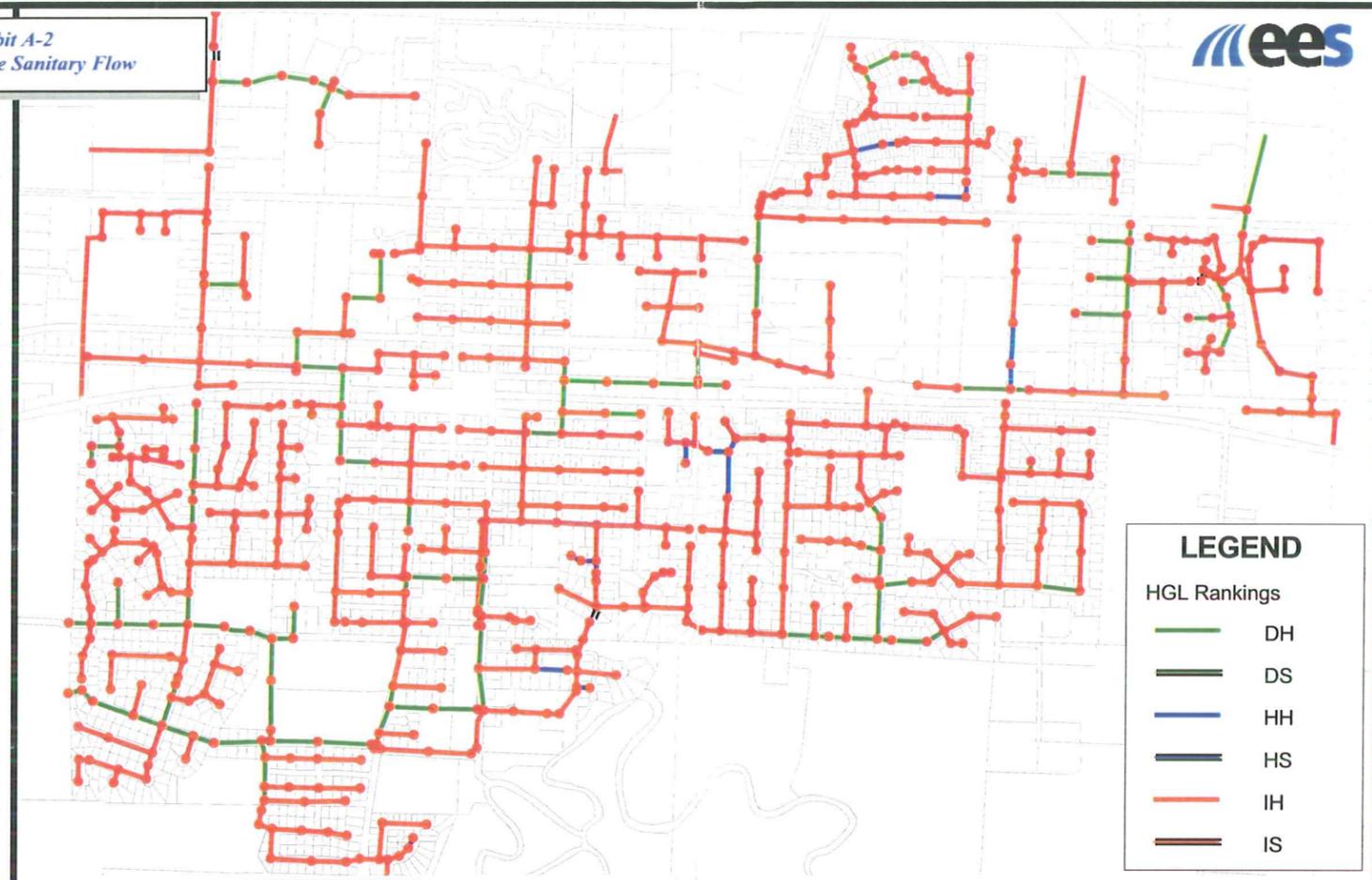
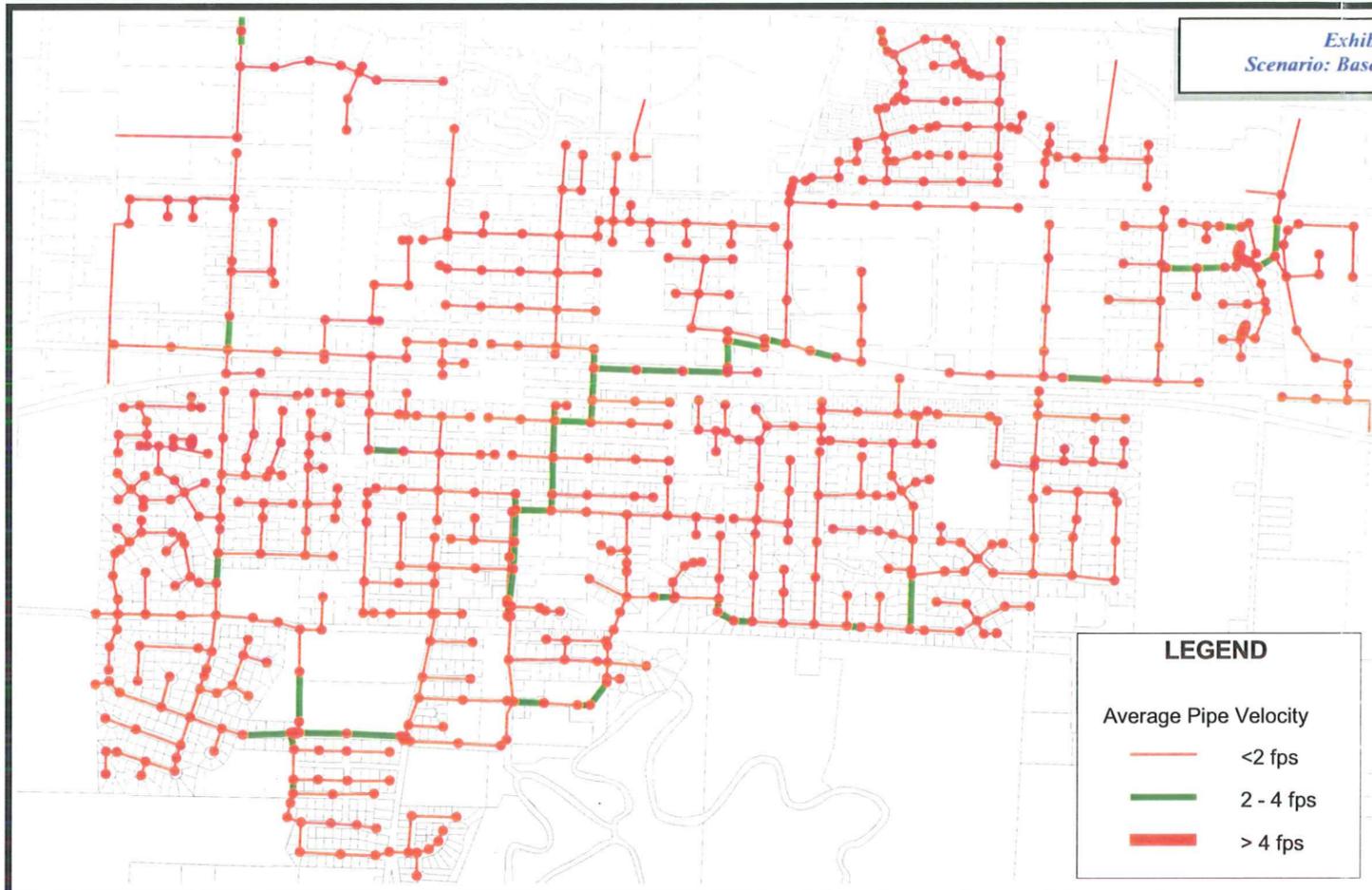


Exhibit A-3
Scenario: Base + Wet Flow

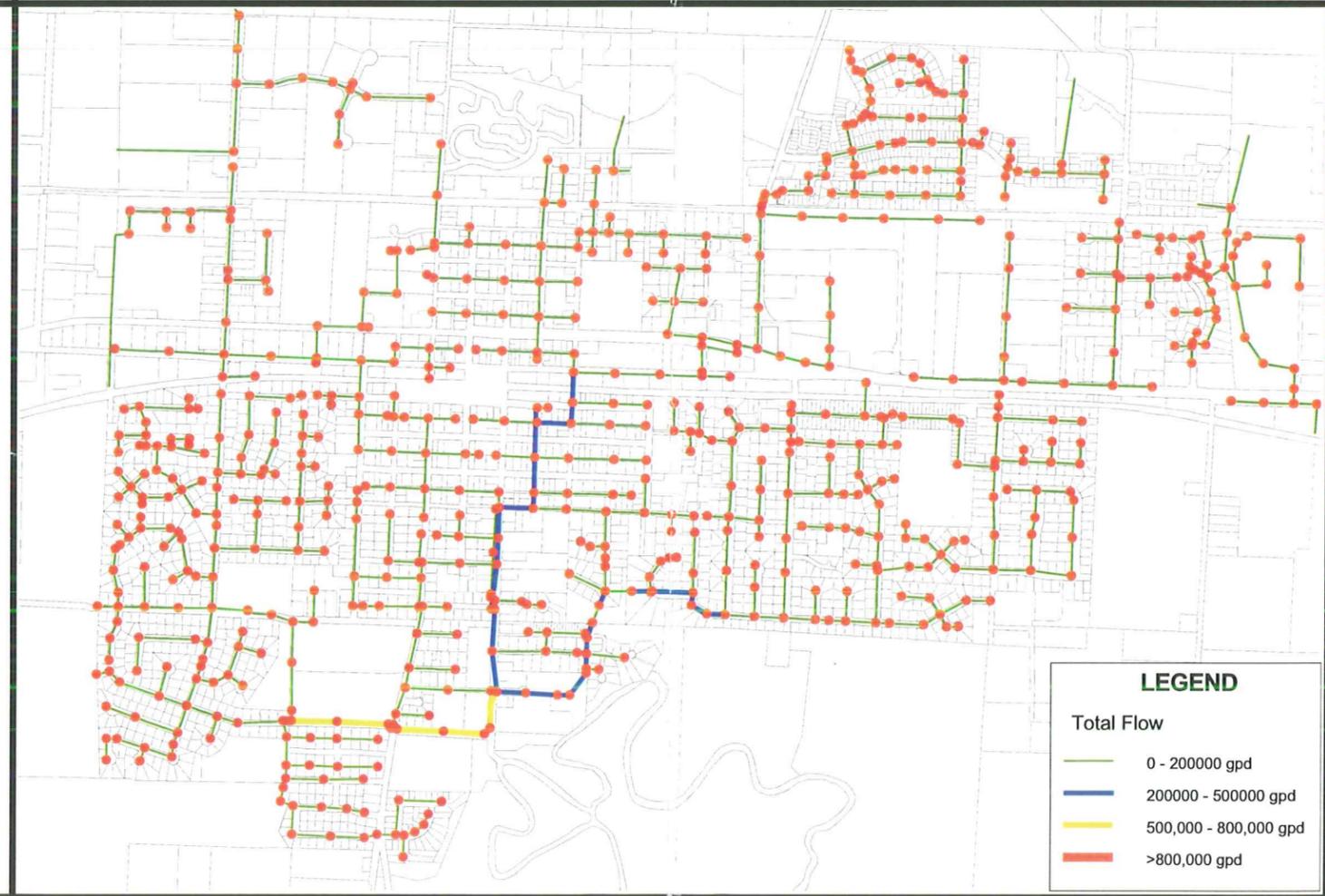
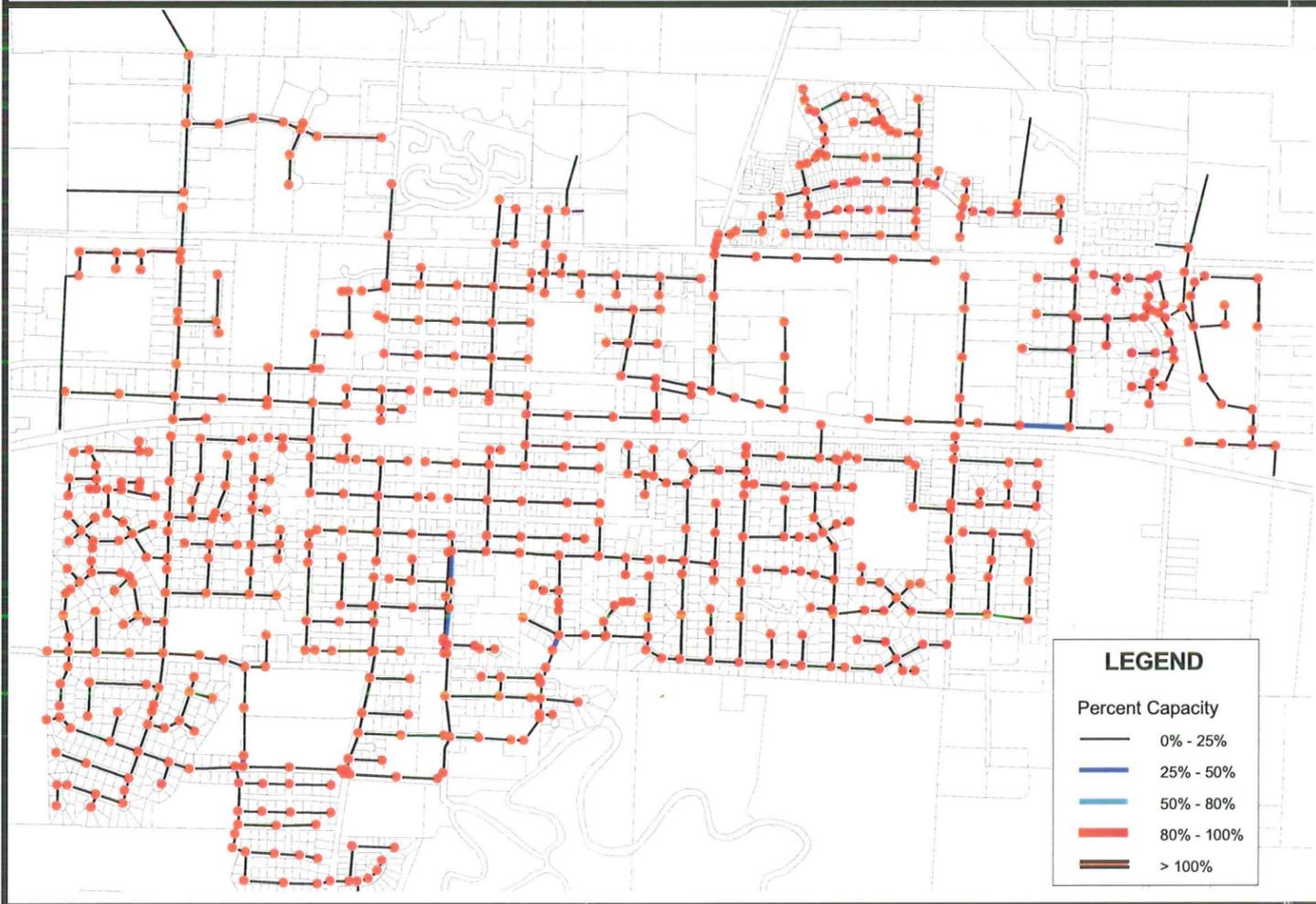
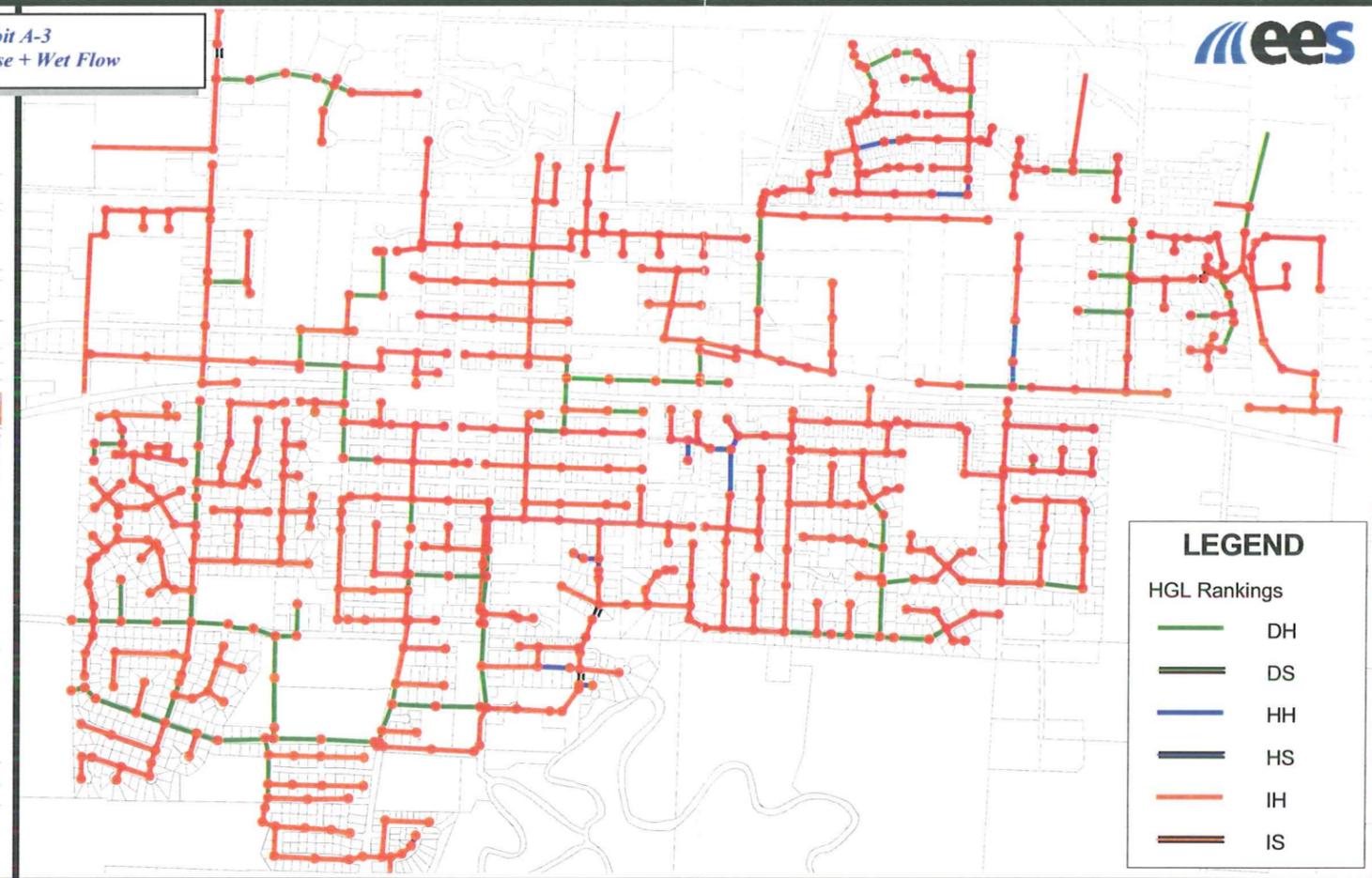
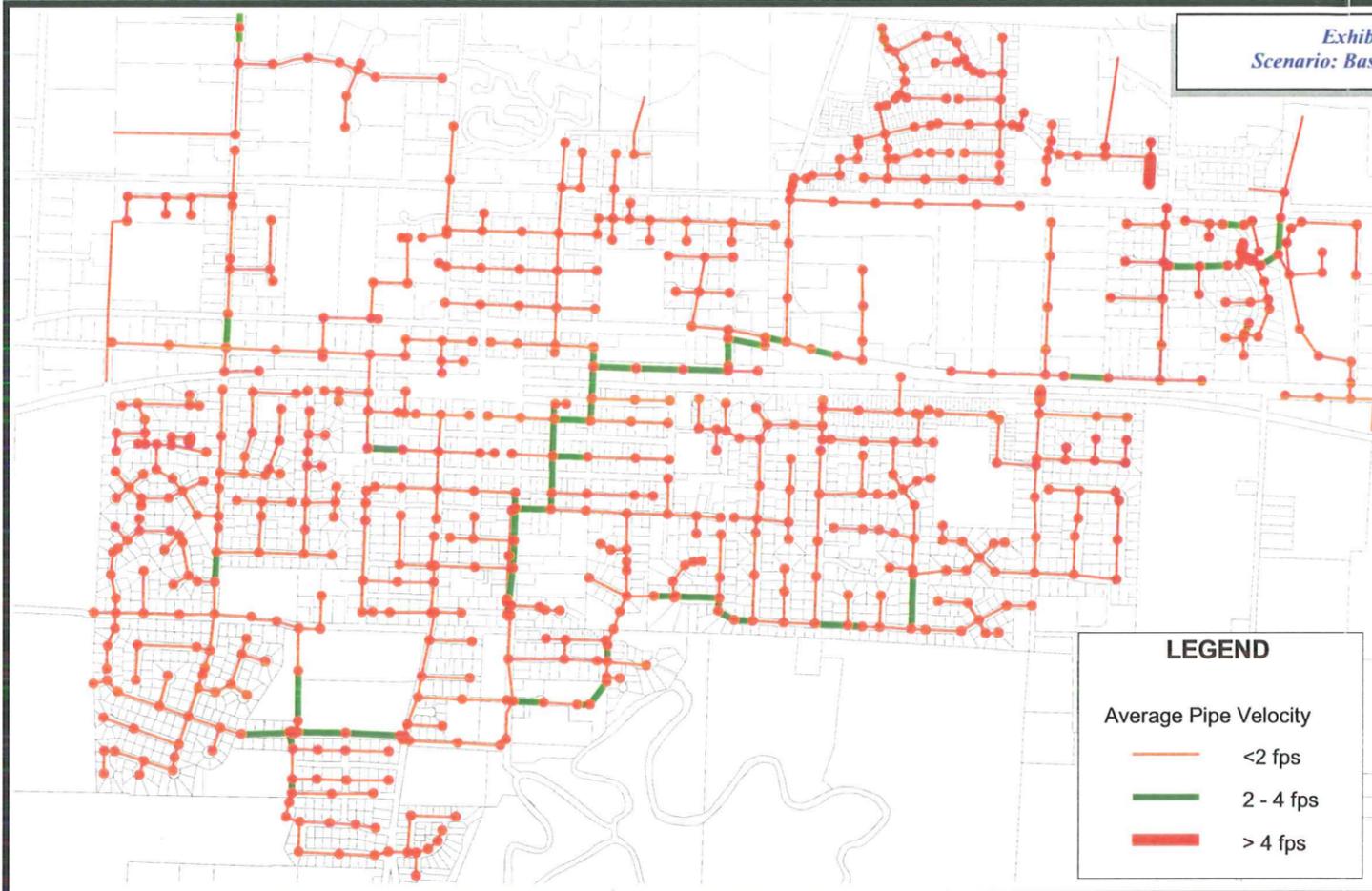
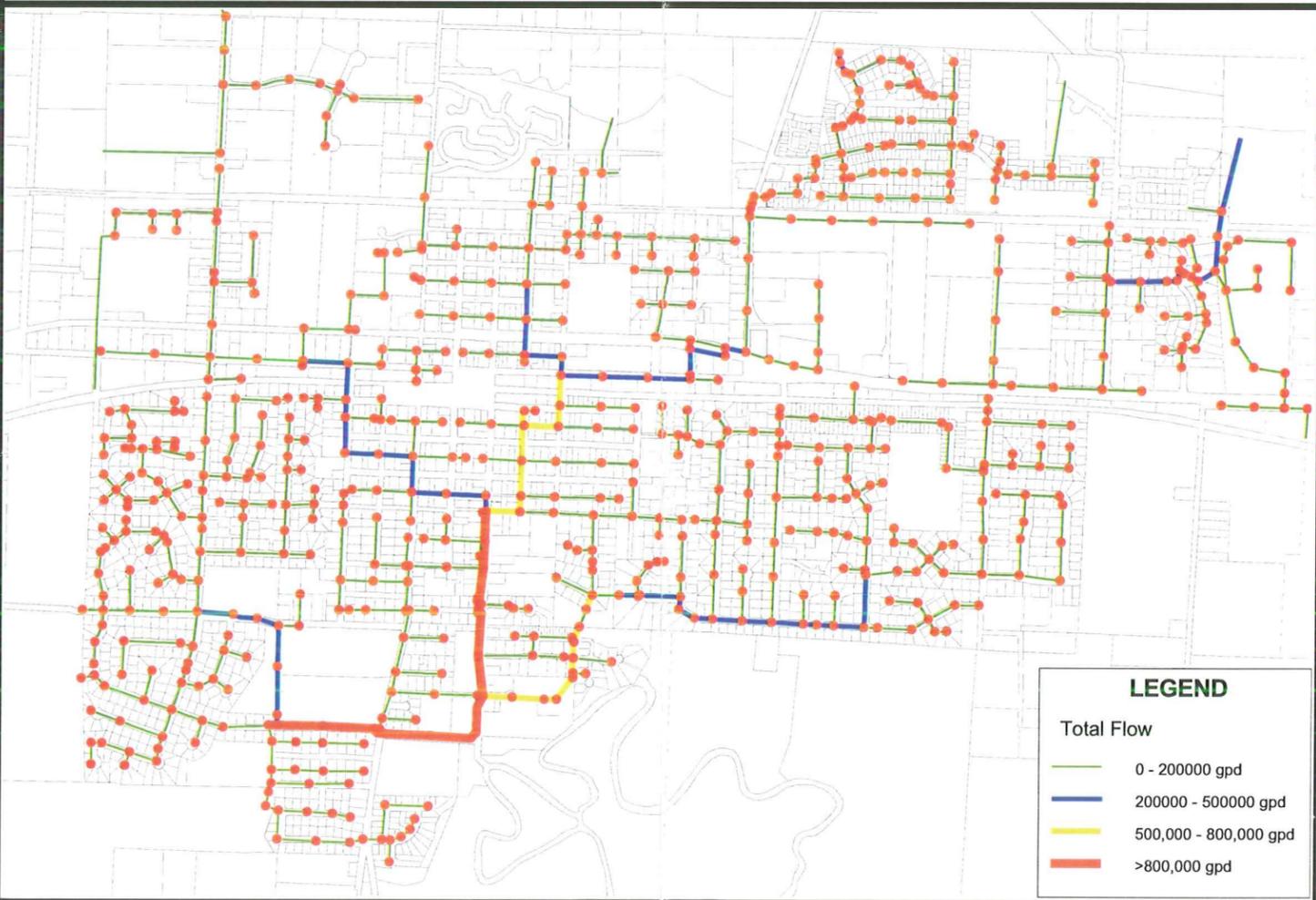
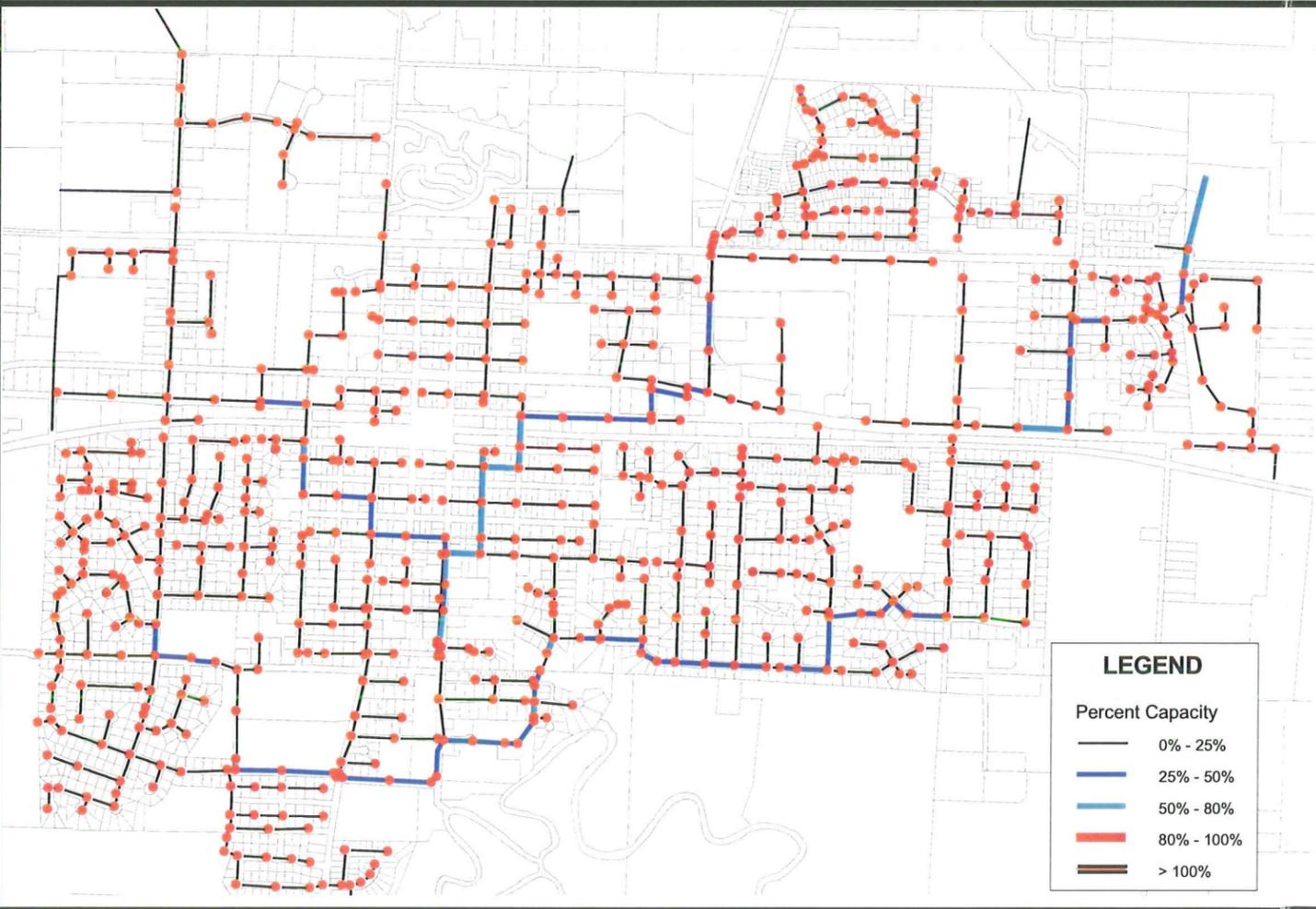
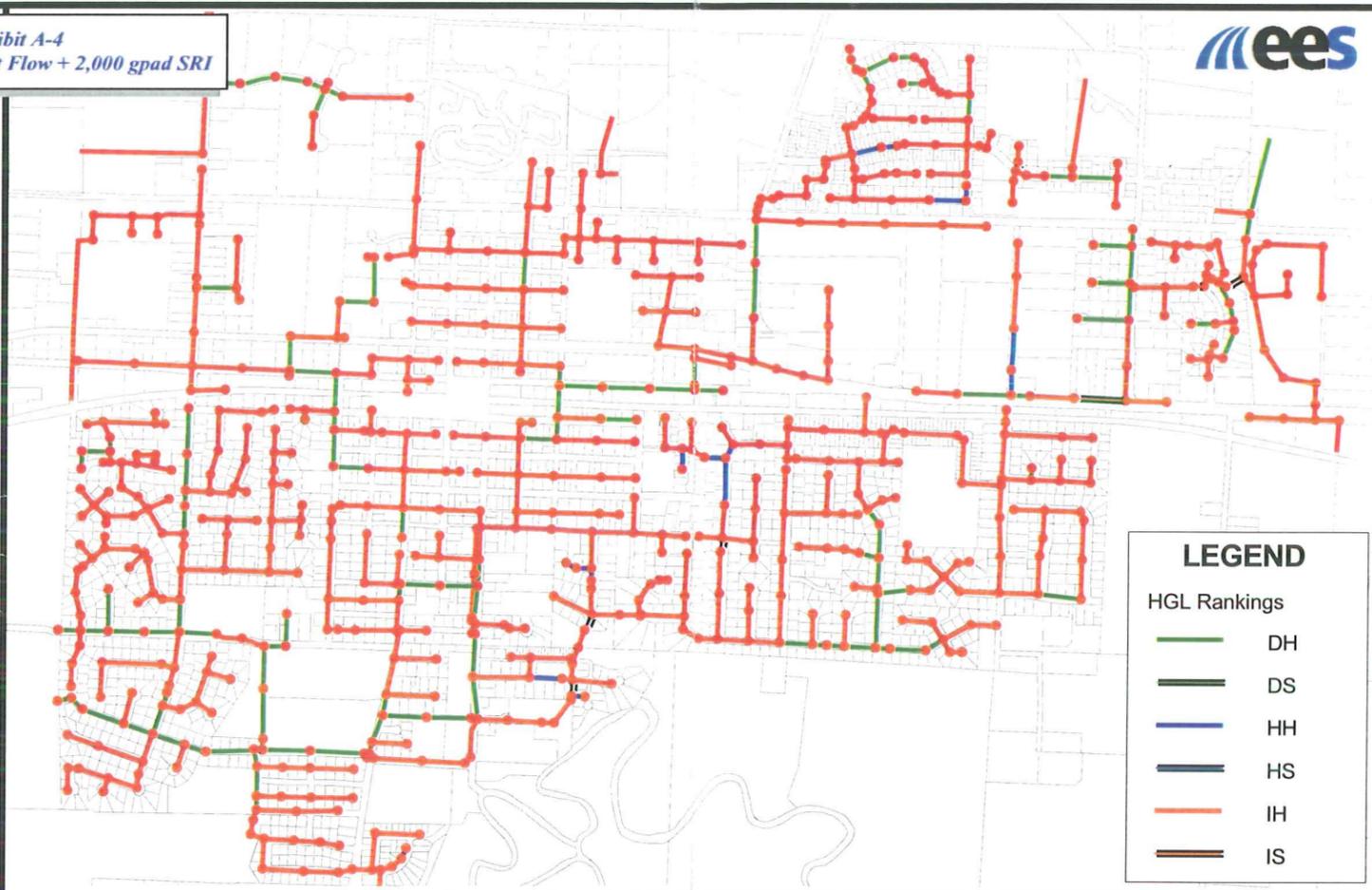
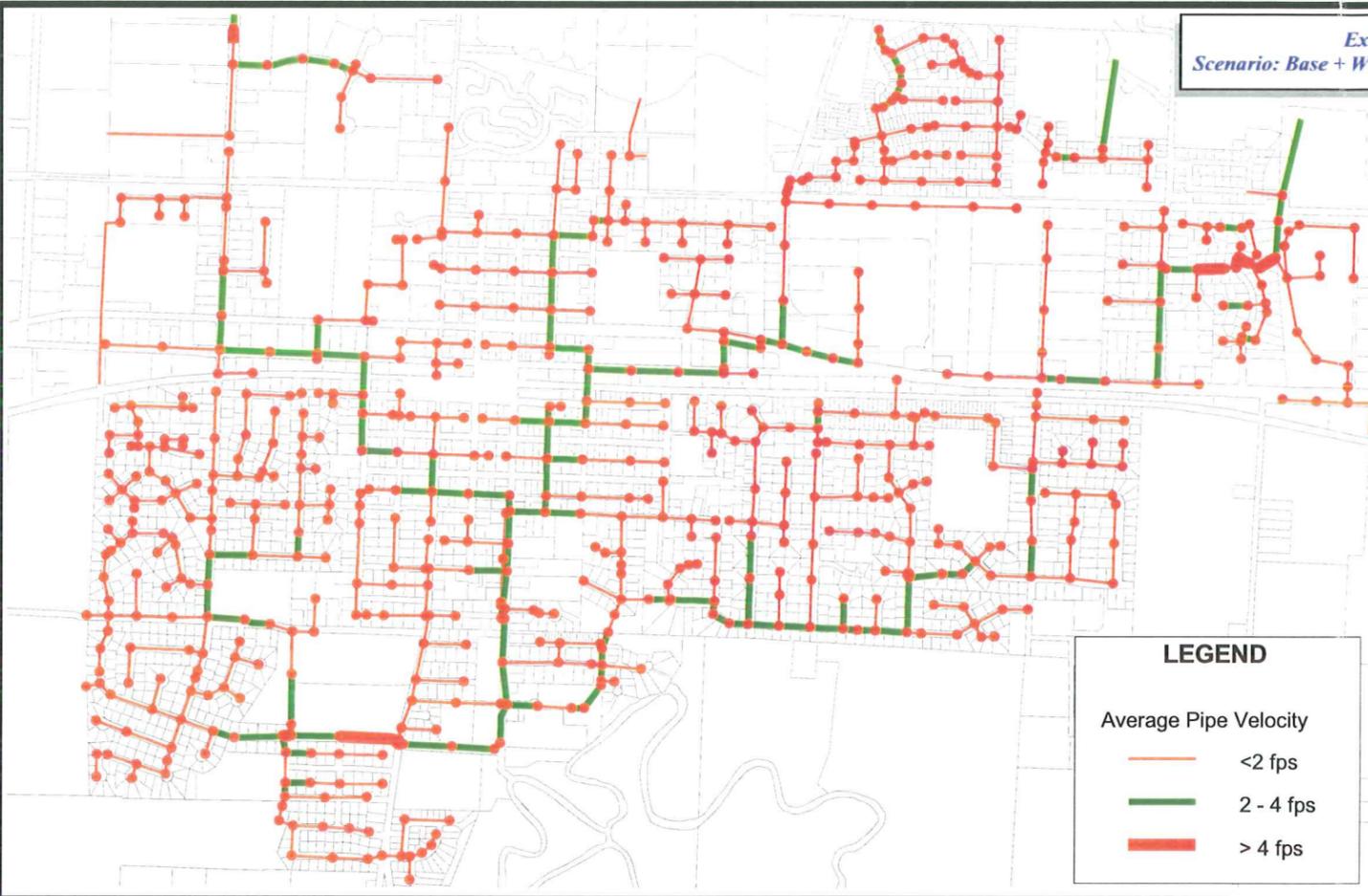


Exhibit A-4
Scenario: Base + Wet Flow + 2,000 gpad SRI



City of Cornelius
Scenario (Base Sanitary Flows + Wet Flow + 2.000 gpd Storm Response Infiltration Flow)

Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (ft/s)	Velocity Out (ft/s)	Capacity (gpd)	Excess Full Capacity (gpd)	Total Flow (gpd)	% Capacity	Section Size	Avg Pipe Cover (ft)	Upstream Crown Elev (ft)	Downstream Crown Elev (ft)	Upstream Ground Elev (ft)	Downstream Ground Elev (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Depth Out (ft)	Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Floodboard Up (ft)	Floodboard Down (ft)	dH	a	Dia (ft)	Test		
50399	0.002	0.0013	IS	1.39	2.56	148,933	174,904	323,277	148.8%	8 inch	7.98	159.17	159.16	167.10	166.57	7.93	7.42	0.45	0.27	0.99	-0.22	-0.39	7.93	7.42	8.15	7.82	0.19	0.03	0.67	1	
50541	0.0026	0.0027	DH	3.33	3.90	1,530,140	349,495	1,879,645	77.2%	12 inch	11.78	154.78	153.72	166.00	166.00	11.24	12.28	0.66	0.68	3.33	-0.34	-0.42	11.24	12.28	11.58	12.70	0.02	0.06	1.00	0	
36553	0.0025	0.0023	HS	3.21	3.79	1,491,118	402,590	1,893,528	73.0%	12 inch	7.81	158.02	155.35	162.00	165.70	5.98	9.85	0.63	0.55	3.21	-0.37	-0.45	5.99	9.85	8.35	10.10	0.03	0.06	1.00	0	
36438	0.0004	0.0007	IS	1.04	2.13	206,997	58,971	148,028	71.5%	8 inch	8.61	168.87	168.89	177.78	177.70	8.91	8.31	0.40	0.23	1.00	-0.26	-0.44	8.31	8.31	9.18	8.75	0.04	0.03	0.67	1	
36516	0.0007	0.0012	HS	1.85	2.54	800,006	280,472	519,534	64.9%	12 inch	4.41	158.14	158.04	163.00	158.00	6.96	1.98	0.54	0.42	1.68	-0.48	-0.58	8.08	1.98	7.32	2.54	0.08	0.05	1.00	1	
P-509	0.0040	0.0015	DH	1.64	1.35	493,932	189,309	304,623	61.7%	8 inch	14.06	145.82	145.28	163.00	158.00	19.30	10.74	0.51	0.76	2.30	-0.15	0.09	17.38	10.74	17.53	10.55	-0.27	0.04	0.87	0	
P-518	0.0040	0.0041	DH	2.30	2.83	493,932	191,758	302,174	61.2%	8 inch	20.44	138.50	137.82	158.00	158.00	17.58	21.38	0.38	0.32	2.30	-0.29	-0.35	19.50	21.38	19.79	17.83	0.03	0.04	0.67	0	
P-518	0.0040	0.0041	DH	2.30	2.83	493,932	191,758	302,174	61.2%	8 inch	20.44	138.50	137.82	158.00	158.00	17.58	21.38	0.38	0.32	2.30	-0.29	-0.35	19.50	21.38	19.79	17.83	0.03	0.04	0.67	0	
36581	0.0040	0.0027	DH	2.29	3.24	1,000,984	398,901	604,083	60.3%	10 inch	13.79	161.98	161.43	178.00	175.00	14.20	13.57	0.47	0.44	2.97	-0.37	-0.40	14.02	13.57	14.38	13.96	0.02	0.05	0.83	0	
36544	0.0037	0.0037	HS	3.32	3.38	1,122,980	458,513	664,477	59.2%	10 inch	7.48	159.08	162.04	175.98	175.10	12.70	12.96	0.37	0.62	2.29	-0.29	-0.05	12.70	12.96	13.00	13.00	-0.18	0.04	0.67	0	
P-583	0.0016	0.0029	HS	2.12	3.02	927,232	388,771	538,461	58.1%	12 inch	3.18	154.40	154.34	158.70	158.40	4.30	2.05	0.50	0.38	1.89	-0.50	-0.82	4.30	2.08	4.80	2.58	0.32	0.05	1.00	1	
50488	0.0028	0.0029	DS	2.37	2.75	514,116	218,633	295,483	57.1%	8 inch	13.39	167.86	167.56	181.00	181.00	13.44	13.44	0.36	0.32	2.38	-0.31	-0.35	13.34	13.44	13.85	13.74	0.00	0.04	0.87	0	
P-876	0.0036	0.0028	HS	2.28	3.17	1,111,388	477,534	633,654	57.0%	10 inch	9.35	180.21	159.08	171.00	167.00	10.79	7.92	0.45	0.48	3.28	-0.38	-0.37	10.79	7.92	11.17	8.29	0.00	0.05	0.83	0	
36545	0.0042	0.0042	HS	3.44	3.44	1,199,308	519,244	680,051	56.7%	10 inch	7.36	157.93	157.34	165.00	165.00	7.07	7.66	0.48	0.47	3.51	-0.38	-0.06	7.07	7.66	7.44	8.02	-0.01	0.05	0.83	0	
36544	0.0048	0.0047	HS	3.52	2.51	1,292,991	570,574	722,417	55.9%	10 inch	6.90	157.24	155.85	165.00	162.60	7.68	6.15	0.47	0.63	3.77	-0.38	-0.20	7.68	6.15	8.02	8.35	-0.05	0.05	0.83	0	
36527	0.0039	0.0039	DH	3.32	3.33	1,149,012	531,159	617,853	53.8%	10 inch	12.17	161.43	160.23	175.00	171.13	13.57	10.77	0.44	0.43	3.32	-0.40	-0.40	13.57	10.77	10.77	13.98	11.17	0.00	0.05	0.83	0
36525	0.0038	0.0037	DH	3.25	2.63	1,130,063	535,413	594,650	52.8%	10 inch	13.51	162.99	161.98	178.00	173.13	13.01	14.02	0.43	0.47	3.25	-0.40	-0.37	13.01	14.02	13.41	14.38	-0.01	0.05	0.83	0	
P-582	0.0020	0.0024	IS	2.08	2.82	1,037,458	502,842	534,614	51.5%	12 inch	4.90	154.77	154.50	160.38	158.70	5.91	4.20	0.51	0.40	2.08	-0.49	-0.00	5.91	4.20	6.10	4.80	0.08	0.05	1.00	1	
50501	0.0038	0.0038	DH	2.78	2.72	625,854	321,247	304,607	48.7%	8 inch	14.21	166.03	164.61	180.00	178.55	13.97	14.44	0.33	0.33	2.78	-0.34	-0.34	13.97	14.44	14.31	14.78	0.00	0.04	0.67	0	
36547	0.0042	0.0042	HS	3.25	3.38	1,195,837	577,204	48.3%	10 inch	9.48	152.33	151.25	161.80	161.53	9.17	9.80	0.42	0.41	3.38	-0.41	-0.43	9.17	9.80	9.58	10.22	0.00	0.05	0.83	0		
P-515	0.0040	0.0040	HS	2.80	2.44	842,112	340,272	301,833	47.9%	8 inch	12.77	164.51	164.51	178.00	178.00	14.44	13.17	0.33	0.43	2.01	-0.34	-0.31	11.25	8.31	14.44	13.01	0.04	0.04	0.67	0	
36511	0.0048	0.0045	DH	2.89	2.11	898,737	368,078	323,860	48.9%	8 inch	13.81	164.51	164.51	178.00	178.00	14.44	13.17	0.33	0.43	2.01	-0.34	-0.31	11.25	8.31	14.44	13.01	0.04	0.04	0.67	0	
50489	0.0040	0.0040	DH	2.80	2.73	643,374	342,071	301,303	48.8%	8 inch	13.71	167.58	168.03	181.00	180.00	13.44	13.87	0.32	0.33	2.80	-0.35	-0.34	13.44	13.87	13.79	14.31	0.00	0.04	0.67	0	
36506	0.0034	0.0034	HS	2.97	3.10	1,065,707	568,065	497,542	46.7%	10 inch	3.58	157.24	156.63	180.00	178.00	2.76	4.37	0.40	0.39	2.97	-0.43	-0.45	2.78	4.37	3.19	4.81	0.01	0.05	0.83	0	
50391	0.0040	0.0040	HS	2.81	2.61	644,338	343,909	300,429	46.8%	8 inch	10.75	142.85	142.86	155.30	151.63	12.45	9.04	0.32	0.32	2.81	-0.35	-0.35	12.45	9.04	12.80	8.39	0.00	0.04	0.67	0	
50581	0.0015	0.0015	HS	1.34	2.48	700,322	383,876	318,448	45.2%	10 inch	11.20	162.02	159.58	174.00	168.00	13.98	8.42	0.39	0.33	1.94	-0.44	-0.45	13.98	8.42	14.82	8.92	0.02	0.04	0.83	0	
50478	0.0044	0.0044	HS	2.78	2.78	678,316	388,263	388,263	44.9%	10 inch	7.68	159.75	158.75	168.75	168.75	8.63	12.26	0.31	0.31	2.88	-0.35	-0.35	8.63	11.81	8.99	11.81	0.00	0.04	0.67	0	
50490	0.0048	0.0047	DH	2.80	2.34	700,447	407,089	292,778	41.8%	10 inch	12.30	168.75	168.00	180.00	181.00	11.26	13.37	0.60	0.56	0.80	-0.41	-0.39	11.26	13.37	10.85	10.85	-0.01	0.09	0.50	0	
36588	0.0030	0.0030	DH	4.00	3.75	4,823,922	2,872,955	1,950,967	40.4%	18 inch	9.90	147.38	148.15	158.00	158.00	9.44	9.85	0.68	0.70	4.00	-0.80	-0.80	9.44	9.85	10.78	10.85	-0.01	0.09	0.50	0	
36555	0.0028	0.0024	DH	3.29	2.60	2,760,874	1,858,131	1,102,743	39.9%	15 inch	10.19	155.80	155.01	165.00	160.00	10.99	10.99	0.55	0.68	3.29	-0.70	-0.59	9.40	10.99	10.10	11.58	-0.05	0.07	1.25	0	
36927	0.0041	0.0041	DH	2.08	2.47	499,819	309,598	198,221	39.2%	8 inch	11.27	159.99	151.88	163.00	164.41	10.01	12.63	0.29	0.28	2.08	-0.38	-0.41	10.01	12.63	10.39	12.04	0.01	0.04	0.67	0	
50475	0.0032	0.0032	HS	2.78	2.78	735,119	448,437	286,682	39.0%	8 inch	8.74	170.58	170.17	179.40	178.80	8.84	8.63	0.31	0.31	3.04	-0.36	-0.35	8.84	8.63	9.20	8.90	0.00	0.04	0.67	0	
P-580	0.0035	0.0034	HS	2.51	2.61	1,386,327	645,113	321,214	38.8%	12 inch	2.89	154.27	152.89	168.00	168.00	9.11	9.90	0.56	0.60	4.19	-0.57	-0.58	2.68	3.18	3.25	3.78	0.01	0.05	1.00	0	
55271	0.0034	0.0034	DH	4.01	4.19	5,156,295	3,228,781	1,929,533	37.4%	18 inch	9.71	149.58	149.00	159.67	157.30	8.84	8.84	0.60	0.60	4.01	-0.80	-0.80	8.84	8.85	10.78	10.85	-0.01	0.09	0.50	0	
P-580	0.0039	0.0039	DH	2.61	2.61	637,229	401,258	235,972	37.0%	8 inch	10.68	165.45	165.19	178.00	178.00	10.55	10.81	0.28	0.28	2.61	-0.39	-0.39	10.55	10.81	10.94	11.20	0.00	0.04	0.67	0	
36457	0.0045	0.0045	DH	2.68	2.49	881,063	431,774	249,289	36.8%	8 inch	11.53	164.64	162.87	177.82	173.04	12.68	10.17	0.29	0.30	2.78	-0.38	-0.38	12.68	10.17	13.28	10.54	0.00	0.04	0.67	0	
36451	0.0040	0.0040	DH	2.02	1.92	492,931	313,639	180,292	36.5%	8 inch	12.10	166.00	164.64	177.38	177.82	11.32	12.68	0.28	0.29	2.02	-0.39	-0.38	11.32	12.68	11.71	12.28	0.00	0.04	0.67	0	
50538	0.0011	0.0011	HS	1.34	2.48	735,119	448,437	286,682	39.0%	15 inch	8.06	153.16	152.92	160.70	161.50	7.65	8.58	0.62	0.36	1.79	-0.73	-0.79	7.55	8.58	8.28	9.47	0.05	0.06	1.25	0	
P-581	0.0040	0.0040	HS	2.63	2.99	1,458,278	933,477	522,805	36.3%	12 inch	4.29	152.02	151.52	168.00	168.00	9.70	8.44	0.41	0.38	2.63	-0.59	-0.62	3.18	5.41	3.78	6.03	0.03	0.06	1.00	0	
36448	0.0040	0.0040	HS	2.80	2.02	1,174,932	318,127	175,805	35.6%	8 inch	10.39	166.78																			

Label	Constructed Slope	HGL Slope	HGL Flowings	Velocity In (ft/s)	Velocity Out (ft/s)	Capacity (gpd)	Excess Full Capacity (gpd)	Total Flow (gpd)	% Capacity	Section Size	Avg Pipe C/P	Upstream		Upstream		Upstream	Downstream	Depth In (ft)	Depth Out (ft)	Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	s	Dia (ft)	Test
												Downstream	Downstream	Downstream	Downstream															
36510	0.0047	0.0047	DH	2.29	1.98	698,816	544,348	152,268	21.9%	8 inch	13.29	166.81	165.44	178.36	180.48	11.55	15.02	0.22	0.25	2.47	-0.44	-0.42	11.55	15.02	12.00	15.44	-0.01	0.04	0.67	0
50534	0.0074	0.0073	IH	2.46	2.08	871,714	681,358	190,356	21.8%	8 inch	8.46	162.87	160.51	175.78	187.40	13.09	8.46	0.25	0.21	3.09	-0.42	-0.48	13.09	8.86	10.51	7.35	0.01	0.04	0.67	0
50534	0.0039	0.0039	IH	2.52	2.43	1,149,252	899,205	250,046	21.8%	10 inch	8.86	167.55	166.33	178.20	178.00	8.85	8.87	0.27	0.28	2.81	-0.56	-0.58	8.85	8.87	9.21	9.22	0.00	0.05	0.83	0
36608	0.0017	0.0018	IH	1.95	2.47	1,237,286	968,556	268,731	21.7%	12 inch	9.64	146.04	147.70	157.28	167.59	9.22	9.66	0.32	0.27	1.95	-0.60	-0.73	9.22	9.06	6.00	6.00	0.00	0.04	0.67	0
36626	0.0040	0.0040	IH	2.23	2.18	842,112	503,975	138,137	21.5%	8 inch	10.18	171.87	170.37	184.00	178.60	12.13	8.23	0.21	0.22	2.27	-0.45	-0.45	12.13	8.23	12.59	8.86	0.00	0.04	0.67	0
P-828	0.0040	0.0040	IH	2.23	2.27	842,112	504,840	137,472	21.4%	8 inch	11.15	173.88	173.03	184.00	185.00	10.34	11.97	0.21	0.21	2.27	-0.45	-0.48	10.34	11.97	10.79	12.42	0.00	0.04	0.67	0
50545	0.0040	0.0039	IH	1.74	1.47	493,533	309,577	104,177	21.1%	8 inch	7.81	156.90	155.79	168.00	162.00	9.40	8.21	0.21	0.24	1.74	-0.48	-0.43	9.40	8.21	9.86	8.84	-0.01	0.04	0.67	0
P-625	0.0040	0.0040	IH	2.21	2.25	842,112	507,340	134,771	21.0%	8 inch	7.81	156.90	155.79	168.00	162.00	9.40	8.21	0.21	0.24	1.74	-0.48	-0.43	9.40	8.21	9.86	8.84	-0.01	0.04	0.67	0
P-624	0.0040	0.0040	IH	2.21	2.25	842,112	507,948	134,164	20.9%	8 inch	7.11	174.82	174.18	180.00	183.00	5.38	8.84	0.21	0.21	2.25	-0.48	-0.48	5.38	8.84	9.30	0.00	0.04	0.67	0	
50544	0.0040	0.0040	IH	1.72	1.91	492,670	391,578	101,094	20.5%	8 inch	10.19	167.01	166.82	168.00	168.00	10.99	9.38	0.20	0.19	1.72	-0.48	-0.48	10.99	9.38	11.48	9.86	0.02	0.04	0.67	0
36626	0.0109	0.0109	IH	2.38	1.95	817,038	649,589	167,489	20.5%	8 inch	8.10	155.79	153.01	162.00	163.00	6.21	9.98	0.24	0.27	2.85	-0.43	-0.40	6.21	9.98	6.64	10.39	-0.01	0.04	0.67	0
50451	0.0040	0.0040	IH	2.05	1.88	921,554	733,297	188,297	20.4%	10 inch	10.44	168.08	165.08	175.00	177.00	8.54	11.94	0.28	0.30	2.05	-0.58	-0.54	8.54	11.94	9.51	12.47	-0.01	0.04	0.83	0
36471	0.0040	0.0040	IH	1.72	1.98	494,348	393,973	100,374	20.3%	8 inch	9.93	174.85	174.64	179.00	180.00	4.15	5.38	0.20	0.20	1.72	-0.48	-0.48	5.38	10.52	9.80	11.01	0.01	0.04	0.67	0
36594	0.0048	0.0046	DH	2.24	2.10	890,330	650,890	139,832	20.2%	8 inch	12.02	168.16	168.81	180.64	178.38	12.49	11.56	0.21	0.22	2.40	-0.45	-0.44	12.49	11.56	12.94	12.94	0.00	0.04	0.67	0
38541	0.0038	0.0038	IH	2.46	2.30	1,132,060	903,896	228,184	20.2%	10 inch	9.06	168.73	167.55	184.00	178.20	9.47	8.65	0.28	0.27	2.51	-0.58	-0.56	9.47	8.65	10.54	9.21	0.00	0.05	0.83	0
38438	0.0198	0.0198	DH	2.53	2.50	1,045,890	835,455	210,428	20.2%	8 inch	11.99	164.68	164.06	178.60	178.12	11.92	12.06	0.28	0.27	3.63	-0.40	-0.40	11.92	12.06	12.33	12.48	0.00	0.04	0.67	0
50511	0.0037	0.0038	DH	2.11	1.93	813,810	493,548	120,264	19.0%	8 inch	12.30	169.22	166.16	181.33	180.84	12.11	12.48	0.20	0.21	2.11	-0.47	-0.45	12.11	12.48	12.58	12.94	0.00	0.04	0.67	0
P-623	0.0040	0.0040	IH	2.17	2.21	842,112	516,653	125,448	19.5%	8 inch	4.78	174.85	174.64	179.00	180.00	4.15	5.38	0.20	0.20	2.21	-0.46	-0.48	4.15	5.38	4.92	5.83	0.01	0.04	0.67	0
P-673	0.0044	0.0040	DS	4.02	4.84	12,671,049	10,195,814	2,474,435	19.5%	24 inch	19.98	138.58	138.30	154.83	158.40	18.25	21.70	0.89	0.80	4.02	-0.40	-0.40	11.92	12.06	12.33	12.48	0.00	0.04	0.67	0
36821	0.0025	0.0025	IH	2.01	1.95	918,011	737,268	178,743	19.5%	10 inch	7.92	167.10	166.06	174.00	175.00	6.84	8.94	0.25	0.28	2.01	-0.59	-0.58	6.84	7.48	9.81	0.00	0.04	0.83	1	
P-622	0.0040	0.0040	IH	2.16	2.20	842,112	517,813	124,299	19.4%	8 inch	4.45	175.24	174.87	180.00	179.00	4.78	4.13	0.20	0.20	2.20	-0.47	-0.47	4.78	4.13	5.23	6.00	0.00	0.04	0.67	0
P-621	0.0040	0.0040	IH	2.15	2.19	842,112	519,510	122,901	19.1%	8 inch	5.12	175.51	175.28	181.00	180.00	4.78	4.74	0.20	0.20	2.19	-0.47	-0.47	4.74	5.95	5.21	0.00	0.04	0.67	0	
50423	0.0134	0.0130	IH	2.56	1.38	1,175,444	852,874	222,569	18.9%	8 inch	7.78	162.32	169.17	189.85	187.10	7.83	7.93	0.27	0.45	4.01	-0.39	-0.22	7.83	7.93	8.03	8.15	-0.07	0.05	0.67	0
55561	0.0032	0.0014	DH	3.48	2.51	10,721,154	8,830,132	1,891,022	17.8%	24 inch	14.96	163.04	162.87	180.48	175.04	15.94	15.59	0.20	0.21	2.98	-0.37	-0.20	12.94	9.75	14.31	10.95	-0.38	0.11	2.00	0
50424	0.0032	0.0052	DH	2.18	2.07	731,240	503,470	127,770	17.5%	8 inch	12.02	172.00	171.97	184.00	184.30	11.10	12.33	0.20	0.21	2.44	-0.48	-0.45	11.70	12.33	12.48	12.94	0.00	0.04	0.67	0
50467	0.0027	0.0028	DH	1.76	1.13	530,889	438,705	91,884	17.3%	8 inch	11.58	173.17	172.17	186.00	182.50	12.83	10.33	0.19	0.28	1.76	-0.48	-0.41	12.83	10.33	13.31	10.74	-0.02	0.04	0.67	0
36483	0.0040	0.0012	IH	2.09	0.49	842,112	531,088	111,044	17.3%	8 inch	7.70	171.89	170.73	179.29	178.80	7.90	7.97	0.19	0.28	1.76	-0.48	-0.19	7.80	7.97	6.00	7.78	-0.31	0.04	0.67	0
36428	0.0173	0.0173	IH	2.57	2.58	1,335,131	1,111,103	225,028	16.8%	8 inch	7.83	159.15	157.47	166.67	165.20	7.42	7.83	0.27	0.28	4.40	-0.39	-0.39	7.42	7.83	8.22	0.00	0.05	0.67	0	
36540	0.0038	0.0037	DH	2.32	2.02	1,128,457	840,221	188,236	16.7%	10 inch	9.48	169.91	168.73	179.40	178.20	9.49	9.47	0.23	0.28	2.37	-0.60	-0.58	9.49	9.47	10.92	10.04	-0.01	0.05	0.83	0
50507	0.0047	0.0047	DH	2.12	2.04	698,048	581,854	116,195	16.6%	8 inch	6.81	181.18	180.20	170.83	167.00	9.47	7.00	0.18	0.19	2.29	-0.47	-0.47	11.28	12.11	11.74	12.38	0.00	0.04	0.67	0
50521	0.0642	0.0395	DS	4.53	12.82	13,750,384	11,475,523	2,274,461	16.5%	15 inch	11.95	145.84	141.09	158.00	154.83	10.16	13.74	0.78	0.34	12.82	-0.49	-0.51	10.16	13.74	10.85	14.85	0.00	0.15	1.00	0
36494	0.0038	0.0038	IH	2.01	1.91	827,854	531,843	96,011	15.3%	8 inch	7.96	162.61	161.16	169.68	170.83	6.45	9.47	0.18	0.18	2.01	-0.49	-0.48	6.45	9.47	6.94	9.80	0.00	0.04	0.67	0
36450	0.0045	0.0045	IH	2.05	2.00	881,942	579,008	102,934	15.1%	8 inch	7.40	174.83	173.86	182.54	181.12	7.71	7.26	0.18	0.19	2.18	-0.48	-0.48	7.71	7.26	8.20	7.74	0.00	0.04	0.67	0
50533	0.0093	0.0076	IH	2.23	0.98	824,328	788,833	137,494	14.9%	8 inch	10.82	171.97	168.87	184.30	177.78	12.35	9.91	0.21	0.40	2.94	-0.45	-0.28	12.33	8.91	12.79	11.88	-0.05	0.04	0.67	0
P-538	0.0148	0.0146	DH	3.94	3.82	8,188,294	6,975,378	1,212,926	14.8%	12 inch	12.50	163.70	161.53	168.00	164.28	12.30	12.70	0.88	0.83	11.58	-0.42	-0.37	12.30	12.70	12.72	13.07	-0.15	0.15	1.00	0
P-550	0.0018	0.0017	IH	1.33	1.48	411,070	245,123	165,947	14.5%	8 inch	9.55	148.33	148.12	152.30	152.30	8.86	11.28	0.18	0.30	1.33	-0.49	-0.51	8.86	10.88	9.38	11.39	0.01	0.03	0.67	0
36495	0.0051	0.0047	IH	2.05	0.78	721,595	618,333	103,262	14.3%	8 inch	8.84	181.18	180.20	170.83	167.00	9.47	7.00	0.18	0.19	2.29	-0.47	-0.47	7.80	8.98	8.09	-0.05	0.04	0.67	0	
36520	0.0040	0.0027	IH	1.98	0.82	842,112	551,743	90,368	14.1%	8 inch	9.03	172.09	171.75	177.00	184.00	5.81	12.25	0.17	0.33	2.01	-0.50	-0.34	5.81	12.25	6.31	12.59	0.00	0.18	0.67	0
50425	0.0040	0.0040	IH	1.99	2.01	843,167	552,658	90,508	14.1%	8 inch	7.11	171.25	170.03	178.70	177.80	7.45	7.77	0.17	0.17	2.01	-0.50	-0.50	7.45	7.77	7.95	8.37	0.00	0.04	0.67	0
50521	0.0037	0.0037	IH	1.91	1.93	820,173	538,648	83,227	13.4%	8 inch	9.46	172.52	171.27	184.00	178.70	11.48	7.43	0.18	0.18											

Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (fps)	Velocity Out (fps)	Capacity (gpd)	Excess Capacity (%)	Total Flow (gpd)	% Capacity	Section Size	Avg Pipe Cover (ft)	Upstream		Upstream		Upstream		Upstream		Upstream		Average Velocity (fps)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	s	Dia (ft)	Test
												Downstream Crown Elev (ft)	Downstream Crown Elev (ft)	Downstream Ground Elev (ft)	Downstream Ground Elev (ft)	Upstream Cover (ft)	Upstream Cover (ft)	Depth In (ft)	Depth Out (ft)													
P-6624	0.0040	0.0040	DH	1.29	1.58	492,000	455,456	37,548	7.0%	8 inch	11.28	158.51	157.98	168.05	171.00	9.54	13.02	0.12	0.11	1.29	-0.54	-0.56	9.54	13.02	10.09	13.58	0.01	0.03	0.87	0		
P-6571	0.0040	0.0040	DH	1.29	1.58	492,000	455,456	37,548	7.0%	8 inch	11.28	158.51	157.98	168.05	171.00	9.54	13.02	0.12	0.11	1.29	-0.54	-0.56	9.54	13.02	10.09	13.58	0.01	0.03	0.87	0		
P-6574	0.0040	0.0040	DH	1.29	1.58	492,000	455,456	37,548	7.0%	8 inch	11.28	158.51	157.98	168.05	171.00	9.54	13.02	0.12	0.11	1.29	-0.54	-0.56	9.54	13.02	10.09	13.58	0.01	0.03	0.87	0		
P-6584	0.0020	0.0020	DS	1.84	1.89	1,338,668	1,237,873	100,793	7.0%	12 inch	12.56	166.78	166.78	166.78	171.00	14.14	10.22	0.18	0.18	1.84	-0.82	-0.84	14.14	10.22	15.75	11.08	-0.34	0.05	1.00	1		
P-6599	0.0054	0.0060	DH	1.77	0.62	809,905	749,852	60,053	7.4%	8 inch	11.37	168.72	164.80	177.35	177.00	10.83	12.10	0.14	0.30	2.10	-0.63	-0.37	10.83	12.10	11.18	12.47	-0.05	0.04	0.87	0		
P-6603	0.0034	0.0034	DH	1.56	0.78	801,491	557,038	244,453	7.4%	8 inch	11.18	174.39	172.80	185.00	185.00	10.61	11.70	0.12	0.20	1.56	-0.54	-0.46	10.61	11.70	11.18	12.17	-0.02	0.04	0.87	0		
P-6604	0.0040	0.0040	DH	1.48	1.74	894,794	829,704	65,090	7.2%	10 inch	9.35	165.48	164.31	175.50	173.00	10.02	8.89	0.15	0.14	1.48	-0.68	-0.70	10.02	8.89	10.70	9.38	0.01	0.04	0.83	0		
P-6605	0.0042	0.0042	DH	1.58	1.38	859,575	811,712	47,864	7.2%	8 inch	8.98	172.12	171.01	180.21	180.64	8.99	8.93	0.12	0.14	1.70	-0.54	-0.53	8.99	8.93	10.64	10.16	-0.01	0.04	0.87	0		
P-6607	0.0050	0.0050	DH	1.89	1.36	717,901	668,182	51,719	7.2%	8 inch	10.47	157.58	157.28	167.80	168.40	8.82	11.12	0.13	0.16	1.85	-0.54	-0.52	8.82	11.12	10.38	11.54	-0.02	0.04	0.87	0		
P-6608	0.0041	0.0041	DH	1.65	1.86	846,163	599,823	246,340	7.2%	8 inch	10.76	144.31	143.87	154.50	155.00	10.19	11.33	0.12	0.12	1.66	-0.55	-0.55	10.19	11.33	10.74	11.88	0.00	0.04	0.87	0		
P-6609	0.0067	0.0067	IH	1.51	1.29	388,383	358,770	27,613	7.1%	8 inch	6.20	182.13	180.37	184.80	188.10	10.87	7.73	0.10	0.11	1.76	-0.40	-0.39	2.67	7.73	3.07	8.12	0.00	0.03	0.50	0		
P-6610	0.0040	0.0040	IH	1.84	1.85	642,112	596,330	45,781	7.1%	8 inch	9.34	171.01	170.30	184.00	178.00	12.99	5.70	0.12	0.12	1.85	-0.55	-0.55	12.99	5.70	13.54	6.24	0.00	0.04	0.87	0		
P-6611	0.0040	0.0040	IH	1.84	1.85	642,112	596,330	45,781	7.1%	8 inch	11.19	170.80	170.00	181.89	181.28	11.09	11.28	0.13	0.13	1.84	-0.55	-0.55	11.09	11.28	11.28	11.74	-0.04	0.04	0.87	0		
P-6612	0.0040	0.0040	IH	1.84	1.84	640,851	595,730	45,101	7.0%	8 inch	7.89	148.07	147.07	155.86	155.28	7.59	8.19	0.12	0.12	1.84	-0.55	-0.55	7.59	8.19	8.14	8.74	0.00	0.04	0.87	0		
P-6613	0.0044	0.0044	IH	1.66	1.72	674,044	626,750	47,294	7.0%	8 inch	5.13	177.47	175.87	183.50	180.10	8.03	4.23	0.12	0.12	1.72	-0.54	-0.55	8.03	4.23	6.73	4.78	0.00	0.04	0.87	0		
P-6614	0.0045	0.0045	IH	1.88	1.50	678,081	632,052	47,829	7.0%	8 inch	4.88	175.87	174.27	180.10	181.00	6.23	6.73	0.12	0.13	1.74	-0.54	-0.53	4.23	6.73	4.78	7.27	0.00	0.04	0.87	0		
P-6615	0.0036	0.0036	DH	1.55	1.61	608,357	585,907	22,449	7.0%	8 inch	11.37	173.24	172.03	184.00	184.00	10.78	11.97	0.12	0.12	1.55	-0.55	-0.55	10.78	11.97	11.31	12.62	0.00	0.04	0.87	0		
P-6616	0.0032	0.0032	IH	1.46	1.19	575,266	535,357	39,909	6.9%	8 inch	5.84	180.15	158.83	198.01	184.74	5.86	5.81	0.12	0.14	1.46	-0.56	-0.53	5.86	5.81	6.41	6.34	0.00	0.03	0.87	0		
P-6617	0.0040	0.0040	IH	1.82	1.83	642,112	598,428	43,685	6.8%	8 inch	8.81	178.80	178.59	180.60	183.60	10.20	7.01	0.12	0.12	1.83	-0.55	-0.55	10.20	7.01	10.75	7.58	0.00	0.04	0.87	0		
P-6618	0.0040	0.0040	IH	1.82	1.55	642,112	598,428	43,685	6.8%	8 inch	7.44	177.03	176.79	181.70	187.60	4.67	10.21	0.12	0.12	1.55	-0.54	-0.54	4.67	10.21	5.22	10.75	-0.01	0.04	0.87	0		
P-6619	0.0045	0.0045	IH	1.84	1.50	681,313	635,465	45,847	6.7%	8 inch	9.34	159.34	157.98	168.20	167.80	8.85	9.82	0.12	0.13	1.72	-0.55	-0.54	8.85	9.82	9.41	10.38	0.00	0.04	0.87	0		
P-6620	0.0045	0.0042	IH	1.84	0.65	679,250	630,851	48,400	6.7%	8 inch	9.45	171.16	169.75	180.40	179.40	9.24	8.65	0.12	0.23	1.71	-0.55	-0.43	9.24	8.65	8.79	10.09	-0.04	0.04	0.87	0		
P-6621	0.1113	0.0946	IS	2.58	8.53	3,387,805	3,161,159	226,646	6.7%	8 inch	10.03	157.47	151.88	165.30	152.90	8.23	12.22	0.28	0.12	2.58	-0.53	-0.45	7.83	12.22	8.22	12.77	0.30	0.09	0.67	1		
P-6622	0.0123	0.0114	IS	2.33	3.89	3,320,821	3,103,435	217,387	6.5%	12 inch	7.00	160.80	160.00	167.40	167.40	8.60	7.40	0.24	0.17	3.89	-0.78	-0.83	8.60	7.40	7.38	8.23	0.10	0.06	1.00	1		
P-6623	0.0038	0.0036	HH	1.56	1.56	622,502	581,969	40,533	6.5%	8 inch	8.27	174.64	174.32	173.00	167.30	7.33	2.13	0.12	0.15	1.56	-0.55	-0.51	7.33	2.13	7.88	2.85	-0.03	0.04	0.87	0		
P-6624	0.0040	0.0036	HH	1.00	0.99	642,112	600,988	41,124	6.4%	8 inch	8.27	174.64	174.32	173.00	167.30	8.21	8.21	0.13	0.13	1.00	-0.55	-0.54	8.21	8.21	8.34	8.84	-0.08	0.04	0.87	0		
P-6625	0.0184	0.0182	DH	1.82	2.83	1,058,274	990,807	67,467	6.4%	8 inch	11.85	145.32	143.19	157.50	154.30	12.16	11.11	0.15	0.11	2.83	-0.52	-0.55	12.16	11.11	12.70	11.87	0.03	0.04	0.83	0		
P-6626	0.0043	0.0043	DH	1.82	1.88	1,211,434	1,134,418	77,016	6.4%	10 inch	10.05	147.82	146.39	158.05	157.00	10.43	9.88	0.15	0.16	1.82	-0.68	-0.68	10.43	9.88	11.11	10.57	0.00	0.04	0.87	0		
P-6627	0.0055	0.0055	DH	1.87	1.84	1,368,440	1,282,812	85,628	6.3%	10 inch	10.05	148.39	144.34	158.07	155.77	9.88	10.43	0.18	0.17	2.18	-0.68	-0.68	9.88	10.43	10.35	11.08	-0.01	0.05	0.83	0		
P-6628	0.0087	0.0098	IH	1.78	0.83	848,187	809,111	39,076	6.2%	8 inch	8.01	158.93	155.79	164.74	162.00	5.81	6.21	0.14	0.24	2.34	-0.53	-0.43	5.81	6.21	6.34	6.84	-0.03	0.04	0.87	0		
P-6629	0.0040	0.0040	IH	1.58	1.58	642,112	602,138	39,974	6.2%	8 inch	7.75	177.00	176.50	185.00	184.00	8.00	7.50	0.11	0.11	1.58	-0.56	-0.55	8.00	7.50	8.55	8.05	0.00	0.04	0.87	0		
P-6630	0.0017	0.0017	DH	1.03	1.42	418,437	392,387	26,050	6.2%	8 inch	11.15	173.16	172.40	184.00	184.00	10.84	11.48	0.11	0.09	1.03	-0.58	-0.58	10.84	11.48	11.40	12.94	0.01	0.03	0.67	0		
P-6631	0.0040	0.0040	DH	1.22	1.38	494,563	463,814	30,769	6.2%	8 inch	11.86	172.40	170.88	184.00	183.00	11.00	12.12	0.11	0.10	1.22	-0.55	-0.58	11.00	12.12	12.18	12.89	0.00	0.03	0.67	0		
P-6632	0.0018	0.0018	IH	1.06	1.12	433,042	406,418	26,626	6.1%	8 inch	7.48	177.89	177.39	185.00	185.00	7.31	7.61	0.11	0.11	1.06	-0.55	-0.56	7.31	7.61	7.87	8.17	0.00	0.03	0.67	0		
P-6633	0.0025	0.0025	IH	1.24	1.48	503,310	472,396	30,916	6.1%	8 inch	7.55	152.07	151.78	159.35	159.60	7.26	7.82	0.11	0.10	1.24	-0.65	-0.57	7.26	7.82	7.84	8.28	0.01	0.03	0.67	0		
P-6634	0.0044	0.0044	DH	1.00	1.23	673,237	631,898	41,341	6.1%	8 inch	10.89	169.19	167.95	180.00	178.52	10.81	10.57	0.11	0.14	1.00	-0.55	-0.53	10.81	10.57	11.37	11.10	-0.01	0.04	0.87	0		
P-6635	0.0041	0.0041	IH	1.51	1.51	650,841	611,052	39,789	6.1%	8 inch	8.21	160.54	159.34	186.10	185.20	7.58	8.88	0.11	0.12	1.51	-0.55	-0.55	7.58	8.88	8.66	11.32	0.00	0.04	0.87	0		
P-6636	0.0030	0.0030	IH	1.08	1.28	552,794	519,018	33,775	6.1%	8 inch	5.69	185.45	183.65	191.00	184.00	3.46	3.46	0.11	0.12	1.08	-0.55	-0.55	3.46	3.46	3.46	3.46	0.00	0.03	0.87	0		
P-6637	0.0040	0.0040	DH	1.21	1.46	493,292	463,383	29,909	6.1%	8 inch	10.88	155.58	154.02	165.30	166.00	6.74	11.58	0.11	0.10	1.21	-0.56	-0.57	6.74	11.58	10.30	12.55	0.00	0.03	0.87	0		
P-6638	0.0040	0.0000	DH	0.26	0.17	642,112	603,598	38,514	6.0%	8 inch	11.42	148.87	148.68	160.98	160.98	12.01	10.82	0.42														

Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (ft/s)	Velocity Out (ft/s)	Capacity (gpm)	Excess Full Capacity (gpm)	Total Flow (gpm)	% Capacity	Section Size	Upstream		Upstream		Upstream		Upstream		Upstream		Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	s	Dia (ft)	Test
											Av. Pipe Elev. (ft)	Crown Elev. (ft)	Downstream Crown Elev. (ft)	Ground Elev. (ft)	Downstream Elev. (ft)	Upstream Cover (ft)	Downstream Cover (ft)	Depth In (ft)	Depth Out (ft)												
36503	0.0040	0.0040	IH	1.38	1.15	645,229	500,418	24,823	3.8%	8 inch	7.65	176.35	174.11	182.75	182.30	7.40	7.69	0.09	0.10	1.38	-0.58	-0.57	7.40	7.89	9.8	8.48	0.00	0.03	0.87	0	
36512	0.0060	0.0060	IH	1.25	0.95	385,163	351,268	13,895	3.6%	6 inch	6.35	169.80	167.20	178.00	178.00	6.40	6.30	0.07	0.09	1.28	-0.43	-0.41	6.40	6.30	6.83	6.71	0.00	0.03	0.87	0	
36643	0.0040	0.0040	IH	1.37	1.40	642,112	617,710	24,402	3.8%	8 inch	10.24	181.46	161.06	173.00	170.30	11.64	8.94	0.09	0.09	1.37	-0.58	-0.58	11.64	8.94	12.12	12.02	0.00	0.03	0.87	0	
36481	0.0130	0.0124	IH	1.51	0.29	888,808	855,218	33,591	3.8%	8 inch	10.20	185.46	160.32	174.78	172.30	11.68	11.68	0.10	0.34	1.89	-0.58	-0.33	9.32	11.88	9.88	12.51	-0.06	0.04	0.87	0	
36379	0.0041	0.0040	IH	1.37	1.04	646,161	621,854	24,307	3.8%	8 inch	7.33	169.87	168.27	177.80	175.20	7.73	6.90	0.09	0.11	1.37	-0.58	-0.58	7.73	6.93	8.31	7.48	0.00	0.03	0.87	0	
36473	0.0032	0.0032	IH	1.41	1.28	733,478	706,255	25,223	3.4%	8 inch	14.86	190.21	149.36	164.99	164.11	14.08	15.05	0.11	0.30	1.32	-0.72	-0.53	14.08	15.05	15.40	15.58	-0.07	0.04	0.87	0	
P-532	0.0048	0.0049	IH	1.41	1.48	710,687	685,311	25,376	3.8%	8 inch	9.70	173.03	171.99	180.41	184.30	7.58	12.01	0.09	0.09	1.48	-0.58	-0.58	7.38	12.01	7.96	12.59	0.00	0.04	0.87	0	
36453	0.0028	0.0013	DH	1.29	0.30	985,328	930,967	34,361	3.6%	10 inch	10.02	183.36	163.03	173.34	173.04	10.03	8.28	0.09	0.08	1.31	-0.58	-0.58	5.81	12.01	10.75	10.54	-0.18	0.04	0.83	0	
50565	0.0039	0.0033	IH	1.51	1.37	630,540	608,167	22,373	3.5%	8 inch	9.95	175.34	173.72	180.95	180.00	6.61	6.28	0.09	0.08	1.48	-0.58	-0.58	6.28	6.28	6.28	6.19	0.00	0.03	0.87	0	
50433	0.0048	0.0046	IH	1.40	0.88	691,044	667,038	24,006	3.5%	8 inch	9.98	175.99	174.39	184.70	185.00	6.71	10.81	0.09	0.12	1.44	-0.58	-0.54	6.71	10.81	6.29	11.14	-0.01	0.03	0.87	0	
50671	0.0040	0.0040	DH	1.33	1.37	642,112	619,672	22,440	3.5%	8 inch	11.34	166.95	161.48	173.00	173.00	11.15	11.52	0.09	0.08	1.33	-0.58	-0.58	11.15	11.62	11.73	12.11	0.00	0.03	0.87	0	
36473	0.0032	0.0032	IH	1.19	1.08	575,501	555,699	19,806	3.4%	8 inch	9.01	170.13	169.15	179.50	177.80	9.37	8.65	0.08	0.09	1.19	-0.58	-0.58	9.37	8.65	9.96	9.23	0.00	0.03	0.87	0	
36556	0.0052	0.0052	IH	1.14	1.28	564,557	548,388	16,171	3.2%	8 inch	7.35	164.48	163.22	173.00	173.00	8.52	9.78	0.13	0.15	1.74	-0.87	-0.85	8.52	9.78	9.39	10.83	-0.01	0.05	1.00	0	
P-698	0.0040	0.0040	IH	1.69	1.38	1,893,159	1,828,070	65,090	3.4%	12 inch	9.15	184.48	162.02	158.72	158.05	9.47	9.73	0.08	0.08	1.20	-0.58	-0.58	4.47	9.73	5.08	10.32	0.00	0.03	0.87	0	
P-578	0.0039	0.0037	IH	1.30	1.35	632,277	610,981	21,296	3.4%	8 inch	7.10	154.47	162.02	158.64	162.35	4.47	10.59	0.08	0.15	1.51	-0.68	-0.62	9.83	10.59	10.51	11.11	-0.02	0.04	0.87	0	
36028	0.0053	0.0051	DH	1.40	0.68	737,575	713,071	24,505	3.3%	8 inch	10.28	148.79	147.48	158.72	158.05	9.93	8.00	0.08	0.13	1.31	-0.58	-0.54	6.60	7.52	7.18	8.06	-0.02	0.03	0.87	0	
P-819	0.0040	0.0039	IH	1.31	0.97	642,112	621,156	20,956	3.3%	8 inch	7.08	174.40	178.48	184.00	184.00	6.80	7.52	0.08	0.08	1.31	-0.58	-0.54	6.60	7.52	7.18	8.06	-0.02	0.03	0.87	0	
P-600	0.0040	0.0037	IH	1.30	0.99	642,112	621,407	20,704	3.2%	8 inch	9.08	177.42	173.72	184.00	184.00	10.28	9.00	0.08	0.14	1.30	-0.58	-0.57	10.28	9.03	10.87	8.78	-0.34	0.03	0.87	0	
P-507	0.0031	0.0030	IH	1.14	0.85	564,557	548,388	16,171	3.2%	8 inch	5.32	166.77	173.00	177.82	177.82	10.33	12.58	0.15	0.29	4.26	-0.52	-0.52	10.33	12.88	10.85	13.28	-0.34	0.05	0.87	0	
36458	0.0438	0.0412	DH	1.82	0.71	2,119,247	2,052,420	66,827	3.1%	8 inch	11.81	153.67	173.20	178.84	178.88	5.17	5.48	0.08	0.10	1.14	-0.58	-0.57	5.17	5.48	5.78	6.03	-0.01	0.03	0.87	0	
50675	0.0028	0.0028	DH	1.24	1.11	998,246	938,224	30,022	3.1%	10 inch	10.52	152.01	150.21	168.40	168.40	15.38	14.68	0.10	0.11	1.24	-0.73	-0.72	15.38	14.68	16.09	15.40	0.00	0.04	0.83	0	
P-693	0.0120	0.0118	IH	1.52	2.22	1,110,150	1,075,788	34,368	3.1%	8 inch	7.88	169.59	168.49	176.73	177.10	7.14	6.81	0.10	0.08	2.22	-0.58	-0.58	7.14	6.81	7.71	9.20	0.03	0.04	0.87	0	
36472	0.0040	0.0040	IH	0.99	0.85	493,532	478,765	15,187	3.1%	8 inch	7.14	171.31	169.87	177.85	177.85	4.44	7.73	0.08	0.09	0.99	-0.58	-0.58	6.54	7.73	7.13	8.31	0.00	0.03	0.87	0	
50509	0.0038	0.0038	IH	1.17	0.83	587,857	570,048	17,810	3.0%	8 inch	8.09	162.39	161.23	165.80	170.00	6.41	8.77	0.08	0.10	1.17	-0.59	-0.57	3.41	8.77	4.00	9.34	-0.01	0.03	0.87	0	
P-604	0.0048	0.0048	IH	1.35	1.18	695,726	676,277	21,374	3.0%	8 inch	7.84	173.02	172.04	180.89	178.84	3.87	7.90	0.08	0.10	1.41	-0.58	-0.57	7.87	7.80	8.48	8.37	-0.01	0.03	0.87	0	
50850	0.0036	0.0036	IH	1.12	1.29	811,479	833,188	18,313	3.0%	8 inch	10.98	165.91	164.39	174.73	174.73	8.58	12.63	0.08	0.10	1.12	-0.58	-0.58	8.58	12.63	8.37	13.12	0.00	0.03	0.87	0	
50544	0.0001	0.0003	DH	0.38	1.18	823,375	604,878	18,498	3.0%	15 inch	9.75	151.72	151.67	161.40	161.50	0.88	8.83	0.14	0.08	0.35	-1.11	-1.10	9.88	8.83	10.79	11.02	0.00	0.03	0.87	0	
36618	0.0038	0.0039	IH	0.95	1.21	483,678	469,463	14,213	2.9%	8 inch	7.23	161.78	161.22	168.61	168.64	7.42	6.08	0.07	0.09	0.95	-0.59	-0.59	7.03	7.42	7.82	8.02	0.01	0.03	0.87	0	
P-596	0.0034	0.0034	IH	1.18	1.27	589,580	572,382	17,181	2.9%	8 inch	6.73	175.06	174.77	182.54	180.74	7.48	5.97	0.08	0.07	1.18	-0.59	-0.59	7.48	5.97	6.07	6.57	0.01	0.03	0.87	0	
36051	0.0049	0.0049	IH	1.31	1.06	660,030	645,630	19,209	2.9%	8 inch	6.84	168.70	155.49	162.64	163.42	5.04	7.93	0.08	0.06	1.31	-0.89	-0.88	6.94	7.93	6.53	6.51	0.00	0.03	0.87	0	
50872	0.0040	0.0040	DH	1.08	1.20	642,112	623,590	18,519	2.9%	8 inch	10.49	162.33	161.87	172.00	172.00	9.67	11.19	0.08	0.08	1.26	-0.59	-0.59	9.67	11.19	9.23	11.72	0.00	0.03	0.87	0	
36804	0.0124	0.0122	DH	1.96	2.91	3,339,826	3,244,517	85,309	2.9%	12 inch	12.98	142.87	140.84	154.40	154.83	11.93	13.90	0.18	0.12	2.81	-0.84	-0.85	11.93	13.90	12.77	13.06	0.00	0.04	0.83	0	
36450	0.0034	0.0034	DH	1.34	1.14	1,071,492	1,041,042	30,449	2.8%	10 inch	10.04	164.39	163.36	174.44	174.44	10.03	10.10	0.11	0.11	1.34	-0.74	-0.73	10.03	10.78	10.78	10.78	0.00	0.04	0.83	0	
P-558	0.0048	0.0046	IH	1.31	1.33	687,339	668,171	19,168	2.8%	8 inch	4.81	153.26	152.93	157.70	157.71	4.44	4.78	0.08	0.08	1.33	-0.80	-0.80	4.44	4.78	5.03	5.37	0.00	0.03	0.87	0	
36512	0.0041	0.0041	IH	0.97	1.21	501,340	487,388	13,942	2.8%	8 inch	7.58	161.97	161.22	166.54	166.54	7.43	7.42	0.08	0.07	0.97	-0.69	-0.69	7.73	7.42	8.32	8.02	0.01	0.03	0.87	0	
P-647	0.0058	0.0056	IH	1.34	1.20	727,242	716,189	21,053	2.8%	8 inch	8.78	149.63	148.79	157.26	157.26	7.63	9.93	0.08	0.09	1.47	-0.59	-0.59	7.63	9.93	9.22	10.51	0.00	0.04	0.87	0	
50439	0.0044	0.0044	IH	1.28	1.12	673,185	655,429	17,756	2.6%	8 inch	7.29	174.04	173.02	180.74	180.74	6.70	7.87	0.07	0.08	1.28	-0.58	-0.58	6.70	7.87	7.30	8.45	0.00	0.04	0.87	0	
50525	0.0057	0.0052	IH	1.32	0.25	783,202	743,386	19,816	2.6%	8 inch	9.48	170.48	168.57	179.80	178.20	3.22	9.63	0.08	0.08	0.28	-1.45	-0.59	-0.41	9.63	9.63	9.21	10.04	-0.05	0.03	0.87	0
36583	0.0280	0.0268	IH	1.38	1.16	788,581	788,420	20,141	2.6%	8 inch	7.28	167.20	158.75	173.00	167.00	6.80	8.25	0.09	0.04	0.85	-0.41	-0.04	6.30	8.25	6.61	7.13	0.25	-0.12	0.03	0.50	0
50551	0.0041	0.0039	IH	1.22	0.55	647,417	630,921	16,496	2.5%	8 inch	8.03	158.78	155.78	163.40	165.19	8.34	9.41	0.07	0.13	1.22	-0.69	-0.69	6.								

Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (ft/s)	Velocity Out (ft/s)	Capacity (gpd)	Excess Full Capacity (gpd)	Total Flow (gpd)	% Capacity	Section Size	Avg Pipe Cover (ft)	Upstream		Upstream		Downstream Cover (ft)	Depth In (ft)	Depth Out (ft)	Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	n	Dia (ft)	Test		
												Downstream Crown Elev (ft)																			
S0660	0.0038	0.0018	IH	0.82	1.06	483,125	474,487	8,658	1.8%	8 inch	3.45	184.78	163.09	170.16	168.58	5.40	5.50	0.06	0.05	0.82	-0.60	-0.61	5.40	5.30	0.01	8.12	0.00	0.00	0.87	0	
P-616	0.0040	0.0040	IH	1.09	1.14	642,112	630,715	11,397	1.8%	8 inch	4.09	178.70	176.11	182.00	183.00	3.30	3.30	0.06	0.06	1.09	-0.60	-0.61	3.30	4.89	3.90	5.49	0.00	0.00	0.87	0	
P-498	0.0043	0.0043	IH	1.12	1.15	662,027	650,279	11,748	1.8%	8 inch	4.27	151.09	150.01	155.30	154.34	4.21	4.33	0.06	0.06	1.12	-0.60	-0.61	4.21	4.53	4.02	4.94	0.00	0.00	0.87	0	
S0608	0.0061	0.0061	IH	1.21	0.93	797,734	783,665	14,069	1.8%	8 inch	7.94	153.70	152.99	161.19	161.37	7.49	8.38	0.07	0.06	1.05	-0.60	-0.59	7.49	8.38	1.09	8.38	0.00	-0.03	0.87	0	
S0501	0.0040	0.0038	IH	0.83	0.57	493,423	484,764	8,659	1.8%	8 inch	3.53	163.36	162.39	167.00	165.80	3.64	3.41	0.06	0.06	0.83	-0.61	-0.59	3.64	3.41	4.26	4.00	-0.01	0.03	0.87	0	
P-911	0.0040	0.0040	IH	1.09	0.70	583,858	572,152	11,745	1.7%	8 inch	8.85	171.70	170.13	179.70	179.50	8.00	9.37	0.06	0.06	1.09	-0.61	-0.60	8.00	9.37	8.01	9.96	-0.01	0.03	0.87	0	
S0444	0.0045	0.0045	IH	1.15	1.15	645,467	634,206	11,261	1.7%	8 inch	7.39	174.71	173.36	178.85	184.00	4.14	3.41	0.06	0.06	1.09	-0.61	-0.61	4.14	10.84	4.75	11.25	0.00	0.03	0.87	0	
S6324	0.0177	0.0164	IH	1.17	0.09	628,733	618,114	10,619	1.7%	8 inch	8.89	171.70	170.13	179.70	179.50	8.00	9.37	0.06	0.06	1.15	-0.61	-0.58	8.00	9.37	8.01	9.96	-0.01	0.03	0.87	0	
S6544	0.0025	0.0025	IH	0.85	0.71	511,303	502,658	8,645	1.7%	8 inch	5.94	160.52	159.15	178.83	177.80	5.99	7.40	0.06	0.06	0.85	-0.61	-0.60	5.99	7.40	9.42	7.44	-0.13	0.03	0.50	0	
S6552	0.0100	0.0095	IH	1.25	0.19	1,015,266	998,630	16,636	1.6%	8 inch	8.87	170.57	167.30	178.10	178.20	8.53	8.81	0.07	0.07	1.00	-0.61	-0.60	7.21	4.68	7.92	5.26	-0.01	0.03	0.87	0	
P-606	0.0061	0.0061	IH	1.18	0.81	791,061	779,104	12,877	1.6%	8 inch	5.63	175.10	173.07	181.18	176.20	6.06	5.17	0.06	0.06	1.31	-0.60	-0.58	6.06	5.17	6.69	5.78	-0.01	0.03	0.87	0	
S0819	0.0041	0.0041	IH	1.08	0.83	653,096	642,511	10,585	1.6%	8 inch	7.36	166.69	166.21	174.26	173.38	7.97	7.15	0.06	0.07	1.08	-0.61	-0.60	7.57	7.15	8.18	7.75	-0.01	0.03	0.87	0	
P-557	0.0048	0.0048	IH	1.13	1.13	685,171	674,118	11,053	1.6%	8 inch	4.13	153.82	153.28	157.74	157.70	3.92	4.34	0.06	0.06	1.13	-0.61	-0.61	3.92	4.34	5.39	4.55	0.00	0.03	0.87	0	
S6465	0.0052	0.0052	IH	1.15	0.98	734,799	722,947	11,852	1.6%	8 inch	9.28	169.47	168.81	176.10	176.73	6.63	9.82	0.06	0.07	1.21	-0.61	-0.60	8.83	9.92	9.24	10.52	-0.01	0.03	0.87	0	
P-587	0.0031	0.0031	IH	0.92	1.08	583,600	554,837	9,863	1.6%	8 inch	8.23	177.88	176.37	184.01	184.10	8.13	7.73	0.06	0.05	0.92	-0.61	-0.61	8.13	7.73	8.74	8.35	0.00	0.03	0.87	0	
S0583	0.0031	0.0031	IH	0.93	0.53	567,801	558,850	8,952	1.6%	8 inch	4.73	176.78	175.34	180.00	178.73	6.84	5.81	0.06	0.05	0.93	-0.61	-0.60	5.81	4.45	5.19	-0.01	0.03	0.87	0		
P-640	0.0010	0.0011	IH	0.53	0.93	327,057	321,969	5,088	1.6%	8 inch	7.72	179.34	179.23	187.00	187.30	7.66	7.77	0.06	0.04	0.53	-0.61	-0.63	7.66	7.77	8.27	8.40	0.02	0.03	0.87	0	
S6840	0.0036	0.0034	DH	1.14	0.40	1,100,941	1,084,157	16,783	1.5%	10 inch	10.82	148.55	147.82	156.78	156.00	11.21	10.88	0.07	0.15	1.14	-0.76	-0.69	11.21	10.88	11.47	11.19	-0.01	0.03	0.87	0	
S6536	0.0040	0.0005	IH	0.79	0.06	299,154	293,833	4,521	1.5%	8 inch	12.37	185.25	186.00	182.00	175.00	15.75	9.00	0.05	0.28	0.80	-0.45	-0.22	15.75	9.00	18.20	9.22	-0.37	0.03	0.50	0	
P-650	0.0059	0.0059	IH	1.15	1.28	778,991	768,275	11,716	1.5%	8 inch	7.25	175.24	173.07	183.00	180.41	7.78	6.74	0.06	0.06	1.28	-0.61	-0.61	7.78	8.74	8.37	7.35	0.00	0.03	0.87	0	
S0457	0.0012	0.0007	IH	0.58	0.28	345,706	340,517	5,189	1.5%	8 inch	9.28	169.47	168.81	176.10	176.73	6.63	9.82	0.06	0.05	0.58	-0.61	-0.58	9.80	8.55	10.21	9.23	-0.05	0.03	0.87	0	
S0684	0.0045	0.0044	IH	1.09	0.47	681,063	670,991	10,071	1.5%	8 inch	7.40	150.59	148.79	167.77	155.41	7.18	7.82	0.06	0.05	1.09	-0.61	-0.60	7.18	7.82	7.79	8.19	-0.01	0.03	0.87	0	
P-642	0.0040	0.0040	IH	1.03	1.09	642,112	632,621	9,491	1.5%	8 inch	7.90	177.70	177.47	186.00	185.10	8.27	7.53	0.06	0.05	1.03	-0.61	-0.61	8.27	7.53	8.88	8.15	-0.03	0.03	0.87	0	
S0415	0.0040	0.0038	DH	0.79	0.09	493,931	488,722	7,210	1.5%	8 inch	16.97	167.65	165.91	186.00	183.35	15.59	10.88	0.06	0.25	0.79	-0.61	-0.42	16.35	15.59	18.98	18.01	-0.04	0.03	0.87	0	
S6569	0.0009	0.0009	DH	0.07	0.07	2,860,755	2,822,242	38,513	1.4%	18 inch	9.99	149.56	148.52	159.40	159.87	18.54	10.16	0.08	0.20	0.84	-0.84	-0.80	9.84	10.16	10.68	10.95	-0.09	0.08	1.50	0	
P-884	0.0040	0.0040	IH	1.34	1.08	1,063,659	1,045,827	22,233	1.4%	12 inch	5.96	161.26	159.78	165.00	166.06	3.74	3.22	0.06	0.09	1.34	-0.62	-0.61	3.74	8.22	4.86	9.13	0.00	0.06	1.00	0	
S0681	0.0044	0.0044	IH	1.07	0.83	671,920	662,267	9,653	1.4%	8 inch	7.35	155.78	154.33	163.82	163.80	7.21	7.49	0.06	0.22	1.01	-0.61	-0.44	12.92	8.31	13.53	8.75	-0.05	0.03	0.87	0	
P-517	0.0039	0.0035	IH	1.01	1.13	637,584	628,887	9,107	1.4%	8 inch	10.52	160.88	160.88	183.00	177.00	12.92	8.31	0.06	0.22	1.01	-0.61	-0.61	8.31	8.31	8.09	7.90	0.00	0.06	1.00	0	
S0815	0.0084	0.0084	IH	1.12	1.14	716,992	708,764	10,228	1.4%	8 inch	7.03	163.74	161.97	170.95	168.81	7.21	6.84	0.06	0.06	1.14	-0.61	-0.61	7.21	6.84	7.82	6.45	-0.03	0.03	0.87	0	
S0395	0.0052	0.0051	IH	1.11	0.85	730,014	710,630	10,384	1.4%	8 inch	8.78	155.41	154.85	165.03	162.54	7.89	6.06	0.06	0.17	1.16	-0.61	-0.60	6.06	9.02	8.99	10.23	8.49	-0.01	0.03	0.87	0
S0413	0.0038	0.0035	IH	0.80	0.19	284,797	280,758	4,041	1.4%	8 inch	7.89	173.72	173.06	180.90	181.60	7.24	6.54	0.04	0.11	0.80	-0.48	-0.39	7.24	6.54	7.70	6.83	-0.05	0.03	0.60	0	
S6628	0.0065	0.0064	IH	1.14	1.14	681,227	671,550	9,677	1.4%	8 inch	4.99	157.66	157.19	162.56	162.32	4.94	5.13	0.06	0.07	1.29	-0.61	-0.59	4.94	5.13	5.45	5.73	-0.02	0.03	0.60	0	
S6239	0.0040	0.0039	DH	0.78	0.31	494,334	487,356	6,978	1.4%	8 inch	12.38	159.78	159.78	183.00	184.05	15.24	9.52	0.06	0.05	0.78	-0.61	-0.56	15.24	9.52	15.65	10.09	-0.02	0.03	0.87	0	
S0570	0.0039	0.0038	IH	1.00	0.62	630,487	621,599	8,888	1.4%	8 inch	7.32	169.77	168.58	177.89	175.80	7.63	7.01	0.06	0.08	1.00	-0.61	-0.59	7.63	7.01	8.24	8.54	-0.01	0.03	0.87	0	
S6117	0.0040	0.0039	IH	1.01	0.42	642,112	633,109	9,002	1.4%	8 inch	5.86	162.45	161.23	165.00	170.00	6.55	6.77	0.06	0.10	1.01	-0.61	-0.57	6.55	6.77	7.23	7.18	0.04	-0.01	0.03	0.87	0
S0589	0.0072	0.0072	IH	0.99	0.88	399,982	394,357	5,625	1.4%	8 inch	8.08	163.43	160.45	170.89	168.80	7.37	8.35	0.05	0.06	1.12	-0.45	-0.44	7.37	8.35	7.82	8.78	0.00	0.03	0.60	0	
S0568	0.0041	0.0041	IH	0.98	0.88	65																									

Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (ft/s)	Velocity Out (ft/s)	Capacity (gpd)	Excess Full Capacity (gpd)	Total Flow (gpd)	% Capacity	Section Size	Avg Pipe Size (ft)	Upstream		Downstream		Upstream Cover (ft)	Downstream Cover (ft)	Depth In (ft)	Depth Out (ft)	Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	a	Dia (ft)	Test
												Down Elev (ft)	Up Elev (ft)	Down Elev (ft)	Up Elev (ft)															
P-555	0.0045	0.0045	HH	0.73	0.93	523,755	518,039	4,916	0.9%	8 In	4.92	152.81	151.87	156.25	150.27	3.44	6.40	0.05	0.04	0.73	-0.62	-0.83	3.44	6.40	4.06	7.03	0.00	0.03	0.67	0
50548	0.0055	0.0055	HH	0.87	0.47	390,806	347,325	3,281	0.9%	8 In	5.11	169.94	168.43	175.40	175.20	4.48	6.77	0.03	0.05	0.87	-0.47	-0.45	5.46	6.77	5.93	7.22	-0.01	0.03	0.50	0
P-592	0.0047	0.0047	HH	0.97	1.00	696,945	690,435	6,510	0.9%	8 In	5.08	178.02	176.30	182.60	181.33	5.46	5.53	0.05	0.04	0.97	-0.82	-0.82	4.58	5.53	5.20	6.00	0.00	0.03	0.67	0
50498	0.0040	0.0041	HH	0.89	0.30	498,379	491,768	4,622	0.9%	8 In	6.32	163.99	163.38	173.00	167.30	9.01	3.82	0.05	0.04	0.89	-0.82	-0.82	3.03	3.82	9.83	6.25	0.00	0.03	0.67	0
50617	0.0040	0.0040	DH	0.89	0.97	840,947	834,988	5,961	0.9%	8 In	16.51	149.54	148.44	167.00	164.30	17.46	15.56	0.05	0.04	0.92	-0.82	-0.82	6.22	9.89	8.84	7.81	0.00	0.03	0.67	0
36814	0.0072	0.0072	HH	0.92	0.97	661,009	654,877	6,132	0.9%	8 In	6.06	166.42	163.97	172.54	170.35	6.22	6.28	0.05	0.04	0.92	-0.82	-0.82	17.46	15.56	18.08	16.19	0.00	0.03	0.67	0
36594	0.0148	0.0140	HH	1.14	0.10	1,236,698	1,225,279	11,419	0.9%	8 In	7.50	163.99	169.42	170.40	168.70	6.41	8.58	0.06	0.33	1.72	-0.81	-0.34	6.41	8.58	7.02	8.92	-0.08	0.03	0.67	0
50537	0.0039	0.0040	HH	0.88	0.73	490,441	485,976	4,466	0.9%	8 In	7.78	161.88	161.58	170.00	169.00	6.14	7.42	0.05	0.04	0.88	-0.82	-0.82	8.14	7.42	8.77	8.05	0.00	0.03	0.67	0
50487	0.0033	0.0031	HH	0.81	0.25	592,744	577,467	5,277	0.9%	8 In	8.05	175.23	174.38	180.90	180.30	6.87	6.42	0.04	0.10	0.81	-0.82	-0.57	5.87	6.42	8.30	8.99	-0.02	0.03	0.67	0
36468	0.0040	0.0040	HH	0.88	0.98	842,106	838,313	3,793	0.9%	8 In	5.10	173.54	173.00	179.58	177.85	5.84	4.85	0.04	0.04	0.89	-0.82	-0.82	5.34	4.85	5.97	5.48	0.00	0.03	0.67	0
50678	0.0041	0.0041	HH	0.86	0.86	968,857	961,128	8,729	0.9%	8 In	5.74	172.12	172.00	182.60	182.30	6.64	4.84	0.05	0.06	0.86	-0.81	-0.81	6.54	4.84	7.26	5.45	0.00	0.03	0.67	0
36441	0.0033	0.0033	HH	0.84	0.47	1,064,792	1,055,239	9,553	0.9%	10 In	5.11	165.90	165.01	172.44	174.70	6.54	6.58	0.06	0.06	0.84	-0.82	-0.82	3.06	4.21	6.12	4.82	-0.01	0.03	0.67	0
50661	0.0031	0.0039	HH	0.60	0.87	438,047	434,140	3,907	0.9%	8 In	7.58	165.14	164.86	175.00	170.18	9.88	5.30	0.04	0.03	0.60	-0.82	-0.83	9.86	5.30	10.48	9.94	0.01	0.03	0.67	0
P-461	0.0040	0.0040	DH	0.88	0.96	890,757	872,947	7,810	0.9%	8 In	8.02	178.21	177.75	187.00	186.00	7.00	8.25	0.05	0.04	0.88	-0.82	-0.82	7.79	8.25	8.41	8.88	0.00	0.03	0.67	0
P-497	0.0039	0.0039	HH	0.87	0.53	637,134	631,552	5,582	0.9%	8 In	4.35	182.11	181.08	189.60	185.20	4.49	14.29	0.04	0.04	0.88	-0.82	-0.83	15.56	14.29	10.19	14.92	0.00	0.03	0.67	0
50894	0.0049	0.0049	HH	0.97	0.79	711,179	705,016	6,163	0.9%	8 In	8.91	157.54	156.75	163.90	164.21	6.36	7.48	0.04	0.05	0.97	-0.82	-0.82	6.38	7.48	8.99	8.08	0.00	0.03	0.67	0
36585	0.0101	0.0100	HH	1.08	0.35	1,020,282	1,011,460	8,802	0.9%	8 In	6.98	165.84	165.54	172.00	168.10	6.30	7.58	0.05	0.11	1.09	-0.81	-0.55	3.98	7.58	8.99	8.12	-0.01	0.03	0.67	0
P-637	0.0053	0.0053	HH	1.00	1.00	805,844	798,987	6,857	0.9%	8 In	2.98	185.01	183.07	188.00	188.00	0.99	9.90	0.05	0.04	1.00	-0.82	-0.82	0.99	4.93	1.81	5.55	0.00	0.03	0.67	0
36452	0.0040	0.0040	HH	0.87	0.88	493,932	489,733	4,199	0.9%	8 In	8.23	186.92	186.24	177.52	178.29	8.90	8.05	0.04	0.04	0.87	-0.82	-0.83	8.60	8.05	9.23	8.68	0.00	0.03	0.67	0
50529	0.0061	0.0060	HH	0.85	0.38	368,972	363,855	3,117	0.8%	8 In	7.74	172.50	172.50	181.00	181.00	6.47	8.17	0.04	0.03	0.88	-0.47	-0.44	8.47	8.00	8.94	9.44	-0.01	0.03	0.50	0
P-602	0.0040	0.0039	DH	0.87	0.51	842,112	836,880	5,431	0.3%	8 In	10.08	175.14	174.74	185.00	185.00	9.88	10.26	0.04	0.02	0.88	-0.82	-0.58	8.02	9.85	10.48	10.87	-0.02	0.03	0.67	0
36444	0.0047	0.0044	HH	0.94	0.33	697,178	691,318	5,858	0.8%	8 In	8.94	165.43	164.85	173.45	174.15	6.02	8.05	0.04	0.09	0.94	-0.82	-0.58	8.02	9.85	10.48	10.87	-0.02	0.03	0.67	0
P-574	0.0080	0.0080	HH	1.00	1.06	788,423	778,876	8,247	0.5%	8 In	3.98	155.13	154.80	160.89	160.01	5.58	5.21	0.04	0.04	1.06	-0.82	-0.82	5.58	5.21	6.19	5.84	0.00	0.03	0.67	0
P-564	0.0043	0.0040	HH	0.89	0.88	509,688	505,454	4,233	0.9%	8 In	5.82	151.27	150.58	158.40	156.69	5.13	6.11	0.04	0.04	0.89	-0.82	-0.83	5.13	6.11	5.78	6.74	0.00	0.03	0.67	0
50507	0.0027	0.0030	HH	0.88	0.08	1,545,832	1,532,791	12,831	0.9%	12 In	3.07	157.45	157.41	161.00	160.00	3.55	2.58	0.06	0.04	0.92	-0.84	-0.80	3.65	2.58	4.19	3.19	-0.27	0.05	1.00	0
50597	0.0059	0.0059	HH	0.94	0.41	363,515	360,503	3,012	0.8%	8 In	5.98	156.12	156.00	173.00	173.00	6.63	6.92	0.03	0.05	0.92	-0.47	-0.45	5.50	6.42	5.97	8.87	-0.01	0.03	0.50	0
P-594	0.0049	0.0049	HH	0.86	0.96	711,464	705,577	5,887	0.8%	8 In	5.93	177.07	175.77	182.60	183.00	4.63	6.29	0.04	0.05	0.96	-0.82	-0.82	4.63	7.23	5.28	7.86	0.00	0.03	0.67	0
36651	0.0050	0.0050	HH	0.98	0.68	718,114	710,196	5,919	0.8%	8 In	7.85	157.56	156.58	165.52	163.89	7.96	9.87	0.04	0.05	0.96	-0.82	-0.81	7.96	9.87	8.59	7.35	-0.02	0.03	0.67	0
P-501	0.0055	0.0051	HH	0.78	0.13	581,248	578,447	4,801	0.8%	8 In	8.87	147.37	146.24	155.27	156.20	6.30	9.83	0.04	0.15	0.78	-0.82	-0.52	7.90	9.83	8.59	10.35	-0.05	0.03	0.67	0
36575	0.0055	0.0053	HH	0.97	0.20	761,310	745,144	6,165	0.8%	8 In	8.38	157.85	155.76	165.20	165.19	7.35	9.41	0.04	0.13	1.01	-0.82	-0.54	7.35	9.41	7.99	9.95	-0.02	0.03	0.67	0
50661	0.0047	0.0047	HH	0.77	0.22	323,283	320,655	2,628	0.9%	8 In	8.58	171.28	170.41	177.75	177.10	6.47	6.89	0.03	0.03	0.77	-0.47	-0.47	6.47	6.89	6.94	7.16	0.00	0.03	0.50	0
50558	0.0040	0.0040	HH	0.86	0.29	643,405	638,294	5,221	0.8%	8 In	5.45	159.19	158.76	162.44	163.43	4.25	6.84	0.04	0.07	0.86	-0.82	-0.59	4.25	6.84	4.88	7.24	-0.01	0.03	0.67	0
50435	0.0045	0.0045	HH	0.91	0.62	862,571	857,033	5,538	0.8%	8 In	7.71	170.21	169.08	178.25	178.25	8.14	7.27	0.04	0.06	0.91	-0.82	-0.81	8.14	7.27	6.77	7.88	-0.01	0.03	0.67	0
50549	0.0083	0.0079	HH	0.88	0.17	428,765	426,311	3,454	0.8%	8 In	6.08	173.19	172.31	178.90	179.29	5.28	6.89	0.04	0.11	0.92	-0.48	-0.48	5.28	6.89	5.72	7.28	-0.05	0.03	0.50	0
36560	0.0180	0.0173	HH	0.96	0.06	633,179	628,131	5,047	0.6%	8 In	6.83	165.80	165.25	172.10	169.00	6.60	8.75	0.04	0.33	1.50	-0.48	-0.17	8.50	8.75	8.96	8.92	-0.08	0.03	0.67	0
50448	0.0044	0.0043	HH	0.90	0.26	875,850	870,486	5,363	0.5%	8 In	7.82	173.17	172.04	178.90	179.84	5.63	7.80	0.04	0.30	1.50	-0.62	-0.57	5.63	7.80	6.26	8.37	-0.02	0.03	0.67	0
50642	0.0040	0.0040	HH	0.85	0.84	493,614	489,743	3,871	0.8%	8 In	14.95	161.33	159.78	178.00	175.00	14.87	15.22	0.04	0.04	0.85	-0.82	-0.83	14.87	15.22	16.30	16.85	0.00	0.03	0.67	0
36521	0.0040	0.0040	HH	0.84	0.27	642,112	637,177	4,935	0.8%	8 In	2.82	162.99	162.47	165.00	165.00	2.01	2.53	0.03	0.04	0.84	-0.83	-0.83	2.01	2.53	2.63	3.18	0.00	0.03	0.67	0
P-580	0.0040	0.0040	HH	0.65	0.58	494,639	490,859	3,780	0.8%	8 In	4.52	154.49	154.49	169.00	169.00	5.51	6.34	0.04	0.05	0.65	-0.83	-0.82	5.51	3.13	6.14	3.78	0.00	0.03	0.50	0
50930	0.0115	0.0115	HH	0.90	0.53	605,923	602,066	3,857	0.8%	8 In	5.61	171.26	167.92	176.80	173.80	6.34	6.88	0.04	0.05	1.18	-0.46	-0.45	3.4	5.88	5.80	6.23	-0.01	0.03	0.50	0
50465	0.0177	0.0178	HH	1.12	0.51	1,349,034	1,338,																							

Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (ft/s)	Velocity Out (ft/s)	Capacity (gpd)	Excess Full Capacity (gpd)	Total Flow (gpd)	% Capacity	Section Size	Upstream		Downstream		Upstream Cover (ft)	Downstream Cover (ft)	Depth In (ft)	Depth Out (ft)	Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	a	Dia (ft)	Test		
											Crown Elev (ft)	Downstream Crown Elev (ft)	Upstream Crown Elev (ft)	Downstream Crown Elev (ft)																	
50622	0.0050	0.0050	IH	0.83	0.83	717,303	717,303	3,997	0.5%	8 inch	8.75	168.44	168.62	175.92	172.84	7.48	6.02	0.04	0.04	0.85	-0.83	-0.83	7.48	6.02	8.11	6.66	0.00	0.03	0.87	0	
50614	0.0144	0.0144	IH	1.00	0.25	1,218,038	1,211,357	6,881	0.5%	8 inch	8.44	183.59	180.15	180.00	176.01	5.41	5.89	0.05	0.12	0.84	-0.82	-0.55	5.41	5.89	6.03	6.41	-0.03	0.03	0.67	0	
50426	0.0035	0.0035	IH	0.83	0.59	1,094,443	1,085,443	6,001	0.5%	10 inch	7.85	166.86	165.90	175.82	172.40	6.18	6.54	0.04	0.06	0.85	-0.79	-0.78	6.18	6.54	9.95	7.31	-0.14	0.04	0.83	0	
26116	0.0268	0.0268	IH	1.06	0.06	1,655,484	1,648,431	9,053	0.5%	8 inch	11.01	170.31	161.27	176.80	175.00	4.49	13.73	0.05	0.44	1.96	-0.61	-0.23	4.49	13.73	7.11	13.96	-0.11	0.04	0.67	0	
50576	0.0148	0.0148	IH	0.84	0.32	989,822	964,542	3,080	0.5%	8 inch	10.07	181.85	158.00	170.90	168.20	9.25	10.00	0.03	0.06	1.23	-0.47	-0.44	9.26	10.90	9.72	11.34	-0.01	0.03	0.50	0	
50590	0.0127	0.0124	IH	0.83	0.18	531,165	528,322	2,833	0.5%	8 inch	8.54	177.30	176.18	182.80	182.75	5.50	5.57	0.03	0.09	1.14	-0.47	-0.41	5.50	5.57	5.97	7.98	-0.03	0.03	0.60	0	
50625	0.0044	0.0044	IH	0.79	0.85	871,717	868,146	3,572	0.5%	8 inch	8.47	166.37	165.21	173.27	171.24	6.90	8.03	0.03	0.03	0.70	-0.63	-0.63	6.90	8.03	7.54	6.67	0.00	0.03	0.67	0	
F-500	0.0041	0.0041	IH	0.78	0.85	852,639	848,197	3,442	0.5%	8 inch	3.88	151.79	151.29	165.50	165.30	3.71	4.01	0.03	0.03	0.94	-0.63	-0.63	3.71	4.01	4.35	4.85	0.00	0.03	0.67	0	
50595	0.0040	0.0040	IH	0.77	0.52	842,560	839,188	3,372	0.5%	8 inch	6.48	152.51	151.08	157.00	157.35	4.49	6.47	0.03	0.04	0.77	-0.63	-0.63	4.49	6.47	5.13	7.10	0.00	0.03	0.67	0	
F-571	0.0076	0.0076	IH	0.91	1.09	885,090	880,458	4,634	0.5%	8 inch	3.35	189.34	188.01	171.17	172.96	1.83	4.87	0.04	0.03	1.06	-0.63	-0.63	1.83	4.87	2.46	5.51	0.00	0.03	0.67	0	
50572	0.0048	0.0047	IH	0.83	0.40	702,877	699,290	3,587	0.5%	8 inch	3.05	196.77	188.10	174.87	172.00	6.10	3.90	0.03	0.03	0.77	-0.63	-0.63	6.10	3.90	0.74	4.54	0.00	0.03	0.67	0	
50587	0.0067	0.0068	IH	0.76	0.38	304,914	282,904	2,009	0.5%	8 inch	6.06	185.95	185.33	172.20	171.20	6.25	5.87	0.03	0.04	0.82	-0.47	-0.48	6.25	5.87	6.72	6.33	-0.02	0.03	0.50	0	
P-614	0.0060	0.0060	IH	0.89	0.94	786,423	782,321	4,102	0.5%	8 inch	3.53	180.87	179.28	185.00	182.00	4.33	2.72	0.04	0.03	0.94	-0.63	-0.63	4.33	2.72	4.96	13.00	-0.11	0.03	0.50	0	
50592	0.0210	0.0200	IH	0.89	0.04	882,983	878,406	3,557	0.5%	8 inch	1.95	167.50	162.19	173.00	175.00	5.50	12.81	0.04	0.31	1.44	-0.48	-0.19	5.50	12.81	5.96	6.20	0.00	0.03	0.67	0	
P-555	0.0041	0.0041	IH	0.78	0.82	848,531	845,313	3,317	0.5%	8 inch	2.42	154.97	154.57	157.14	167.23	2.17	2.06	0.03	0.03	0.78	-0.63	-0.63	2.17	2.06	2.81	3.30	0.00	0.03	0.67	0	
P-579	0.0032	0.0032	IH	0.79	0.91	1,046,757	1,041,412	5,345	0.5%	10 inch	3.15	155.91	155.37	159.53	158.05	3.02	2.68	0.04	0.04	0.79	-0.79	-0.79	3.02	2.68	4.41	3.47	0.00	0.04	0.83	0	
50542	0.0208	0.0193	IH	0.88	0.03	875,809	872,383	3,426	0.5%	8 inch	7.08	170.58	169.77	177.10	177.40	6.52	7.63	0.03	0.06	0.83	-0.63	-0.63	8.11	6.52	7.63	7.16	8.24	-0.01	0.03	0.67	0
36046	0.0032	0.0032	DH	0.78	0.38	1,046,812	1,041,644	5,268	0.5%	10 inch	10.84	149.76	148.55	160.22	160.78	10.47	11.21	0.04	0.07	0.78	-0.47	-0.47	11.21	11.28	11.97	-0.01	0.04	0.83	0		
50686	0.0084	0.0083	IH	0.73	0.43	824,636	821,504	3,132	0.5%	8 inch	5.51	183.95	183.08	169.48	168.68	6.51	5.60	0.03	0.05	0.73	-0.63	-0.63	5.51	5.60	6.15	8.12	-0.02	0.03	0.67	0	
F-496	0.0034	0.0034	IH	0.89	0.82	595,544	592,561	2,983	0.5%	8 inch	4.48	152.53	152.21	157.10	159.60	4.57	4.39	0.03	0.03	0.89	-0.63	-0.63	4.57	4.39	5.21	5.03	0.00	0.03	0.67	0	
50403	0.0057	0.0056	IH	0.88	0.44	789,139	785,359	3,780	0.5%	8 inch	9.12	187.37	186.71	177.09	175.23	9.72	8.52	0.03	0.05	0.89	-0.63	-0.63	9.12	8.52	10.38	9.14	-0.02	0.03	0.67	0	
36502	0.0031	0.0030	IH	0.79	0.39	581,288	578,000	2,750	0.5%	8 inch	4.08	158.89	158.84	163.02	162.62	4.13	3.99	0.03	0.05	0.85	-0.63	-0.63	4.13	3.99	4.77	4.60	-0.02	0.03	0.67	0	
50612	0.0045	0.0044	IH	0.89	0.39	883,423	880,092	3,331	0.5%	8 inch	7.56	166.68	166.08	178.00	177.88	9.34	6.78	0.03	0.05	0.89	-0.63	-0.63	6.78	6.78	9.98	6.40	-0.02	0.03	0.67	0	
P-586	0.0051	0.0051	IH	0.83	0.85	724,907	721,379	3,528	0.5%	8 inch	4.51	179.28	178.08	182.47	184.01	3.09	5.93	0.03	0.03	0.79	-0.63	-0.63	5.93	5.93	6.80	6.40	-0.02	0.03	0.67	0	
50559	0.0187	0.0188	IH	0.84	0.38	844,182	841,091	3,091	0.5%	8 inch	6.40	168.32	163.82	174.55	170.49	6.23	6.58	0.03	0.06	1.31	-0.47	-0.44	6.23	6.58	6.70	7.02	-0.01	0.03	0.67	0	
P-670	0.0040	0.0040	IH	0.73	0.82	842,112	839,079	3,033	0.5%	8 inch	10.23	168.77	167.85	183.00	174.08	14.23	6.23	0.03	0.03	0.73	-0.63	-0.63	14.23	6.23	14.87	6.87	0.00	0.03	0.67	0	
50691	0.0039	0.0039	IH	0.73	0.54	834,868	831,895	2,973	0.5%	8 inch	5.88	172.75	162.14	168.08	168.59	5.31	6.44	0.03	0.04	0.73	-0.63	-0.63	5.31	6.44	5.95	7.07	0.00	0.03	0.67	0	
50669	0.0195	0.0195	IH	0.81	1.08	828,286	814,712	6,574	0.5%	8 inch	8.98	153.62	148.39	160.20	159.78	8.58	11.37	0.05	0.07	1.63	-0.82	-0.59	6.58	11.37	7.20	11.97	-0.01	0.04	0.67	0	
50624	0.0008	0.0000	DH	0.05	0.05	4,683,480	4,671,824	21,648	0.5%	24 inch	12.08	152.68	152.81	166.00	164.23	13.34	11.82	0.04	0.05	1.64	-0.82	-0.83	9.82	11.82	8.67	11.81	0.00	0.03	0.67	0	
F-571	0.0208	0.0208	IH	1.00	1.64	1,457,354	1,450,670	6,684	0.5%	8 inch	8.00	167.77	163.69	175.28	169.59	11.70	8.59	0.03	0.05	0.59	-1.50	-1.45	13.34	11.82	14.84	13.97	-0.06	0.10	2.00	0	
P-584	0.0039	0.0038	IH	0.71	0.03	833,631	830,640	2,991	0.5%	8 inch	3.13	154.71	154.27	156.54	158.70	7.83	4.43	0.03	0.30	0.71	-0.63	-0.37	1.83	4.43	2.47	4.82	-0.24	0.03	0.67	0	
50599	0.0049	0.0048	IH	0.68	0.20	331,089	329,581	1,507	0.5%	8 inch	7.31	158.41	157.68	165.50	160.20	1.09	7.52	0.02	0.04	0.68	-0.48	-0.48	7.52	7.52	7.67	7.67	-0.01	0.03	0.50	0	
50453	0.0031	0.0031	IH	1.05	0.08	1,789,022	1,780,886	8,134	0.5%	8 inch	8.21	189.19	181.21	174.42	172.40	6.22	11.19	0.05	0.31	2.00	-0.82	-0.38	5.23	11.19	6.85	11.55	-0.10	0.04	0.67	0	
50274	0.0044	0.0044	IH	0.74	0.89	1,683,351	1,675,989	7,362	0.5%	8 inch	4.33	183.88	178.67	185.00	184.00	5.23	6.23	0.05	0.03	1.89	-0.82	-0.83	1.32	7.33	1.94	7.07	0.01	0.04	0.67	0	
50507	0.0043	0.0042	IH	0.74	0.38	851,874	850,874	3,000	0.5%	8 inch	3.98	171.87	170.31	177.90	178.80	6.23	8.48	0.03	0.05	0.74	-0.63	-0.61	6.23	8.48	8.97	7.11	-0.01	0.03	0.67	0	
50491	0.0040	0.0040	IH	0.72	0.80	842,112	838,208	2,903	0.5%	8 inch	8.50	161.27	159.83	169.30	171.00	8.03	11.17	0.03	0.03	0.72	-0.63	-0.64	8.03	11.17	8.67	11.81	0.00	0.03	0.67	0	
P-667	0.0118	0.0116	IH	0.93	1.23	1,085,541	1,080,593	4,948	0.5%	8 inch	6.57	189.81	168.11	178.18	178.00	6.37	4.77	0.04	0.03	1.23	-0.83	-0.83	6.37	4.77	7.00	5.41	0.00	0.03	0.67	0	
50585	0.0062	0.0062	IH	0.74	0.63	371,068	369,394	1,674	0.5%	8 inch	5.28	167.09	165.95	171.40	172.20	3.31	6.25	0.02	0.03	0.74	-0.48	-0.47	4.31	6.25	4.70	6.72	0.00	0.03	0.50	0	
50567	0.0042	0.0042	IH	0.74	0.25	858,354	856,490	2,864	0.4%	8 inch	4.50	176.17	173.90	179.40	178.70	4.23	4.23	0.03	0.05	0.74	-0.63	-0.61	4.23	4.77	4.87	5.39	-0.01	0.03	0.67	0	
50408	0.0031	0.0028	DH	0.83	0.25	565,589	563,068	2,529	0.4%	8 inch	12.78	188.54	188.20	181.50	180.75	12.96	12.81	0.03	0.06	0.83	-0.63	-0.61	12.96	12.81	13.90	12.22	-0.02	0.03	0.67	0	
50488	0.0047	0.0045	IH																												

L-Label	Constructed Slope	HGL Slope	HGL Rankings	Velocity In (fps)	Velocity Out (fps)	Capacity (gpd)	Excess Full Capacity (gpd)	Total Flow (gpd)	% Capacity	Section size	Avg Pipe Cover (ft)	Upstream			Upstream			Upstream Cover (ft)	Downstream Cover (ft)	Depth In (ft)	Depth Out (ft)	Average Velocity (ft/s)	Surcharge Up (ft)	Surcharge Down (ft)	Cover Up (ft)	Cover Down (ft)	Freeboard Up (ft)	Freeboard Down (ft)	dH	n	Dia (ft)	Test
												Crown Elev (ft)	Downstream Elev (ft)	Ground Elev (ft)	Downstream Elev (ft)	Ground Elev (ft)	Downstream Elev (ft)															
P-639	0.0111	0.0110	IH	0.84	0.68	1,067,524	1,084,148	3,376	0.3%	8 inch	8.26	181.14	179.35	168.00	187.00	4.86	7.64	0.03	0.04	1.07	-0.83	-0.83	4.88	7.64	5.50	8.27	0.00	0.03	0.67	0		
50618	0.0074	0.0071	IH	0.79	0.21	871,009	888,282	2,727	0.3%	8 inch	8.92	167.13	168.21	173.81	173.36	6.68	7.15	0.03	0.07	0.87	-0.84	-0.80	6.68	7.16	7.32	7.75	-0.03	0.03	0.67	0		
50441	0.0059	0.0059	IH	0.71	0.21	717,901	715,709	2,192	0.3%	8 inch	8.15	172.40	171.70	180.70	179.70	8.30	8.00	0.03	0.06	0.71	-0.84	-0.81	8.30	8.00	8.94	8.61	-0.02	0.03	0.67	0		
50468	0.0147	0.0144	IH	0.86	0.19	1,221,879	1,228,133	3,748	0.3%	8 inch	7.02	165.16	163.04	171.30	170.94	6.14	7.90	0.03	0.10	1.21	-0.83	-0.87	6.14	7.90	8.78	8.47	-0.04	0.03	0.67	0		
50602	0.0232	0.0232	IH	0.78	0.81	718,585	718,424	2,171	0.3%	8 inch	4.68	189.70	187.33	173.40	173.00	3.70	5.67	0.03	0.03	1.26	-0.47	-0.47	5.62	6.27	6.28	6.91	0.00	0.03	0.50	0		
P-666	0.0100	0.0100	IH	0.82	0.99	1,013,243	1,010,209	3,034	0.3%	8 inch	5.95	172.41	169.91	178.03	178.18	5.62	6.27	0.03	0.03	0.99	-0.84	-0.84	6.27	6.91	7.88	7.88	-1.03	0.03	0.67	0		
50478	0.0204	0.0102	IH	0.89	0.02	1,450,596	1,448,253	4,343	0.3%	8 inch	7.86	167.46	164.01	173.78	173.00	6.32	8.99	0.04	1.78	1.42	-0.83	-1.11	8.32	8.99	8.99	9.91	0.00	0.03	0.67	0		
P-504	0.0134	0.0134	IH	0.85	1.15	1,178,782	1,173,245	3,517	0.3%	8 inch	8.93	154.96	150.97	158.80	160.58	3.84	10.01	0.03	0.03	1.15	-0.83	-0.84	3.84	10.01	4.48	10.85	0.00	0.03	0.67	0		
P-608	0.0275	0.0275	IH	0.91	0.44	1,684,724	1,679,941	4,782	0.3%	8 inch	5.83	158.99	151.28	165.12	156.81	6.13	5.53	0.04	0.06	1.62	-0.83	-0.80	6.13	5.53	6.78	8.14	-0.01	0.04	0.67	0		
P-528	0.0794	0.0743	IH	1.05	2.77	2,859,932	2,851,887	8,046	0.3%	8 inch	11.64	173.83	167.72	181.35	183.48	7.52	15.78	0.05	0.03	2.77	-0.82	-0.84	7.52	15.78	8.14	16.40	0.03	0.04	0.67	0		
P-675	0.0050	0.0050	IH	0.90	0.91	2,108,397	2,102,569	5,828	0.3%	12 inch	7.19	164.48	163.94	171.70	171.00	7.22	7.16	0.04	0.04	0.90	-0.98	-0.98	7.22	7.16	8.18	8.12	0.00	0.05	1.00	0		
50670	0.0170	0.0169	IH	0.85	0.27	1,324,821	1,320,596	3,625	0.3%	8 inch	5.78	180.22	157.19	166.61	162.32	6.39	5.13	0.03	0.07	1.27	-0.83	-0.59	6.39	5.13	7.03	5.73	-0.02	0.03	0.67	0		
50495	0.0054	0.0054	IH	0.72	0.48	748,042	746,013	2,030	0.3%	8 inch	4.23	159.27	158.89	163.59	163.02	4.92	4.13	0.03	0.03	0.72	-0.64	-0.64	4.92	4.13	4.98	4.77	-0.01	0.03	0.67	0		
50687	0.0197	0.0194	IH	0.86	0.21	1,423,789	1,419,942	3,847	0.3%	8 inch	7.11	168.44	155.49	164.73	163.42	6.29	7.93	0.03	0.06	1.38	-0.83	-0.58	6.29	7.93	8.93	8.51	-0.04	0.03	0.67	0		
50443	0.0155	0.0154	IH	0.85	0.33	1,263,653	1,260,244	3,409	0.3%	8 inch	7.17	178.27	171.70	182.60	179.70	6.33	8.00	0.03	0.06	1.21	-0.83	-0.81	6.33	8.00	6.97	8.61	-0.01	0.03	0.67	0		
50653	0.0053	0.0050	IH	0.70	0.13	738,312	734,338	1,974	0.3%	8 inch	7.59	153.80	152.99	160.80	161.37	6.80	8.38	0.03	0.06	0.70	-0.84	-0.59	8.00	8.38	7.44	8.97	-0.03	0.03	0.67	0		
P-685	0.0267	0.0267	IH	0.90	1.58	1,659,829	1,655,381	4,447	0.3%	8 inch	6.33	166.38	159.09	175.39	165.12	9.03	6.03	0.04	0.03	1.58	-0.83	-0.84	9.03	6.03	6.68	6.67	0.00	0.04	0.67	0		
50571	0.0062	0.0061	IH	0.82	0.28	370,048	369,089	959	0.3%	8 inch	6.33	171.02	170.41	177.00	177.10	5.98	6.69	0.02	0.03	0.62	-0.48	-0.47	5.98	6.69	6.48	7.16	-0.02	0.03	0.50	0		
50517	0.0040	0.0039	IH	0.81	0.38	842,112	840,456	1,656	0.3%	8 inch	2.33	162.86	162.47	165.00	165.00	2.12	2.53	0.02	0.04	0.61	-0.84	-0.83	2.12	2.53	2.78	3.18	-0.01	0.03	0.67	0		
P-566	0.0037	0.0037	IH	0.58	0.69	616,671	615,131	1,540	0.2%	8 inch	5.49	170.17	169.79	175.02	172.92	4.85	6.13	0.02	0.02	0.58	-0.64	-0.64	4.85	6.13	5.50	6.78	0.00	0.03	0.67	0		
50405	0.0267	0.0268	IH	0.89	0.48	1,857,926	1,853,808	4,117	0.2%	8 inch	7.89	172.15	168.71	179.40	175.23	7.25	8.62	0.04	0.05	1.54	-0.83	-0.81	7.25	8.62	7.88	9.14	-0.01	0.04	0.67	0		
50508	0.0201	0.0200	IH	0.85	0.23	1,440,615	1,437,057	3,558	0.2%	8 inch	4.41	168.39	162.39	173.90	165.30	5.41	3.41	0.03	0.06	1.34	-0.83	-0.58	5.41	3.41	6.05	4.00	-0.02	0.03	0.67	0		
50655	0.0033	0.0028	DH	0.54	0.08	581,084	579,701	1,392	0.2%	8 inch	10.00	149.17	148.79	158.23	158.72	10.08	9.93	0.02	0.09	0.54	-0.84	-0.58	10.08	9.93	10.71	10.51	-0.05	0.03	0.67	0		
50400	0.0441	0.0439	IH	0.91	0.38	2,131,552	2,128,847	4,705	0.2%	8 inch	9.40	161.35	154.85	172.43	162.44	11.06	7.89	0.04	0.07	1.91	-0.83	-0.80	11.08	7.89	11.71	8.49	-0.02	0.04	0.67	0		
50438	0.0058	0.0055	IH	0.80	0.33	758,987	758,315	1,672	0.2%	8 inch	8.95	171.39	170.74	180.32	179.70	8.93	8.98	0.02	0.04	0.68	-0.84	-0.83	8.93	8.98	9.58	9.59	-0.01	0.03	0.67	0		
50437	0.0051	0.0047	IH	0.84	0.10	728,075	724,533	1,543	0.2%	8 inch	7.87	173.69	173.02	181.55	180.89	7.86	7.87	0.02	0.06	0.84	-0.84	-0.58	7.86	7.87	8.51	8.46	-0.05	0.03	0.67	0		
36652	0.0044	0.0044	DH	0.69	0.39	1,228,045	1,223,452	2,593	0.2%	10 inch	10.47	150.34	149.75	160.22	160.22	10.48	10.47	0.03	0.04	0.69	-0.80	-0.79	10.48	10.47	11.28	11.28	-0.01	0.04	0.83	0		
P-530	0.0078	0.0070	IH	0.72	0.78	886,168	884,339	1,828	0.2%	8 inch	8.29	174.39	173.91	182.74	182.14	8.35	8.23	0.02	0.02	0.78	-0.84	-0.84	8.23	8.23	9.00	8.68	0.00	0.04	0.67	0		
50401	0.0828	0.0820	DH	0.97	0.78	2,817,832	2,811,884	5,948	0.2%	8 inch	17.84	167.17	149.99	178.36	174.07	11.19	24.08	0.04	0.05	2.55	-0.82	-0.82	11.19	24.08	11.82	24.70	0.00	0.04	0.67	0		
50687	0.0048	0.0047	IH	0.61	0.25	703,961	702,575	1,387	0.2%	8 inch	8.08	162.64	162.14	168.35	168.58	5.71	8.44	0.02	0.04	0.61	-0.84	-0.83	5.71	8.44	6.38	7.07	-0.02	0.03	0.67	0		
P-529	0.0032	0.0032	IH	0.49	0.62	574,322	573,243	1,079	0.2%	8 inch	7.04	174.99	174.59	180.92	182.74	5.93	8.15	0.02	0.02	0.49	-0.65	-0.65	5.93	8.15	8.58	8.50	0.00	0.03	0.67	0		
P-570	0.0112	0.0111	IH	0.73	0.30	1,074,458	1,072,449	2,012	0.2%	8 inch	5.57	170.17	168.77	175.41	174.06	5.24	5.89	0.03	0.05	0.91	-0.84	-0.82	5.24	5.89	5.88	6.51	-0.02	0.03	0.67	0		
50699	0.0027	0.0024	DH	0.40	0.08	734,163	732,808	1,355	0.2%	10 inch	13.94	152.18	151.85	168.36	165.08	14.18	13.70	0.03	0.08	0.40	-0.81	-0.75	14.18	13.70	14.98	14.45	-0.03	0.04	0.83	0		
50679	0.0054	0.0052	IH	0.63	0.17	746,829	745,287	1,362	0.2%	8 inch	5.76	180.85	180.12	185.52	186.78	4.97	6.64	0.02	0.05	0.63	-0.65	-0.65	6.64	6.64	5.62	6.48	-0.01	0.03	0.67	0		
50660	0.0040	0.0033	DH	0.54	0.09	844,922	843,789	1,133	0.2%	8 inch	11.41	161.71	161.48	168.10	173.00	11.29	11.52	0.02	0.07	0.54	-0.65	-0.65	11.29	11.52	11.84	12.12	-0.08	0.03	0.67	0		
50573	0.0039	0.0038	IH	0.53	0.28	637,574	636,465	1,108	0.2%	8 inch	4.04	175.45	175.17	179.30	179.40	3.85	4.23	0.02	0.03	0.53	-0.65	-0.63	3.85	4.23	4.50	4.87	-0.02	0.03	0.67	0		
50528	0.0099	0.0092	IH	0.70	0.02	1,012,158	1,010,410	1,748	0.2%	8 inch	8.89	170.84	167.39	179.80	178.20	8.96	8.81	0.02	0.02	0.74	-0.84	-0.40	8.96	8.81	9.81	9.21	-0.08	0.03	0.67	0		
50676	0.0068	0.0068	IH	0.67	0.69	839,249	837,841	1,408	0.2%	8 inch	3.99	160.93	160.62	164.80	164.83	3.67	4.31	0.02	0.02	0.69	-0.85	-0.85	3.67	4.31	4.32	4.96	0.00	0.03	0.67	0		
50654	0.0185	0.0180	IH	0.74	0.06	1,305,342	1,303,212	2,130	0.2%	8 inch	4.82	182.07	168.83	186.20	163.93	4.13	5.10	0.03	0.14	1.07	-0.84	-0.53	4.13	5.10	4.77	5.63	-0.06	0.03	0.67	0		
50690	0.0234	0.0233	IH	0.78	0.23	1,554,596	1,552,253	2,343	0.2%	8 inch	5.97	164.87	160.52	169.39	167.73	4.72	7.21	0.03	0.08	1.25	-0.84	-0.81	4.72	7.21	5.38	7.82	-0.02	0				

Section 9

Operating Strategy

9.1 Introduction

As described in Section 3, the City of Cornelius (City) has an intergovernmental agreement with Clean Water Services (CWS) to cooperatively operate and maintain the sanitary sewerage and surface water management services for the City. Through the agreement a division of responsibilities exists between the City and CWS, wherein the City essentially operates and maintains the collection system lines that are less than 24 inches in diameter within the City's service boundary. This section documents the City's operation, maintenance, and rehabilitation program to meet the goal of preventing sanitary sewer overflows (SSO) from the collection and conveyance system for which the City is responsible.

SSOs can be caused by capacity-related problems resulting from improper design or population growth exceeding design flows. However, SSOs are most commonly caused by stoppages resulting from roots, debris, and other material that can build to partially or completely block flow through the pipe is addressed under the maintenance program discussed in this section. Other causes include structural defects such as leaks, exfiltration and force main failures, and loss of power. These types of SSOs are more likely to contribute large volumes of wastewater to receiving streams. In the City of Cornelius, sanitary sewer overflows occur mainly as a result of sewer blockages that cause sewage to overflow from manholes or back up into buildings. SSOs in the City are periodic, emergency events that are often unavoidable.

This section includes a description of the maintenance strategies, information management and maintenance scheduling, overflow response plans, and other operation programs currently employed by the City, as well as recommended activities to improve operation and maintenance of the collection system. The maintenance issues covered in this section primarily address the non-capacity-related problems. Capacity issues are addressed under the capital improvement section of this master plan.

9.2 Capacity, Management, Operation and Maintenance (CMOM)

In 2001, EPA drafted a proposed rule to address SSOs, and although the proposed rule was withdrawn from the Federal Register, it reflected EPA's perspective on the SSO problem. The proposed rule called for improvements in the operation of sanitary sewer collection systems and to reduce the frequency and occurrence of sewer overflows. One of the major components of the draft rule was to develop and implement a Capacity, Management, and Operation & Maintenance (CMOM) program. Several guidance documents were developed by EPA to help communities and agencies meet the rule goals (Black and Veatch, 1999, 2000, 2004). Thus, while the rule was never finalized, many communities and agencies began modeling their

programs under such a structure. The City's maintenance activities reflect many of the recommendations in the guidance manual.

9.2.1 Local Regulations and Permitting

Local regulation and permitting is used to control both the types of discharges and the quantity of discharges to the City's sewer system. These are achieved through the following:

- **Municipal Code** – documents containing requirements such as characteristics of wastewater discharges, lawful connections to
 - collection system, and penalties for illicit connection and discharges into the system.
- **Plumbing Code/City Ordinance** – sets circumstances under which a connection can be made to the collection system; makes it illegal to connect private inflow sources to the collection system
- **Permitting** – the City can determine if its system can convey the flows from a proposed development to prevent overloading the system; after an application is submitted by the develop, a feasibility study is needed to identify whether the development is feasible from a capacity and fee standpoint.

9.3 Current Maintenance Strategies

An aggressive maintenance program can mitigate the impact of the overflow, as well as significantly reduce the frequency of occurrence of dry-weather SSOs. An aggressive program also includes system assessment and a rehabilitation program to identify the needed corrections and to target structural and leakage problems.

The three primary types of maintenance strategies implemented by the City include:

- **Emergency/Reactive Maintenance** – involves containing or minimizing the impacts of a SSO by applying equipment and personnel resources to stop the overflow in the quickest, safest manner available to the City. Effective emergency maintenance requires a rapid response to mitigate damage and limit exposure.
- **Corrective Maintenance** – focuses on long-term solution of eliminating the cause(s) of SSOs. Activities may include repairing damaged sewer pipes, patching leaks, and other repairs to appurtenances. An effective monitoring and reporting plan is important to implement a corrective maintenance program.
- **Proactive Maintenance** – precludes the conditions that cause SSOs and backups once the problems have been identified. These activities involve primarily cleaning operations.
- **Inspection and Monitoring** – provides basis for identifying corrective and proactive maintenance. These activities include visual and TV inspections to locate potential problems

and trouble areas within the system and monitoring the flows within the system to locate problems associated with excessive inflow and/or infiltration

Table 9-1 lists the sanitary sewer maintenance responsibilities of the City and CWS based on the intergovernmental agreement. Table 9-1 also indicates the type of maintenance activity (emergency, corrective or proactive). The information shown is based on an effective date of July 1, 2004. Presently, the proactive maintenance activities include TV inspection of the lines on a regular basis. The City also regularly performs line cleaning and root cutting to make sure the lines maintain their capacities. A minimum frequency of TV inspection and line cleaning activities are required by CWS as part of their maintenance agreement. All other proactive and corrective maintenance activities are conducted on an as-needed basis, which is primarily controlled by the findings of the TV inspection or from field observation or overflow response/customer complaints.

The frequencies listed in Table 9-1 are based on requirements under the agreement with CWS. It was beyond the scope of this work to conduct an optimization review of the maintenance activities. However, EPA published a guidance manual on optimizing frequency of maintenance activities (Black and Veatch, 1999), which can be used as basis for performing such a review.

If a complaint or problem is reported, a maintenance crew is dispatched to resolve the issue. There are currently six (6) staff on a rotating basis assigned to have a pager at all times, who are required to respond to the call report within ten (10) minutes. Furthermore, the City is required to be on site within 30 minutes of the call report, if necessary. The City Operations devotes approximately 1.2 full-time equivalents to the sanitary sewer maintenance field activities.

Table 9-1
City of Cornelius
Summary of Current Sanitary Sewer Maintenance Activities

Maintenance Activity	Responsibility	Frequency
Proactive Maintenance		
Line Cleaning	City	All lines cleaned at least once every 3 years as required by CWS; City has cleaned the entire system 3 times in the past five years; City cleans certain portions of the system more often as dictated by accumulation of debris and blockages
Root Cutting	City	As needed
Cross Connection Investigation and Response	City	As needed
TV Inspection; Compilation of TV Reports and System Evaluation	City	Entire system inspected a minimum of once every 7 years; but coordinated with line cleaning as appropriate
Root Foaming	City & CWS	N/A
Corrective Maintenance		
Manhole Adjustment	City	As needed
I/I Abatement and System Rehabilitation Projects	City & CWS	As needed; conducted based on findings from TV inspections
Structural Line Repairs	City	As needed; conducted based on findings from TV inspections
Lateral Repairs in Public Right of Way	City	As needed; conducted based on findings from TV inspections
Line Replacements	City	Conducted based on capital improvement plan; as needed; conducted based on findings from TV inspections
Vector Control	City	As needed
Manhole Rehabilitation	City & CWS	N/A
Non-structure Line Sealing and Point Repair	City & CWS	N/A
Pump Station Maintenance	CWS	N/A
Emergency Maintenance		
Emergency Response	City	As needed; contact from the City 10 minutes from initiation of a call; City responds on site within 30 minutes of initiation of a call
Overflow and Complaint Response Investigation and Reporting	City	As needed; City receptionist contacts utility service to respond to and address complaint

Notes:

- CWS – Clean Water Services
- Activities listed above are conducted inside and outside the City boundaries, but within the responsibility boundary.
- Activities described in this table are for sanitary sewer lines 24 inches and smaller. All maintenance, inspection, repair and replacement for sewer lines 24 inches and larger are conducted by Clean Water Services.

9.4 Data and Information Management

Maintenance records are essential in scheduling preventive maintenance, determining operation budgets, and classifying problem areas within the sewer system. Also, a record keeping system should:

- Identify individual components of the entire system.
- Contain maintenance and/or repair information for individual system components.
- Provide a preventive maintenance scheduling tool.
- Identify and update repeated problem areas within the sewer system.

The City does not currently have a software package that serves as a formal database or information system specifically for sanitary sewer system data and information management. However, the City does maintain an index map and master plot in CAD format that is continuously updated with changes to the system. The map and master plot are used to keep records of the entire system and for maintenance scheduling. The City is currently updating its system to be more efficient, and cost effective in accomplishing these tasks.

9.5 Overflow and Emergency Response Plan

The City does not currently have an emergency response plan for their sanitary sewer system. However, in the event an emergency arises which causes, or threatens to cause, a discharge of raw sewage that might endanger public health, the City follows the CWS guidelines for reporting the release. The Operations Manager would immediately notify the Oregon Department of Environmental Quality (ODEQ) and CWS. Other common emergency conditions are listed in Table 9-2 along with recommended actions.

Table 9-2
City of Cornelius
Emergency Conditions and Response Actions

Emergency Condition	Recommended Action
Rupture of sewer line or accidental damage to a manhole or pump station	<ul style="list-style-type: none"> ■ Isolate the pipe break by plugging the outlet of the upstream manhole. ■ Notify the customers affected and fire department personnel. ■ Monitor the plugged manhole for wastewater backup into adjacent buildings. ■ Install a temporary bypass pump and gravity/force main if necessary. ■ Repair the damage.
Failure of pumps at pump station	<ul style="list-style-type: none"> ■ Notify the customers affected and fire department personnel. ■ Monitor the wet well level for backup into adjacent buildings. ■ Install a temporary bypass pump and force main if necessary. ■ Repair the failed pump.
Spill of hazardous material into sewer system	<ul style="list-style-type: none"> ■ Notify fire department personnel. ■ Determine amount, type, and nature of spill. ■ Notify wastewater treatment plant personnel. ■ Notify Oregon Department of Environmental Policy (ODEQ) for treatment procedures.
Power failure at pump station	<ul style="list-style-type: none"> ■ Check to insure that backup power if available is functioning. ■ Monitor wet well level for backup into adjacent buildings. ■ Emergency power should be supplied if wet well levels become critical and backup power is not available. ■ After main power is restored, an inventory of the electrical equipment is necessary to insure proper operation.
Personal injury	<ul style="list-style-type: none"> ■ For injuries resulting from medical causes, call the local ambulance (911). ■ For injuries resulting from accidents (falls, fire, explosion, etc.), call the fire department for a rescue unit. ■ Render first aid only if qualified. If not qualified, find someone who is. ■ All injuries, even minor injuries, should be reported to a supervisor. ■ Complete an accident form and submit it to the Operations Manager's office.

9.6 Other O&M Programs

9.6.1 Training and Safety

An existing sanitary sewer system safety program for the City is not documented at this time. However, the City does maintain a general safety program for its staff, including regular safety meetings during field activities. A safety program should be documented and centered around the well-being of workers. The collection system maintenance crews should also be aware of the following list of safety equipment and its proper use:

- First aid kit
- Fire extinguisher
- High visibility safety vests
- Manhole hooks
- Traffic cones
- Traffic barriers
- Hardhats
- Explosion-proof lead lights or battery lights
- Explosion-proof forced air blower
- Explosion-proof oxygen deficiency meter (with audio-visual alarm)
- Parachute type safety harness (with nylon safety rope)
- Explosive gas meter (with audio-visual alarm)
- Hydrogen sulfide detector (with audio-visual alarm)

9.6.2 Certification

Certification of collection system personnel provides an independent assessment of job skills and experience that is important where safety and performance is integral to the daily execution of the system. The City currently has one staff certified as a Level 2 wastewater collection system operator.

9.7 Recommended Maintenance Improvements

As described in the previous sections, the City of Cornelius already implements many critical activities recommended for effective sanitary sewer maintenance (ASCE 2004). However, there are areas where formal plans and programs can provide additional benefits and improved performance and service. These are described further below.

A program self-assessment checklist is included in Appendix C. The checklist is a screening-level tool which allows the City to identify general areas of strength and weakness and establish performance goals and plans for improving their maintenance program.

9.7.1 Overflow Response Plan

The City can improve its maintenance program by developing a formal overflow (emergency) response plan (ORP) for its sanitary sewer system. The City relies on the CWS guidelines for reporting hazardous releases, but a formal ORP can be used to provide a more comprehensive management of responding to any type of release, and can also be used to explicitly define roles and responsibilities. A typical ORP could include the following elements:

- *Goals* – the ORP should establish operational goals in the responding to SSOs. For example, the City may formally set a goal of providing initial response within 30 minutes of the SSO report.

- *SSO response team* – provides a description of the organizational structure, available crew, equipment and other resources used to respond to SSOs.
- *SSO response procedures* – describes the dispatch procedures both during business hours and during off-hours.
- *Corrective action* – documents the remedial measures to be used for a given release or overflow event which may range from relieving a stoppage to repairing or replacing a section of pipe.
- *Coordination with agencies* – in some circumstance coordination with other agencies such as fire/police departments or local health department may be necessary, and the ORP should include the contact information
- *Reporting requirements* – include directly or by reference to another document, instructions or procedures for reporting SSOs to regulatory agencies
- *Public advisory and access limitations* – includes provisions for determining under what circumstances a public advisory or public access limitation should be issued.
- *Water quality sampling* – water quality sampling may be performed to support decision making about public notification and public access issues.
- *Training* – includes provisions for annual training on SSO response procedures for all appropriate personnel.

9.7.2 Information Management

Although the City currently has a method for recording system inventory, a formal information management system can be used to improve effectiveness in decision making when responding to emergencies or to the customer, as well as developing an improved maintenance schedule.

It is recommended that the City develop and maintain a geographic information system (GIS), not only for system inventory, but also for a more comprehensive maintenance management system. Such a relational database can be developed that links maintenance schedule, frequency of cleaning, equipment/staff used, allocation of resources, maintenance histories, SSO record keeping, and effectiveness of reducing SSOs. The database can be used to map, measure, and track historical maintenance activities and performance trends, which can then be used to develop proactive strategies precluding the problems from occurring in the future.

9.7.3 Public Awareness Program

Two of the most prominent causes of overflows are blockages due to fats, oil, and grease (FOG) and private party infiltration/inflow. The public can play a significant role in detecting and locating SSOs. To maximize the public participation in minimizing SSOs, the City can strive to increase public awareness through several avenues in coordination with CWS:

- Development and dissemination of educational brochures
- Presentation by staff at community meetings
- Participation in local schools and colleges environmental awareness programs
- Submission of educational articles to local press
- Issuing of an annual report

9.8 References

Black and Veatch. 2004. "Sanitary Sewer Overflow Solutions." Prepared for American Society of Engineers under Agreement with U.S. Environmental Protection Agency. April.

Black and Veatch. 1999. "Optimization of Collection System Maintenance Frequencies and System Performance." Prepared for American Society of Engineers under Agreement with U.S. Environmental Protection Agency. February.

Black and Veatch. 2000. "Protocols for Identifying Sanitary Sewer Overflows." Prepared for American Society of Engineers under Agreement with U.S. Environmental Protection Agency. June.

Appendix B

Intergovernmental Agreement between City of
Cornelius and Clean Water Services

COPY

INTERGOVERNMENTAL AGREEMENT
BETWEEN CITY OF CORNELIUS AND
CLEAN WATER SERVICES

THIS AGREEMENT is made and entered into as of the 4 day of July, 2003, between the City of Cornelius a municipal corporation of the State of Oregon, hereinafter referred to as "City," and Clean Water Services, formerly Unified Sewerage Agency, a municipal corporation and county service district, hereinafter referred to as the "District."

WHEREAS, the District was duly formed and organized under ORS Chapter 451, has the authority to provide sanitary sewerage treatment facilities, and to provide for storm and surface water management within its boundaries; and City is within the District by action of its Council pursuant to an election duly conducted within the boundaries of the District; and

WHEREAS, City and District have the authority to enter into contracts for the cooperative operation of service facilities under ORS 451.560 and ORS Chapter 190; and

WHEREAS, the District and Cities have established and will continue to maintain an effective partnership for sanitary sewerage and surface water management services which this agreement is designed to support, enhance, and clarify; and

WHEREAS, City and District previously entered into an Agreement for the cooperative operation of sanitary sewer and surface water facilities, and said Agreement is in need of amendment.

NOW, THEREFORE, in consideration of the covenants and agreements to be kept and performed by the parties hereto, it is agreed as follows:

Section 1. Definition of Terms

Wherever the following terms are used in this agreement they shall have the following meaning unless otherwise specifically indicated by the context in which they appear:

- A. Area of Geographic Responsibility means the area set forth in the map attached as Exhibit A as may be amended.
- B. Board means the Board of Directors of the District, its governing body.
- C. Chief Executive Officer means the City official responsible for managing the day-to-day business affairs of City.
- D. Council means the City Council, governing body of City.

- E. Industrial Waste means any liquid, gaseous, radioactive or solid waste substance or a combination thereof resulting from any process of industrial or manufacturing business, or from the development or recovery of natural resources. For the purposes of this agreement, Industrial Waste shall also include any substance regulated under 33 USC Sec 1317, together with regulations adopted thereunder.
- F. Operation and Maintenance means the regular performance of work required to assure continued functioning of the storm and surface water system and the sanitary sewerage system and corrective measures taken to repair facilities to keep them in operating condition, and in compliance with the requirements of applicable laws, regulations, and permits.
- G. Order means Resolutions, Orders and Directives of the District prescribing general standards and conditions for construction or use of the storm and surface water facilities and the sanitary sewerage facilities, and Rates and Charges.
- H. Person means the state of Oregon, any individual, public or private corporation, political subdivision, governmental agency, municipality, industry, co-partnership, association, firm, trust, estate or any other legal entity whatsoever.
- I. Program Funding means the revenues made available to City through Section 4. of this agreement to follow the adopted work programs and performance standards.
- J. Rates and Charges are defined in the District's "Rates and Charges" Resolution and Order (R&O) No. 01-34, or as may be amended. The following terms when used in this agreement shall be as defined in that R&O:
1. Dwelling Unit Equivalent (DUE)
 2. Equivalent Service Unit (ESU)
 3. Impervious Surface Area
 4. Permit Application and Inspection
 5. Sanitary Sewer Service Charge
 6. Sanitary System Development Charge (SDC; Connection Charge)
 7. Storm and Surface Water Service Charge
 8. Storm and Surface Water System Development Charge
- K. Sanitary Sewerage System means any combination of sewer treatment plant, pumping or lift facilities, sewer pipe, force mains, laterals, manholes, side sewers, laboratory facilities and equipment, and any other facilities for the collection, conveyance, treatment and disposal of sanitary sewage comprising the total publicly-owned Sanitary Sewerage System

within District jurisdiction, to which storm, surface and ground waters are not intentionally admitted.

- L. Standards means the standards and conditions of use of the storm and surface water system and the sanitary sewer system as specified and adopted by the District. Standards also shall mean applicable statutes and rules of the United States and the State of Oregon.
- M. Storm and Surface Water System means any combination of publicly owned storm and surface water quality treatment facilities, pumping or lift facilities, storm drain pipes and culverts, open channels, creeks and rivers, force mains, laterals, manholes, catch basins and inlets, grates and covers, detention and retention facilities, laboratory facilities and equipment, and any other publicly owned facilities for the collection, conveyance, treatment and disposal of storm and surface water comprising the total publicly owned Storm and Surface Water System within District's jurisdiction, to which sanitary sewage flows are not intentionally admitted.
- N. Work Program and Performance Standards are adopted by the District after considering input from the cities to define the activities required to operate and maintain the sanitary sewer and storm and surface water systems.

Section 2. Determination of Programs, Rules, Policies and Standards

The District is responsible for the management and operation of the sanitary sewer and storm and surface water systems within its boundary, and is the designated permittee who shall obtain and enforce timely compliance with relevant Federal and delegated State Clean Water Act permits for treatment plants, collection systems, and stormwater. The District, after considering input from the cities, shall adopt orders, standards, specifications, work programs, and performance criteria for the proper and effective operation of the sanitary sewer and storm and surface water systems and to comply with State and Federal permits, laws and regulations. In addition, the District, after considering input from the cities, shall have the authority to make changes to its orders, work programs and performance Standards. Any such changes to work programs and performance standards that the Board determines are required by state and/or federal permits or regulations will become effective 90 days from the date of notice to City by District or as mutually agreed to. Any changes to work programs and performance standards, not required by state and/or federal permits and regulations, shall be mutually agreed to by the District and City before they become effective. Proposed changes not required by state and/or federal permits and regulations should be communicated between the District and the City in or before December of the year before they are to be implemented to allow District and City to budget appropriately for the following fiscal year.

- A. City agrees to follow and enforce the Orders, Standards, specifications, work programs, and performance criteria promulgated by the District, subject, however, to program funding and to the extent that City may be lawfully authorized to act. The City shall not be responsible for any failure to act or defect in performance caused by lack of adequate program funding, inadequacies in the Work Program and Performance Standards as adopted by the District, or lack of lawful authority to act. Lack of adequate funding from the District and compliance with the Work Program and Performance Standards as adopted by the District shall be absolute defenses to any claim against the City under this Agreement. City further agrees to notify District of apparent violations of the subject Orders, Standards, specifications, work programs, and performance criteria, of which it has knowledge, which may require District legal action or enforcement.

Section 3. Division of Responsibilities

A. Division of Responsibilities

1. The purpose of this agreement is to delegate to and contract with the City to perform specific functions. The responsibilities of the District and City are defined in this Section and Appendix A. Exhibit A is a map showing boundaries of responsibility between the District and City and is hereby made a part of Appendix A and incorporated into this agreement.
2. All functions relating to the subject matter of this Agreement not specifically listed in this Section or Appendix A as being the responsibility of City shall remain the responsibility of the District.

B. Procedure for Modifying the Division of Responsibilities

1. Responsibilities defined in this Section and Appendix A may be modified from time to time with approval in writing by the City Manager or designee and the District General Manager or designee.
2. Responsibilities defined in this Section and Appendix A may be modified by the District Board after receiving input from the City and determining the change is necessary to comply with State or Federal permits, laws or regulations. The District Board shall not reduce the total scope of City responsibilities without consent of the City unless there is a change in the program or funding requiring the reduction, or unless the Board determines the City has failed to correct identified instances of nonperformance related to the adopted standards.
3. Upon reasonable notice from City to District, District shall assume responsibility for any portion of the program defined in this Section and Appendix A. Reasonable notice shall be at least 6 months, unless agreed

to in writing by the District and City. Corresponding adjustments to the revenue allocation shall be made to reflect the change in responsibility upon implementation of such changes. City shall be responsible for correcting or paying to have corrected any deficiencies in the system resulting from non-performance of the programs under its responsibility, subject, however, to funding availability.

4. The responsibilities defined in Appendix A and responsibility boundaries defined in Exhibit A are not changed due to City annexations of area currently inside the District's boundary. Provided that after formal adoption and subsequent consultation between the City and District, service area boundaries may be altered based on Senate Bill 122 boundary revisions. For annexations of territory not currently within the District's boundary, the District will amend Appendix A and Exhibit A to define the responsibilities for the new area in consultation with the City and in cooperation with adjacent cities.

C. Additional City Responsibilities

1. Prior to issuing any non-residential sanitary sewer permit, City shall require the applicant to prepare and submit to City a District Sewer Use Information form. City shall submit the completed form to the District. The District will determine if an Industrial Waste Discharge Permit is required. The District will respond within 15 days.
2. Require persons who are proposing 'development', as defined in the District's Design and Construction Standards Resolution and Order, to obtain a Service Provider Letter from the District. City shall not issue a stormwater construction permit without verification that the District has issued a Service Provider Letter.
3. Following City review and initial approval, forward proposed construction drawings to the District for the following:
 - a) Any addition, modification, construction, or reconstruction (other than repairs) of the publicly-owned sanitary sewerage system and storm and surface water system. District will review these drawings to assure conformance to adopted District standards, orders, and master plans.
 - b) Any "development" as defined in the District's Design and Construction Standards Resolution and Order. District will review these drawings to assure conformance with the conditions of the Service Provider Letter issued following the provisions in Section 3.C.2.

The District shall not charge a fee for these types of reviews. The City shall not approve or issue permits for such work until it receives notification of District approval.

4. The City may notify the District in writing that it wishes the District to issue Connection Permits for either or both of the sanitary or storm water systems. In such cases, the District shall not issue Connection Permits until the City indicates in writing that the development complies with the City's standards. City will collect all connection, permit, and development fees for developments within the City unless City and District agree that the District will collect the fees.
5. Other than for issuance of connection permits, obtain District review and approval prior to entering into any agreement for the use of the Storm and Surface Water System or the Sanitary Sewerage System.
6. Inform the District in writing not less than 30 days prior to initiating or entering into any agreement for the financing or incurring of indebtedness relating to the storm and surface water system or the sanitary sewerage system. Revenues allocated by the District to the City for the performance of functions identified in Appendix A are considered restricted, and may only be used to perform those functions (including reasonable administration) delegated to the City for such things as operation and maintenance of the sanitary or storm and surface water system. City shall not obligate any assets or facilities of the District's sanitary or storm and surface water system for any debt. For purposes of debt funding, the District's asset schedule for storm and surface water and sanitary sewer facilities shall be the basis for determining ownership within City boundaries. In general, sanitary sewer lines 24" and over are the property of the District regardless of location, as are sanitary treatment plants and pump stations, and storm and surface water quality and quantity facilities that are one acre or greater in surface area.
7. Allow the District access at any reasonable time upon reasonable notice to inspect and test storm and surface water facilities and sewerage facilities within City and City Area of Geographic Responsibility.
8. Grant the District permits from time to time as may be necessary for the installation of storm and surface water facilities and sewerage facilities in the public streets and ways of City without imposing permit issuance fees, provided that the District shall adhere to any conditions required pursuant to ORS 451.550(6).
9. To issue no new permit for the construction within, or modification to, a wetland, floodway, or floodplain without first receiving the written approval by the District, pursuant to Section 5.D. This paragraph shall

not apply to permits issued by City pursuant to a current permit under 33 USC Section 1344(e) (a section 404 general permit), and within the scope of such permit. This section does not apply to actions related to City flood insurance program.

10. To pursue, when City deems feasible and appropriate, the conversion of storm and surface water facilities from private to public ownership, through the acquisition of easements and other property rights as necessary, for those privately owned storm and surface water facilities which are identified as being necessary or appropriately a part of the public system.
11. To the extent that it is so required by law or regulation, City shall comply with Oregon Administrative Rules (OAR) Chapter 340, Division 49, "Regulations Pertaining to Certification of Wastewater System Operator Personnel," including the obligation that City shall have its wastewater collection system supervised by one or more operators certified at a grade level equal to or higher than the system classification shown on page 1 of District's NPDES permit, issued by the State. The District shall notify City of any modification to the NPDES permits affecting their operations.

D. City Responsibilities Outside of its City Limits

1. City is not obligated by this agreement to accept responsibility for any programs or work activities outside of its City limits.
2. To the extent City has agreed to responsibilities both inside and outside of its City limits, for activities which are the responsibility of City, City shall perform the work to meet the minimum requirements specified in the District's adopted Work Programs and Performance Standards. When the same type of service is being performed by City both inside and outside City, the service shall be prioritized and performed in a like manner in each area, including the response to storms and other emergencies. The exception shall be if City provides a higher degree of service inside City due to its own supplemental funding.

Section 4. Determination and Division of Revenue; Operating Procedures and Rules Relating to Revenue

- A. After consultation between City and district staff, the District Board shall determine and certify annually for both the sanitary sewerage system and for the storm and surface water system the monthly service charge and system development charge. The City agrees to impose these charges as a minimum. The City may impose additional charges as allowed in Section 4.E.4.

- B. After consultation between City and district staff, the District Board shall determine and certify annually for both the sanitary sewerage system and for the storm and surface water system the portion of the monthly service charge and system development charge to be retained by the City for performance of the functions defined in this Agreement and for the City's share of annual debt service payment.
- C. The District Board shall not implement any significant change in the division of monthly service charge revenue from that shown in the Rates and Charges Resolution and Order No. 01-34 effective Fiscal Year 2001/2002 until July 1, 2005 with the following exceptions:
1. The Board may make routine principal and interest adjustments for debt service repayment.
 2. The Board may make adjustments in response to significant increases or decreases in program responsibilities
- D. Changes in the division of revenue will typically be made as a part of the annual Fiscal Year budget process. However, the division of revenue may be adjusted by the District to recognize changes in responsibilities that occur outside the normal budget cycle after coordination and communication with the Cities. Any such mid-year changes in the division of revenue initiated by the District Board shall only be implemented when the Board determines such a change is necessary to comply with State or Federal permits, laws or regulations. If there is a mid-year change in responsibilities, which the District determines to be significant, the District Board may, upon 60 days notice to City, adjust the division of revenue outside of the annual budget process
- E. Operating Procedures Relating to Revenue
1. City shall remit to the District the portion of sanitary sewer service charges and systems development charges collected, and storm and surface water service charges and systems development charges collected, less the City Portion, as identified in Section 4.B.
 2. Payments shall be remitted on a monthly basis, with a report on District designated forms.
 3. Payments to the District of revenue collected by the billing party shall be due within 20 days following the end of each month, unless the payment has been appealed by the billing party.
 4. City may charge and collect a service charge or system development charge at a higher rate per DUE and ESU than that set by the District

when the City determines it is needed for the local City system. The City shall retain 100% of these additional revenues collected. Such additional charge shall be consistent with the services provided by City and with applicable federal rules in order to preserve eligibility for grants and other funding programs.

5. City may request District to perform permit and inspection services for private development construction of public storm and surface water facilities and sanitary sewer facilities, and for erosion control. City shall remit to the District the fee set forth in District's Rates and Charges to compensate District for its costs for such services performed relative to these fees, as prescribed by District Order or separate agreement with City.
6. For Industrial Waste fees, District shall remit to City a percentage of system development charges, volume, and monthly service charges collected equal to the percentages of service charges retained by the City as defined in Section 4.B. District shall retain one hundred percent (100%) of the annual Industrial Waste permit fee, and any penalty fees, COD, SS (as those terms are defined in the Rates and Charges) and other fees related to Industrial Waste that may be assessed.
7. City will institute administrative procedures to diligently maintain regular billings and collection of fees, adjust complaints thereto, and pursue delinquency follow-ups and take reasonable steps for collection thereof.
8. City and District shall each establish separate accounts for the storm and surface water program and sanitary sewerage program for the purpose of accounting for service charges and systems development charges collected and received pursuant to this agreement.
9. District or City may at any reasonable time upon reasonable notice inspect and audit the books and records of the other with respect to matters within the purview of this Agreement.
10. City and District shall each prepare and submit to each other a performance report of the storm and surface water functions, and the sanitary sewer functions for which each is responsible. After consultation with the City, District will specify the requirements, frequency, and content of the performance report.
11. The City and District may, each at its own cost, install permanent and temporary volume and quality monitoring stations, and other

monitoring equipment, to determine the effectiveness of City and District programs.

12. Interest shall accrue on late monthly payments as specified in Section 4.E.1 at a rate of 1.25 times the monthly Local Government Investment Pool (LGIP) earnings rate as posted for the previous month, and will be applied each month to the unpaid balance.

Section 5. Administrative and Operating Provisions

- A. The District will not extend sewer service to areas outside the City except with prior approval of the City where such areas are included in the Urban Planning Area Agreement between the City and the appropriate county or counties and any of the following exists:
 1. A new or existing single family property desires sewer service and needs to directly connect to a sewer line within the city.
 2. A new development desires sewer service and needs to directly connect a lateral or mainline public sewer directly to a sewer line within the city.
- B. Each party shall obtain and maintain in full force and effect for the term of this agreement, at its own expense, comprehensive general liability and automobile insurance policies for bodily injury, including death, and property damage, including coverage for owned, hired or non-owned vehicles, as applicable, for the protection of the party, and the other party, its elected and appointed officials, officers, agents, employees and volunteers as additional insureds. The policies shall be primary policies, issued by a company authorized to do business in the State of Oregon and providing single limit general liability coverage of \$2,000,000 and separate automobile coverage of \$1,000,000 or the limit of liability contained in ORS 30.260 to 30.300, whichever is greater. The certificates shall provide that the other party will receive thirty (30) days' written notice of cancellation or material modification of the insurance contract at the address listed below. Each party shall provide certificates of insurance to the other party prior to the performance of any obligation under this agreement. If requested, complete copies of insurance policies shall be provided to the other party. Each party shall be financially responsible for their own deductibles, self-insurance retentions, self-insurance, or uninsured risks.
- C. District will not establish local assessment districts within City, without first obtaining City approval.
- D. District will process applications from City pursuant to Section 3.C.9 for Wetland, Floodplain, and Floodway modifications. Timely review of the

application shall be provided by the District. Upon review and approval by District, and upon request by City, the District shall act as a facilitator and liaison for State and Federal review and permit processes.

- E. The City shall report all sanitary sewer overflows that it becomes aware of to the District within 24 hours of learning of the overflow. The City shall require all permittees of the City to report sanitary sewer overflows to the City. City agrees to reimburse District for any expense, costs, damages, claims, fines, or penalties incurred by District that result from or are related to City's failure to so timely and adequately report.
- F. This agreement is for the benefit of the parties only. Each party agrees to indemnify and hold harmless the other party and its officers, employees, and agents, from and against all claims, demands and causes of actions and suits of any kind or nature for personal injury, death or damage to property or the environment on account of or rising out of the operation of this agreement, including the performance or non-performance of duties under this agreement, or in any way resulting from the negligent or wrongful acts or omissions of the indemnifying party and its officers, employees, and agents. In addition, each party shall be solely responsible for any contract claims, delay damages or similar items arising from or caused by the action or inaction of the party under this agreement. Inability to perform an activity or to properly perform because of insufficient funding from the District is not a negligent act or omission or willful misconduct of the party charged with the activity but shall be the responsibility of the District. Performance of any activity in compliance with the Work Program and Performance Standards as adopted by the District is not a negligent act or omission or willful misconduct.
- G. District and City acknowledge that District may receive notices of violation or fines from state or federal agencies for violations of state or federal rules. As the permittee and the entity that establishes standards and controls payment, District shall be responsible for responding to notices of violations and for payment of all fines. District shall invite the City to participate in any discussions with State and Federal agencies regarding notices of violation involving City actions or responsibility. City will cooperate with District in the investigation and response to any notice of violation involving actions relating to actions or responsibilities of the City. If a fine is imposed, City shall reimburse District to the extent that the fine results from non-performance of adopted programs or non-compliance with District, State, or Federal rules or policies by the City and those acting on behalf of the City. If possible, the City shall reimburse the District prior to the date due for payment of the fine. The City shall not be responsible for reimbursement if the City's non-performance or non-compliance was caused by lack of adequate funding by District. If more than one party is responsible, the City's responsibility for reimbursement payment will be allocated based on the degree of responsibility and degree of fault of the City. Disputes over the amount of reimbursement

shall be resolved by the dispute resolution process set out in Section 6 of this Agreement. To the extent that the City is required to perform any work to correct a violation, District shall provide adequate funding for the work to be performed, unless the violation was caused by the City's omission or misconduct.

- H. Nothing in this Agreement shall be construed as a limitation upon or delegation of the statutory and home rule powers of City, nor as a delegation or limitation of the statutory powers of District. This Agreement shall not limit any right or remedy available to City or District against third parties arising from illegal acts of such third parties.
- 1. Where this Agreement calls for review or approval of a fee or charge, District shall perform such review in a timely manner, shall not unreasonably withhold approval, and shall provide its decision to City in writing. If, within 30 days of written request by City for approval by District, the District has failed to provide a written response, the request shall be deemed approved.

Section 6. Dispute Resolution; Remedies

- A. In the event of a dispute between the parties regarding their respective rights and obligations pursuant to this Agreement, the parties shall first attempt to resolve the dispute by negotiation. If a dispute is not resolved by negotiation, the exclusive dispute resolution process to be utilized by the parties shall be as follows:
 - 1. Step 1. Upon failure of those individuals designated by each party to negotiate on its behalf to reach an agreement or resolve a dispute, the nature of the dispute shall be put in writing and submitted to City's Chief Executive Officer and District's General Manager, who shall meet and attempt to resolve the issue. If the issue in dispute is resolved at this step, there shall be a written determination of such resolution, signed by City's Chief Executive Officer and District's General Manager, which determination shall be binding on the parties. Resolution of an issue at this step requires concurrence of both parties' representatives.
 - 2. Step 2. In the event a dispute cannot be resolved at Step 1, the matters remaining in dispute after Step 1 shall be reduced to writing and forwarded to the Mayor and the Chairman of the Board of Directors. Upon receipt of the written issue statement, the Mayor and Chairman shall meet and attempt to resolve the issue. If the issue is resolved at this step, a written determination of such resolution shall be signed by the Mayor and Chairman. Resolution of an issue at this step requires concurrence of both the Mayor and the Chairman.

3. Step 3. In the event a dispute cannot be resolved at Step 2, the parties shall submit the matter to mediation. The parties shall attempt to agree on a mediator. In the event they cannot agree, the parties shall request a list of five (5) mediators from the American Arbitration Association, or such other entity or firm providing mediation services to which the parties may further agree. Unless the parties can mutually agree to a mediator from the list provided, each party shall strike a name in turn, until only one name remains. The order of striking names shall be determined by lot. Any common costs of mediation shall be borne equally by the parties, who shall each bear their own costs and fees therefor. If the issue is resolved at this step, a written determination of such resolution shall be signed by both parties. Resolution of an issue at this step requires concurrence by both parties. In the event a dispute is not resolved by mediation, the aggrieved party may pursue any remedy available to it under applicable law.
- B. Neither party may bring a legal action against the other party to interpret or enforce any term of this Agreement in any court unless the party has first attempted to resolve the matter by means of the dispute resolution of subsection A above. This shall not apply to disputes arising from a cause other than interpretation or enforcement of this Agreement.
 - C. Parties may mutually agree in writing to waive any of the above steps, or to enter into alternate processes or additional processes such as binding arbitration prior to filing legal action.

Section 7. Effect of this Agreement

This Agreement shall supersede all prior agreements of similar scope and subject matter, including amendments and the "City Committee Agreement" between the parties with respect to sanitary sewerage and service, storm and surface water management; provided that, except as expressly modified herein, all rights, liabilities, and obligations of such prior agreements shall continue. This agreement shall be effective upon its execution by both parties hereto, and shall continue in effect for four renewable terms of five years each. This Agreement shall be deemed automatically renewed for a single succeeding five year term up to a limit of 25 years, unless either party gives the other written notice not less than one year prior to the nominal expiration of term of its intent not to renew this agreement. If District enters into an intergovernmental agreement with any other city in its territory covering the same subject as this Agreement and if any of the provisions of the other agreement differ from this Agreement, the City may elect to replace any provision of this Agreement with the parallel provision from the other agreement, with the exception of Appendix A and Exhibit A. The replacement shall be effective on receipt by District of written notice from the City. This Agreement may not otherwise be modified except by written amendment or as otherwise specified in this Agreement.

Section 8. Amendments

At any time, either party may request in writing to open this Agreement for specific amendment. If such request is made, the other party must respond within 90 days. If the parties do not agree and the party requesting such amendment desires to proceed with the amendment, then remedies pursuant to Section 6 shall apply. All amendments shall be in writing and approved by the governing body of the respective parties.

Section 9. Severability

In the event a court of competent jurisdiction shall deem any portion or part of this agreement to be unlawful or invalid, only that portion or part of the agreement shall be considered unenforceable. The remainder of this agreement shall continue to be valid.

IN WITNESS WHEREOF, this instrument has been executed in duplicate by authority of lawful actions by the Council and District Board of Directors.

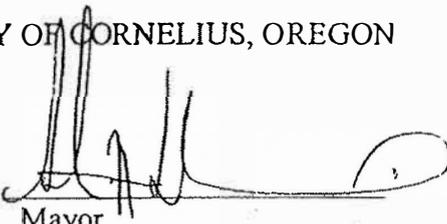
CLEAN WATER SERVICE
OF WASHINGTON COUNTY, OREGON

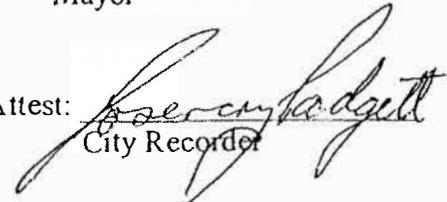
By _____
Chairman, Board of Directors

Approved as to Form:

Attorney for District

CITY OF CORNELIUS, OREGON

By 
Mayor

Attest: 
City Recorder

City Attorney

APPENDIX A

Jan, 2004

DIVISION OF RESPONSIBILITIES

EFFECTIVE JULY 1, 2004 to JUNE 30, 2005

	Inside City, and Inside Responsibility Boundary	Outside City, and Inside Responsibility Boundary	Inside City, and Outside Responsibility Boundary
Cornelius			
Sanitary Maintenance			
Lines under 24"			
Line Cleaning	City	City	
Root Cutting	City	City	
Emergency response	City	City	
Overflow and Complaint response			
Investigation and reporting	City	City	
Cross connection investigation and response	City	City	
Manhole adjustment	City	City	
Non-structure line sealing and point repair	City and District	District	
Manhole rehabilitation (sealing)	City and District	District	
TV inspection	City	City	
Compilation of TV reports and system evaluation	City and District	City and District	
I&I abatement and system rehabilitation projects	City and District	City and District	
Root Foaming	City and District	District	
Structural line repairs	City	City	
Lateral Repairs in Public Right of Way	City	City	
Line replacements	City	City	
Pump station maintenance	District	District	
Vector Control	City	City	
Offroad inspection and locator post maintenance	City	City	
Easement and Access Road Maintenance	City	City	
Lines 24" and Larger			
All maintenance, inspection, repair, and replacement	District	District	
SWM Maintenance			
Line Cleaning	City	City	
Root Cutting	City	City	
Catch Basin cleaning	City	City	
Water quality manhole maintenance	City	City	
Storm and emergency response	City	City	
Complaint response investigation and reporting	City	City	
Street Sweeping	City	City	
Water Quality facility maintenance	City for local, District for Regional	City for local, District for Regional	

	City for local, District, City for local, District' for Regional	City for local, District' for Regional
Water Quantity facility maintenance		
Maintenance of public Streams/creeks/open channels	City	City
Processing and disposal of sweeper, catch basin and storm line material (excluding leaves)	City and District	City and District
Structural line repairs	City	City
Line replacements	City	City
Pump station maintenance and operation	District	District
Roadside ditches and piping system in County Roads	District	District
Roadside ditches and piping system in City Roads	City, Funded by Street Fund	None
TV inspection	City	City
Compilation of TV reports and system evaluation	City and District	City and District
Proactive Leaf management program	City	City
Utility Locates	City	City
ENGINEERING, INSPECTION, AND SUPPORT ELEMENTS		
Development Process (development review plan review)	District and City	District and City
Sanitary Sewer connection permit issuance	City	District
SWM connection permit issuance	City	District
Billing and collection of monthly service charges	City	District
Inspection of developer projects	City	District
Installation of Sanitary Sewer Masterplan Projects	City 21" and under, District 24" & up	District
Installation of Masterplan Pump Station Projects	District	District
Installation of SWM Masterplan Projects	City	District
Erosion control permit issuance	City	District
Erosion control inspection	City	District
Accounting	City	District
Industrial Waste Program	District	District
Fat, Oil and Grease Program	City and District	District
Maintaining GIS information	City and District	City and District
Maintaining system mapping	City and District	City and District
Maintaining Engineering records of systems	City and District	City and District
Preparing and revising sanitary sewer masterplans	City 10" and less, District above 10"	District
Preparing and revising SWM masterplans	City and District	District
Response to customer billing inquiries	City	District
Public information, newsletters, etc., for SWM and Sanitary programs	City and District	City and District

Flow Monitoring	District	District	
Formation and Administration of LID's	City and District	District	
Inspection of Private Facilities	City	District	
Marking Utilities	City	City	
Fixture Counting	City	District	
Field Yard General Maintenance	City	City	

APPENDIX A		Jan-04		
DIVISION OF RESPONSIBILITIES		EFFECTIVE JULY 1, 2005		
		Inside City, and Inside Responsibility Boundary	Outside City, and Inside Responsibility Boundary	Inside City, and Outside Responsibility Boundary
Comelius				
Sanitary Maintenance				
Lines under 24"				
	Line Cleaning	City	City	
	Root Cutting	City	City	
	Emergency response	City	City	
	Overflow and Complaint response investigation and reporting	City	City	
	Cross connection investigation and response	City	City	
	Manhole adjustment	City	City	
	Non-structure line sealing and point repair	District	District	
	Manhole rehabilitation (sealing)	District	District	
	TV inspection	City	City	
	Compilation of TV reports and system evaluation	City and District	City and District	
	I&I abatement and system rehabilitation projects	City and District	City and District	
	Root Foaming	District	District	
	Structural line repairs	City	City	
	Lateral Repairs in Public Right of Way	City	City	
	Line replacements	City	City	
	Pump station maintenance	District	District	
	Vector Control	City	City	
	Offroad inspection and locator post maintenance	City	City	
	Easement and Access Road Maintenance	City	City	
Lines 24" and Larger				
	All maintenance, inspection, repair, and replacement	District	District	
SWM Maintenance				
	Line Cleaning	City	City	
	Root Cutting	City	City	
	Catch Basin cleaning	City	City	
	Water quality manhole maintenance	City	City	
	Storm and emergency response	City	City	
	Complaint response investigation and reporting	City	City	
	Street Sweeping	City	City	
	Water Quality facility maintenance	City for local, District for Regional	City for local, District for Regional	

	City for local, District for Regional	City for local, District for Regional	
Water Quantity facility maintenance			
Maintenance of public Streams/creeks/open channels	City	City	
Processing and disposal of sweeper, catch basin and storm line material (excluding leaves)	City and District	City and District	
Structural line repairs	City	City	
Line replacements	City	City	
Pump station maintenance and operation	District	District	
Roadside ditches and piping system in County Roads	District	District	
Roadside ditches and piping system in City Roads	City, Funded by Street Fund	None	
TV inspection	City	City	
Compilation of TV reports and system evaluation	City and District	City and District	
Proactive Leaf management program	City	City	
Utility Locates	City	City	
ENGINEERING, INSPECTION, AND SUPPORT ELEMENTS			
Development Process (development review, plan review)	District and City	District and City	
Sanitary Sewer connection permit issuance	City	District	
SWM connection permit issuance	City	District	
Billing and collection of monthly service charges	City	District	
Inspection of developer projects	City	District	
Installation of Sanitary Sewer Masterplan Projects	City 21" and under, District 24" & up	District	
Installation of Masterplan Pump Station Projects	District	District	
Installation of SWM Masterplan Projects	City	District	
Erosion control permit issuance	City	District	
Erosion control inspection	City	District	
Accounting	City	District	
Industrial Waste Program	District	District	
Fat, Oil and Grease Program	District	District	
Maintaining GIS information	City and District	City and District	
Maintaining system mapping	City and District	City and District	
Maintaining Engineering records of systems	City and District	City and District	
Preparing and revising sanitary sewer masterplans	City 10" and less, District above 10"	District	

	City-conveyance system in city limits, District- water quality and technical standards, and regional planning	District	
Preparing and revising SWM masterplans		District	
Response to customer billing inquiries	City	District	
Public information, newsletters, etc., for SWM and Sanitary programs	City and District	City and District	
Flow Monitoring	District	District	
Formation and Administration of LID's	City and District	District	
Inspection of Private Facilities	City	District	
Marking Utilities	City	City	
Fixture Counting	City	District	
Field Yard General Maintenance	City	City	

Appendix C

CMOM Program and Self Assessment Checklist

About the CMOM Program Self Assessment Checklist

Introduction

A sanitary sewer collection system is a vital element of any community's infrastructure and a critical component of the wastewater treatment process. The nation's sanitary sewer infrastructure has been built over the last 100 years or more using a variety of materials, design standards, installation techniques, and maintenance practices. As this valuable infrastructure ages, the importance of preventive and predictive maintenance increases.

What is CMOM?

CMOM stands for "capacity, management, operations, and maintenance." It is a flexible, dynamic framework for municipalities to identify and incorporate widely-accepted wastewater industry practices to:

- Better manage, operate, and maintain collection systems
- Investigate capacity constrained areas of the collection system
- Respond to sanitary sewer overflow (SSO) events

The CMOM approach helps municipal wastewater utility operators provide a high level of service to customers and reduce regulatory noncompliance. CMOM can help utilities optimize use of human and material resources by shifting maintenance activities from "reactive" to "predictive"--often leading to cost savings through avoided overtime, emergency construction costs, increased insurance premiums, and the possibility of lawsuits. CMOM information and documentation can also help improve communications with the public, other municipal works and regional planning organizations, and regulators.

In CMOM planning, the utility selects performance goal targets, and designs CMOM activities to meet the goals. The CMOM planning framework covers operation and maintenance (O&M) planning, capacity assessment and assurance, capital improvement planning, and financial management planning. Information collection and management practices are used to track how well each CMOM activity is meeting the performance goals, and whether overall system efficiency is improving. On an ongoing basis, activities are reviewed and adjusted to better meet the performance goals. As the CMOM program progresses, performance goals can change. For instance, an initial goal may be to develop a geographic information system (GIS) of the system. Once the GIS is complete, a new goal might be to use the GIS to track emergency calls and use the information to improve maintenance planning.

An important component of a successful CMOM program is to periodically collect information on current systems and activities and develop a "snapshot-in-time" analysis. From this analysis, the utility establishes its performance goals and plans its CMOM program activities.

Additional information describing CMOM can be found at: www.epa.gov/npdcs/ssc or www.epa.gov/region4/water/wpeb/pdfs/self-audit_review2-3.pdf.

About this Checklist (Continued)

What is the purpose of the CMOM program checklist?

This document is a screening-level tool that can help utilities evaluate CMOM programs and identify general areas of strength and weakness. Completing this CMOM assessment will allow the utility to flag CMOM program areas that need improvement and establish priorities for additional, more detailed assessments. In addition, the checklist will allow the utility to compare annual performance (e.g., percent of employees meeting training standards).

This document is not intended to be all-inclusive. It addresses the types of practices EPA believes should be considered by most utilities when implementing a CMOM program. However, the ways in which utilities use the information gathered through the checklist will depend on the complexity and site-specific issues facing individual collection systems. When reviewing the questions, utilities should use their judgment to determine if the question is reasonable for their collection system size and design.

How do I use this checklist?

The questions on the checklist will request answers in three different formats:

- Check yes, no, or not applicable (NA),
- Fill in the blank, and
- Check all that apply.

At the end of each section, additional space is provided to allow for comments on or explanations of the answers recorded (information that will be useful to the utility in follow-on planning). Each utility should make an effort to answer all the questions that are applicable to its system. If a particular question takes a significant amount of time to answer, this could be an indication of an area of weakness. Utilities should plan to invest approximately one day to complete the checklist.

This document is designed to help utilities perform an initial evaluation of CMOM activities. **It is not intended to serve as an absolute indicator of a successful CMOM program, nor will all of the questions apply to every utility.** By working through these questions, utilities will be able to identify strengths and areas for improvements in their CMOM programs. If a utility has a significant number of "no" answers or very few items selected in the checklist, this could indicate an area of weakness. The utility manager then can make a more detailed evaluation, including identifying specific actions needed to address areas for improvement.

General Information

CHECKLIST COMPLETED BY:

Date

Name

Daytime Telephone Number

UTILITY CONTACT INFORMATION	
Utility Name _____	
LOCATION _____ Street Address _____ Street Address (Secondary) _____ _____	STATE _____ Zip _____ City _____ _____

PERMITTED TREATMENT & COLLECTION FACILITIES				
NPDES or STATE PERMIT #	PERMITTEE/CO-PERMITTEE/JURISDICTIONS	UTILIZATION	Collection System	Wastewater Facility
<input type="text"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="text"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="text"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="text"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="text"/>	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Collection System Description

SYSTEM INVENTORY		Conveyance & Pumping			
Treatment Facilities	# of Treatment facilities	<input type="text"/>	Gravity Sewers	Force Mains	Pump Stations
	WWTP design capacity	<input type="text"/>	Pipes and pumps Length/quantity	<input type="text"/>	<input type="text"/>
	Average daily flow	<input type="text"/>	Age of system 0 - 25 years old	<input type="text"/> %	<input type="text"/> %
	Average dry weather flow	<input type="text"/>	26 - 50 years old	<input type="text"/> %	<input type="text"/> %
Access & Maintenance	Manholes	<input type="text"/>	51 - 75 years old	<input type="text"/> %	<input type="text"/> %
	Number of air vacuum relief valves	<input type="text"/>	>76 years old	<input type="text"/> %	<input type="text"/> %
			Number of inverted siphons	<input type="text"/>	<input type="text"/>

SERVING AREA CHARACTERISTICS																							
Service area	<input type="text"/>	<table border="1"> <thead> <tr> <th colspan="4">Number of Service Connections</th> </tr> <tr> <th>Residential</th> <th>Commercial</th> <th>Industrial</th> <th>TOTAL</th> </tr> </thead> <tbody> <tr> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> </tr> <tr> <td>NUMBER</td> <td>+</td> <td>NUMBER</td> <td>+</td> <td>NUMBER</td> <td>=</td> <td>NUMBER</td> </tr> </tbody> </table>			Number of Service Connections				Residential	Commercial	Industrial	TOTAL	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	NUMBER	+	NUMBER	+	NUMBER	=	NUMBER
Number of Service Connections																							
Residential	Commercial	Industrial	TOTAL																				
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>																				
NUMBER	+	NUMBER	+	NUMBER	=	NUMBER																	
Service population	<input type="text"/>																						
Annual precipitation	<input type="text"/>																						
Collection system service lateral responsibility (check one) <table border="0"> <tr> <td><input type="checkbox"/> All main line connection only</td> <td><input type="checkbox"/> Beyond property line/clean out</td> </tr> <tr> <td><input type="checkbox"/> From main line to property line or easement/cleanout</td> <td><input type="checkbox"/> Other _____</td> </tr> </table>					<input type="checkbox"/> All main line connection only	<input type="checkbox"/> Beyond property line/clean out	<input type="checkbox"/> From main line to property line or easement/cleanout	<input type="checkbox"/> Other _____															
<input type="checkbox"/> All main line connection only	<input type="checkbox"/> Beyond property line/clean out																						
<input type="checkbox"/> From main line to property line or easement/cleanout	<input type="checkbox"/> Other _____																						
Combined Sewer Systems What percent of sewer system is served by combined sewers (i.e., sanitary sewage and storm water in the same pipe)? <input type="text"/> %																							

Collection System Description

	Gravity Sewers	Force Mains
PIPE DIAMETER		
8 inches or less	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
9 - 18 inches	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
19 - 36 inches	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
> 36 inches	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
PIPE MATERIALS		
Prestressed concrete cylinder pipe (PCCP)	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
High density polyethylene (HDPE)	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Reinforced concrete pipe (RCP)	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Polyvinyl chloride (PVC)	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Vitrified clay pipe (VCP)	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Ductile iron	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Non-reinforced concrete pipe	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Asbestos cement pipe	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Cast iron	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Brick	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Fiberglass	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>
Other (Explain) _____	<input type="text"/> % <small>PERCENT</small>	<input type="text"/> % <small>PERCENT</small>

Engineering Design (ED)

ED-01	Is there a document which includes design criteria and standard construction details?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-02	Is there a document that describes the procedures that the utility follows in construction design review?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-03	Are WWTP and O&M staff involved in the design review process?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-04	Is there a procedure for testing and inspecting new or rehabilitated system elements both during and after the construction is completed?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-05	Are construction sites supervised by qualified personnel (such as professional engineers or certified engineering technicians) to ascertain that the construction is taking place in accordance with the agreed upon plans and specifications?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-06	Are new manholes tested for inflow and infiltration?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-07	Are new gravity sewers checked using closed circuit TV inspection?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-08	Does the utility have documentation on private service lateral design and inspection standards?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
ED-09	Does the utility attempt to standardize equipment and sewer system components?	<input type="checkbox"/> YES	<input type="checkbox"/> NO

Satellite Communities and Sewer Use Ordinance (SUO)

SUO-01 Does the utility receive flow from satellite communities? IF NO, GO TO PAGE 6 YES NO

SUO-02 What is the total area from satellite communities that contribute flow to the collection system? (Acres or square miles) _____

SUO-03 Does the utility require satellite communities to enter into an agreement? IF NO, GO TO QUESTION SUO-06. YES NO

SUO-04 Does the agreement include the requirements listed in the sewer use ordinance (SUO)? YES NO

SUO-05 Do the agreements have a date of termination and allow for renewal under different terms? YES NO

SUO-06 Does the utility maintain the legal authority to control the maximum flow introduced into the collection system from satellite communities? YES NO

SUO-07 Are standards, inspections, and approval for new connections clearly documented in a SUO? YES NO

SUO-08 Does the SUO require satellite communities to adopt the same industrial and commercial regulator discharge limits as the utility? YES NO

SUO-09 Does the SUO require satellite communities to adopt the same inspection and sampling schedules as required by the pretreatment ordinance? YES NO

SUO-10 Does the SUO require that satellite communities or the utility to issue control permits for significant industrial users? YES NO

SUO-11 Does the SUO contain provisions for addressing overstrength wastewater from satellite communities? YES NO

SUO-12 Does the SUO contain procedures for the following? (Check all that apply)

Inspection standards Pretreatment requirements Building/sewer permit issues

SUO-13 Does the SUO contain general prohibitions of the following materials? (Check all that apply)

Fire and explosions hazards Corrosive materials Obstructive materials

Oils or petroleum Material which may cause interference at the wastewater treatment plant

SUO-14 Does the SUO contain procedures and enforcement actions for the following? (Check all that apply)

Fats, oils, and grease (FOG) Storm water connections to sanitary lines (downspouts)

Infiltration and inflow Defects in service laterals located on private property

Building structures over the sewer lines Sump pumps, air conditioner connections

Organizational Structure (OC)

OC-01 Is an organizational chart available that shows the overall personnel structure for the utility, including operation and maintenance staff? YES NO

OC-02 Are up-to-date job descriptions available that delineate responsibilities and authority for each position? YES NO

OC-03 Are the following items discussed in the job descriptions? (Check all that apply)

<input type="checkbox"/> Nature of work to be performed	<input type="checkbox"/> Examples of the types of work
<input type="checkbox"/> Minimum requirements for the position	<input type="checkbox"/> List of licenses required for the position
<input type="checkbox"/> Necessary special qualifications or certifications	<input type="checkbox"/> Performance measures or production potential

OC-04 What percent of staff positions are currently vacant? _____ %

OC-05 On average how long do positions remain vacant? (months) _____

OC-06 What percent of utility work is contracted out? _____ %

Internal Communications (IC)

IC-01 Which of the following methods are used to communicate with utility staff? (Check all that apply)

Regular meetings Bulletin boards E-mail Other (walkie talkie/pager)

IC-02 How often are staff meetings held? (e.g. Daily, Weekly, Monthly, etc.)

IC-03 Are incentives offered to employees for performance improvements? YES NO

IC-04 Does the utility have an "Employee of the Month/Quarter/Year" program? YES NO

IC-05 How often are performance reviews conducted? (e.g. Semi-annually, Annually, etc.)

IC-06 Does the utility regularly communicate/coordinate with other municipal departments? YES NO

Budgeting (BUD)

BUD-01 What is the average annual fee for residential users? \$ _____

BUD-02 How often are user charges evaluated and adjusted? (e.g. annually, biannually, etc.) _____

BUD-03 Are utility-generated funds used for non-utility programs? YES NO

BUD-04 Are costs for collection system operation and maintenance (O&M) separated from other utility services such as water, storm water, and treatment plants? IF NO, GO TO QUESTION BUD-07. YES NO

BUD-05 What is your average annual (O&M) budget? \$ _____

BUD-06 What percentage of the utility's overall budget is allocated to maintenance of the collection system? _____ %

BUD-07 Does the utility have a Capital Improvement Plan (CIP) that provides for system repairs/replacements on a prioritized basis? YES NO

BUD-08 What is your average annual CIP budget? \$ _____

BUD-09 What percentage of the maintenance budget is allotted to the following maintenance?

Predictive maintenance (tracking design, life span, and scheduled parts replacements)	_____ %
Preventive maintenance (identifying and fixing system weaknesses which, if left unaddressed, could lead to overflows)	_____ %
Corrective maintenance (fixing system components that are functioning but not at 100% capacity/efficiency, for example partially blocked lines)	_____ %
Emergency maintenance (reactive maintenance, overflows, equipment breakdowns)	_____ %

BUD-10 Does the utility have a budgeted program for the replacement of under-capacity pipes? YES NO

BUD-11 Does the utility have a budgeted program for the replacement of over-capacity pipes? YES NO

Training (TR)

- TR-01 Does the utility have a formal job knowledge, skills, and abilities (KSA) training program? YES NO
- TR-02 Does the training program address the fundamental mission, goals, and policies of the utility? YES NO
- TR-03 Does the utility have mandatory training requirements identified for key employees? YES NO

TR-04 What percentage of employees met or exceeded their annual training goals during the past year? _____ %

TR-05 Does the utility provide training in the following areas? (Check all that apply)

<input type="checkbox"/> Safety	<input type="checkbox"/> Traffic control	<input type="checkbox"/> Public relations
<input type="checkbox"/> Routine line maintenance	<input type="checkbox"/> Record keeping	<input type="checkbox"/> SSO/Emergency response
<input type="checkbox"/> Confined space entry	<input type="checkbox"/> Electrical and instrumentation	<input type="checkbox"/> Pump station operations and maintenance
<input type="checkbox"/> Other	<input type="checkbox"/> Pipe repair	<input type="checkbox"/> CCTV and trench/shoring
	<input type="checkbox"/> Bursting/CIPP	

- TR-06 Are operator and maintenance certification programs used? IF NO, GO TO QUESTION TR-08 YES NO
- TR-07 Are operator and maintenance certification programs required? YES NO
- TR-08 Is on-the-job training progress and performance measured? YES NO

TR-09 Which of the following methods are used to assess the effectiveness of the training? (Check all that apply)

None Periodic testing Drills Demonstrations

TR-10 What percentage of the training offered by the utility is in the form of the following?

Manufacturer training _____ %	In-house classroom training _____ %
On-the-job training _____ %	Industry-wide training _____ %

Safety (SAF)

- SAF-01 Does the utility have a written safety policy? YES NO
- SAF-02 How often are safety procedures reviewed and revised? (e.g. *Semiannually, Annually, etc.*) YES NO
- SAF-03 Does the utility have a safety committee? YES NO
- SAF-04 Are regular safety meetings held with the utility employees? YES NO
- SAF-05 Does the utility have a safety training program? YES NO
- SAF-06 Are records of employee safety training kept up to date? YES NO

SAF-07 Does the utility have written procedures for the following? (Check all that apply)

<input type="checkbox"/> Lockout/tagout	<input type="checkbox"/> Biological hazards and wastewater
<input type="checkbox"/> Material safety data sheets (MSDS)	<input type="checkbox"/> Traffic control and work site safety
<input type="checkbox"/> Chemical handling	<input type="checkbox"/> Electrical and mechanical systems
<input type="checkbox"/> Confined spaces permit program	<input type="checkbox"/> Pneumatic and hydraulic systems safety
<input type="checkbox"/> Trenching and excavations safety	

SAF-08 What is your agency's lost time injury and ... /6 or ... hours

SAF-09 Are the following equipment items available and in adequate supply? (Check all that apply)

<input type="checkbox"/> Rubber/disposable gloves	<input type="checkbox"/> Full body harness
<input type="checkbox"/> Confined space ventilation equipment	<input type="checkbox"/> Protective clothing
<input type="checkbox"/> Hard hats, safety glasses, rubber boots	<input type="checkbox"/> Traffic/public access control equipment
<input type="checkbox"/> Antibacterial soap and first aid kit	<input type="checkbox"/> 5-minute escape breathing devices
<input type="checkbox"/> Tripods or non-entry rescue equipment	<input type="checkbox"/> Life preservers for lagoons
<input type="checkbox"/> Fire extinguishers	<input type="checkbox"/> Safety buoy at activated sludge plant
<input type="checkbox"/> Equipment to enter manholes	<input type="checkbox"/> Fiberglass or wooden ladders for electrical work
<input type="checkbox"/> Portable crane/hoist	<input type="checkbox"/> Respirators and/or self contained breathing apparatus
<input type="checkbox"/> Atmospheric testing equipment and gas detectors	<input type="checkbox"/> Methane gas or optical vector (OVA) analyzer
<input type="checkbox"/> Oxygen sensors	<input type="checkbox"/> Lower explosion limit (LEL) metering
<input type="checkbox"/> H ₂ S Monitors	

- SAF-10 Are safety monitors clearly identified? YES NO

Customer Service (CS)

CS-01 Does the utility have a customer service and public relations program? IF NO GO TO QUESTION CS-03 YES NO

CS-02 Does the customer service program include giving formal presentations on the wastewater field to the following? (Check all that apply)

<input type="checkbox"/> Schools and universities	<input type="checkbox"/> Local officials	<input type="checkbox"/> Media	<input type="checkbox"/> Building Inspector(s)
<input type="checkbox"/> Community gatherings	<input type="checkbox"/> Businesses	<input type="checkbox"/> Citizens	<input type="checkbox"/> Public utility officials

CS-03 Are employees of the utility specifically trained in customer service? YES NO

CS-04 Are there sample correspondence, Q/A's, or "scripts" to help guide staff through written or oral responses to customers? YES NO

CS-05 What methods are used to notify the public of major construction or maintenance work? (Check all that apply)

<input type="checkbox"/> Door hangers	<input type="checkbox"/> Newspaper	<input type="checkbox"/> Flyers	<input type="checkbox"/> Signs	<input type="checkbox"/> Other	<input type="checkbox"/> None
<input type="checkbox"/> Public radio or TV announcements					

CS-06 Is a homeowner notified prior to construction that his/her property may be affected? YES NO

CS-07 Do you provide information to residents on cleanup and safety procedures following basement backups and overflows from manholes when they occur? YES NO

CS-08 Does the utility have a customer service evaluation program to obtain feedback from the community? YES NO

CS-09 Do customer service records include the following information? (Check all that apply)

<input type="checkbox"/> Personnel who received the complaint or request	<input type="checkbox"/> Name, address, and telephone number of customer
<input type="checkbox"/> Nature of the complaint or request	<input type="checkbox"/> Location of the problem
<input type="checkbox"/> To whom the follow-up action was assigned	<input type="checkbox"/> Date the follow-up action was assigned
<input type="checkbox"/> Date of the complaint or request	<input type="checkbox"/> Cause of the problem
<input type="checkbox"/> Date the complaint or request was resolved	<input type="checkbox"/> Feedback to customer
<input type="checkbox"/> Total days to end the problem	

CS-10 Does the utility have a goal for how quickly customer complaints (or emergency calls) are resolved? IF NO, GO TO THE NEXT PAGE. YES NO

CS-11 What percentage of customer complaints (or emergency calls) are resolved within the timeline goals? _____ %

Equipment and Collection System Maintenance (ESM)

ESM-01 Is a maintenance card or record kept for each piece of mechanical equipment within the collection system? IF NO, GO TO QUESTION ESM-03. YES NO

ESM-02 Do equipment maintenance records include the following information? (Check all that apply)

<input type="checkbox"/> Maintenance recommendation	<input type="checkbox"/> Maintenance schedule
<input type="checkbox"/> Instructions on conducting the specific maintenance activity	<input type="checkbox"/> A record of maintenance on the equipment to date
<input type="checkbox"/> Other observations on the equipment	

ESM-03 Are dated tags used to show out-of-service equipment? YES NO

ESM-04 Is there an established system for prioritizing equipment maintenance needs? YES NO

ESM-05 What percent of repair funds are spent on emergency repairs? _____ / %

ESM-06 Are corrective repair work orders backlogged more than six months? YES NO

ESM-07 Do collection system personnel coordinate with state, county, and local personnel on repairs, before the street is paved? YES NO

Equipment Parts Inventory (EPI)

- EPI-01 Have critical spare parts been identified? YES NO
- EPI-02 Are adequate supplies on hand to allow for two point repairs in any part of the system? YES NO
- EPI-03 Is there a parts standardization policy in place? YES NO
- EPI-04 Does the utility have a central location for storing spare parts? YES NO
- EPI-05 Does the utility maintain a stock of spare parts on its maintenance vehicles? YES NO
- EPI-06 Does the utility have a system in place to track and maintain an accurate inventory of spare parts? YES NO
- EPI-07 For those parts which are not kept in inventory, does the utility have a readily available source or supplier? YES NO

Management Information System (MIS)

- MIS-01 Does the utility have a management information system (MIS) in place for tracking maintenance activities? (Either electronic or good paper files) IF NO, GO TO PAGE 15. YES NO
- MIS-02 Are the MIS records maintained for a period of at least three years? YES NO
- MIS-03 Is the MIS able to distinguish activities taken in response to an overflow event? YES NO

MIS-04 Are there written instructions for managing and tracking the following information? (Check all that apply)

<input type="checkbox"/> Complaint work orders	<input type="checkbox"/> Scheduled inspections	<input type="checkbox"/> Compliance/overflow tracking
<input type="checkbox"/> Scheduled work orders	<input type="checkbox"/> Sewer system inventory	<input type="checkbox"/> Equipment/tools tracking
<input type="checkbox"/> Customer service	<input type="checkbox"/> Safety incidents	<input type="checkbox"/> Parts inventory
<input type="checkbox"/> Scheduled preventive maintenance	<input type="checkbox"/> Scheduled monitoring/sampling	

MIS-05 Do the written instructions for tracking procedures include the following information? (Check all that apply)

<input type="checkbox"/> Accessing data and information	<input type="checkbox"/> Updating the MIS
<input type="checkbox"/> Instructions for using the tracking system	<input type="checkbox"/> Developing and printing reports

MIS-06 How often is the management information system updated? (Check one)

<input type="checkbox"/> Immediately	<input type="checkbox"/> Within one week of the "incident"
<input type="checkbox"/> Monthly	<input type="checkbox"/> As time permits

System Mapping (MAP)

- MAP-01 Are "as built" plans (record drawings) or maps available for use by field crews in the office and in the field? YES NO
- MAP-02 Is there a procedure for field crews to record changes or inaccuracies in the maps and update the mapping system? YES NO
- MAP-03 Do the maps show the date the map was drafted and the date of the last revision? YES NO

MAP-04 Do the sewer line maps include the following? *(Check all that apply)*

<input type="checkbox"/> Scale	<input type="checkbox"/> Street names	<input type="checkbox"/> Pipe material
<input type="checkbox"/> North arrow	<input type="checkbox"/> SSOs occurrences/CSOs outfalls	<input type="checkbox"/> Pipe diameter
<input type="checkbox"/> Date the map was drafted	<input type="checkbox"/> Flow monitors	<input type="checkbox"/> Installation date
<input type="checkbox"/> Date of last revision	<input type="checkbox"/> Force mains	<input type="checkbox"/> Slope
<input type="checkbox"/> Service area boundaries	<input type="checkbox"/> Pump stations	<input type="checkbox"/> Manhole rim elevation
<input type="checkbox"/> Property lines	<input type="checkbox"/> Lined sewers	<input type="checkbox"/> Manhole coordinates
<input type="checkbox"/> Other landmarks (Roads, water bodies, etc.)	<input type="checkbox"/> Main trunk and interceptor sewers	<input type="checkbox"/> Manhole invert elevation
<input type="checkbox"/> Manhole and other access points	<input type="checkbox"/> Easement lines and dimensions	<input type="checkbox"/> Distance between manholes
<input type="checkbox"/> Location of building laterals		

MAP-05 Are the following sewer attributes recorded? *(Check all that apply)*

<input type="checkbox"/> Size	<input type="checkbox"/> Invert elevation	<input type="checkbox"/> Separate/combined sewer
<input type="checkbox"/> Shape	<input type="checkbox"/> Material	<input type="checkbox"/> Installation Date

MAP-06 Are the following manhole attributes recorded? *(Check all that apply)*

<input type="checkbox"/> Shape	<input type="checkbox"/> Depth	<input type="checkbox"/> Age
<input type="checkbox"/> Type (e.g., precast, cast in place, etc.)	<input type="checkbox"/> Material	

- MAP-07 Is there a systematic numbering and identification method/system established to identify sewer system manhole, sewer lines, and other items (pump stations, etc.)? YES NO

Internal TV Inspection (TVI)

- TVI-01 Does the utility have a standardized pipeline condition assessment program? YES NO
- TVI-02 Is internal TV inspection used to perform condition assessment? IF NO, GO TO PAGE 17. YES NO
- TVI-03 Are there written operation procedures and guidelines for the internal TV inspection program? YES NO

TVI-04 Do the internal TV record logs include the following? (Check all that apply)

<input type="checkbox"/> Pipe size, type, length, and joint spacing	<input type="checkbox"/> Internal TV operator name
<input type="checkbox"/> Distance recorded by internal TV	<input type="checkbox"/> Cleanliness of the line
<input type="checkbox"/> Results of the internal TV inspection (including a structural rating)	<input type="checkbox"/> Location and identification of line being televised by manholes

- TVI-05 Is a rating system used to determine the severity of the defects found during the inspection process? YES NO
- TVI-06 Is there documentation explaining the codes used for internal TV results reporting? YES NO

TVI-07 Approximately what percent of the total defects determined by TV inspection during the past 5 years were the following?

Failed coatings or linings _____ %	Line deflection _____ %
House connection leaks _____ %	Joint separation _____ %
Illegal connections _____ %	Crushed pipes _____ %
Pipe corrosion (H ₂ S) _____ %	Collapsed pipes _____ %
Fats, oil, and grease _____ %	Offset joints _____ %
Broken pipes _____ %	Root intrusions _____ %
Debris _____ %	Minor cracks _____ %
Other _____ %	

- TVI-08 Are main line and lateral repairs checked by internal TV inspection after the repair(s) have been made? YES NO

Sewer Cleaning (CLN)

CLN-01 What is the system cleaning frequency? (the entire system is cleaned every _____ years) _____ %

CLN-02 What is the utility's plan for system cleaning (% or frequency in years)? _____ %

CLN-03 What percent of the sewer lines are cleaned, even high/repeat cleaning trouble spots during the past year? _____ %

CLN-04 Is there a program to identify sewer line segments, with chronic problems, that should be cleaned on a more frequent schedule? YES NO

CLN-05 Does the utility have a root control program? YES NO

CLN-06 Does the utility have a fats, oils, and grease (FOG) program? YES NO

CLN-07 What is the average number of stoppages experienced per mile of sewer pipe per year? _____ %

CLN-08 Has the number of stoppages increased, decreased, or stayed the same over the past _____ years?
 Increased Decreased Stayed the same

CLN-09 Are stoppages plotted on maps and correlated with other data such as pipe size and material or location? YES NO

CLN-10 Do the sewer cleaning records include the following information? (Check all that apply)

<input type="checkbox"/> Date and time	<input type="checkbox"/> Method of cleaning	<input type="checkbox"/> Identity of cleaning crew
<input type="checkbox"/> Cause of stoppage	<input type="checkbox"/> Location of stoppage or routine cleaning activity	<input type="checkbox"/> Further actions necessary/initiated

CLN-11 If sewer cleaning is done by a contractor are videos taken of before and after cleaning? YES NO

Manhole Inspection and Assessment (MAN)

MAN-01 Does the utility have a routine manhole inspection and assessment program? IF NO, GO TO QUESTION MAN-06. YES NO

MAN-02 Are the results and observations from the routine manhole inspections recorded? YES NO

MAN-03 Does the utility have a goal for the number of manholes inspected annually? YES NO

MAN-04 How many manholes were inspected during the past year? _____

MAN-05 Do the records for manhole/pipe inspection include the following? (Check all that apply)

<input type="checkbox"/> Conditions of the frame and cover	<input type="checkbox"/> Presence of corrosion
<input type="checkbox"/> Evidence of surcharge	<input type="checkbox"/> If repairs necessary
<input type="checkbox"/> Offsets or misalignments	<input type="checkbox"/> Manhole identification number/location
<input type="checkbox"/> Atmospheric hazards measurements (especially hydrogen sulfide)	<input type="checkbox"/> Wastewater flow characteristics (flowing freely or backed up)
<input type="checkbox"/> Details on the root cause of cracks or breaks in the manhole or pipe, including: <i>in-place</i>	<input type="checkbox"/> Accumulation of grease, fibers, or other debris
<input type="checkbox"/> Recording condition of (or lack of) walk boards (rough and pipe seals)	<input type="checkbox"/> Presence of infiltration, location and estimated quantity
	<input type="checkbox"/> Inlets from manhole covers

MAN-06 Does the utility have a grouting program? YES NO

Pump Stations (PS)

PS-01	Are Standard Operation Procedures (SOPs) and Standard Maintenance Procedures (SMPs) used for each pump station?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-02	Are there enough trained personnel to properly maintain all pump stations?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-03	Is there an emergency operating procedure for each pump station?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-04	Is there an alarm system to notify personnel of pump station failures and overflow?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-05	Percent of pump stations with back-up power sources	_____/_____%	
PS-06	Does the utility use the following methods when loss of power occurs? (Check all that apply)		
	<input type="checkbox"/> On-site electrical generators	<input type="checkbox"/> Portable electric generators	<input type="checkbox"/> Alternate power source
	<input type="checkbox"/> Other		
	<input type="checkbox"/> Vacuum trucks to bypass pump station		
PS-07	Is there a procedure for manipulating pump operations (manually or automatically) during wet weather to increase in-line storage of wet weather flows?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-08	Are wet well operating levels set to limit pump start/stops?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-09	Are the lead, lag, and backup pumps rotated regularly?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-10	Are operation logs maintained for all pump stations?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-11	Are the original manuals that contain the manufacturers recommended maintenance schedules for all pump station equipment easily available?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-12	On average, how often were pump stations inspected during the past year?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-13	Are records maintained for each inspection?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
PS-14	Average annual labor hours spent on pump station inspection	_____	
PS-15	Percent of pump stations with pump capacity redundancy	_____%	
PS-16	Percent of pump stations with dry weather capacity limitations	_____%	
PS-17	Percent of pump stations with wet weather capacity limitations	_____%	
PS-18	Percent of pump stations calibrated annually	_____%	
PS-19	Percent of pump stations with permanent flow meters	_____%	

Capacity Assessment (CA)

- CA-01 Does the utility have a flow monitoring program? YES NO
- CA-02 Does the utility have a comprehensive capacity assessment and planning program? YES NO
- CA-03 Are flows measured prior to allowing new connections? YES NO
- CA-04 Do you have a tool (hydraulic model, spreadsheet, etc.) for assessing whether adequate capacity exists in the sewer system? IF NO, GO TO QUESTION CA-06. YES NO
- CA-05 Does your capacity assessment tool produce results consistent with conditions observed in the system? YES NO

CA-06 What is the ratio of peak wet weather flow to average dry weather flow at the wastewater treatment plant? _____

CA-07 How many permanent flow meters are currently in the system? (Include meters at pump stations and wastewater treatment plants) _____

CA-08 How frequently are the flow meters checked? (e.g. Daily, Weekly, Monthly, etc.) _____

CA-09 Do the flow meter checks include the following? (Check all that apply)

Independent water level Velocity reading Downloading data

Checking the desiccant Cleaning away debris Battery condition

CA-10 Are records maintained for each inspection? IF NO, GO TO QUESTION CA-12. YES NO

CA-11 Do the flow monitoring records include the following? (Check all that apply)

Descriptive location of flow meter Frequency of flow meter inspection

Type of flow meter Frequency of flow meter calibration

- CA-12 Does the utility maintain any rain gauges or have access to local rainfall data? YES NO
- CA-13 Does the utility have any wet weather capacity problems? YES NO
- CA-14 Are low points or flood-plain areas monitored during rain events? YES NO
- CA-15 Does the utility have any dry weather capacity problems? YES NO
- CA-16 Is flow monitoring used for billing purposes, capacity analysis, and/or inflow and infiltration investigations? YES NO

Tracking SSOs (TRK)

TRK-01 How many SSO events have been reported in the past 5 years? _____

TRK-02 What percent of the SSOs were less than 1,000 gallons in the past 5 years? _____ %

TRK-03 Does the utility document and report all SSOs regardless of size? YES NO

TRK-04 Does the utility document basement backups? YES NO

TRK-05 Are there areas that experience frequent basement or street flooding? YES NO

TRK-06 Approximately what percent of SSO discharges were from each of the following in the last 5 years?

Manholes _____ %	Main and trunk sewers _____ %	Structural bypasses _____ %
Pump stations _____ %	Lateral and branch sewers _____ %	

TRK-07 Approximately what percent of SSO discharges were caused by the following in the last 5 years?

Debris buildup _____ %	Root intrusion _____ %	Excessive infiltration and inflow _____ %
Collapsed pipe _____ %	Capacity limitations _____ %	Fats, oil, and grease _____ %
Vandalism _____ %		

TRK-07A What percentage of SSOs were released to:

Soil _____ %	Basements _____ %	Paved area _____ %
Surface water (rivers/lakes/streams) _____ %	Coastal, ocean beaches _____ %	

TRK-07B For surface water releases, what percent are to areas that could affect:

Contact recreation (beaches, swimming, areas) _____ %	Drinking water sources _____ %
Shellfish growing areas _____ %	

TRK-08 How many chronic SSO locations are in the collection system? _____

TRK-09 Are pipes with chronic SSOs being monitored for sufficient capacity and/or structural condition? YES NO

TRK-10 Prior to collapse, are structurally deteriorating pipelines being monitored for renewal or replacement? YES NO

Overflow Emergency Response Plan (OERP)

OERP-01 Does the utility have a documented OERP available for utility staff to use? IF NO, GO TO QUESTION OERP-04. YES NO

OERP-02 How often is the OERP reviewed and updated? (*Annually, Biannually, etc.*)

OERP-03 Are specific responsibilities detailed in the OERP for personnel who respond to emergencies? YES NO

OERP-04 Are staff continuously trained and drilled to respond to emergency situations? YES NO

OERP-05 Do work crews have immediate access to tools and equipment during emergencies? YES NO

OERP-06 Does the utility have standard procedures for notifying state agencies, local health departments, the NPDES authority, the public, and drinking water authorities of significant overflow events? YES NO

OERP-07 Does the procedure include a current list of the names, titles, phone numbers, and responsibilities of all personnel involved? YES NO

OERP-08 Does the utility have a public notification plan? YES NO

OERP-09 Does the utility have procedures to limit public access to and contact with areas affected with SSOs? (*Procedure can be delegated to another authority*) YES NO

OERP-10 Does the utility use containment techniques to protect the storm drainage systems? YES NO

OERP-11 Do the overflow records include the following information? (*Check all that apply*)

<input type="checkbox"/> Date and time	<input type="checkbox"/> Location	<input type="checkbox"/> Any remediation efforts
<input type="checkbox"/> Cause(s)	<input type="checkbox"/> How it was stopped	<input type="checkbox"/> Estimated flow/volume discharged
<input type="checkbox"/> Names of affected receiving water(s)	<input type="checkbox"/> Duration of overflow	

OERP-12 Does the utility have signage to keep public from effected area? YES NO

Smoke and Dye Testing (SDT)

- SDT-01 Does the utility have a smoke testing program to identify sources of inflow and infiltration? YES NO
- SDT-01A Does the utility have a smoke testing program to identify sources of inflow and infiltration in illegal connectors? YES NO
- SDT-01B Does the utility have a smoke testing program to identify sources of inflow and infiltration in house laterals (private service laterals)? YES NO
- SDT-02 Are there written procedures for the frequency and schedule of smoke testing? YES NO
- SDT-03 Is there a documented procedure for isolating line segments? YES NO
- SDT-04 Is there a documented procedure for notifying local residents that smoke testing will be conducted in their area? YES NO

SDT-05 What is the guideline for the maximum amount of the line to be tested at one time? (Feet or Miles)

- SDT-06 Are there guidelines for the weather conditions under which smoke testing should be conducted? YES NO
- SDT-07 Does the utility have a goal for the percent of the system smoke tested each year? YES NO

SDT-08 What percent of the system has been smoke tested over the past year? 0/0

- SDT-09 Do the written records contain location, address, and description of the smoking element that produced a positive result? YES NO
- SDT-10 Does the utility have a dye testing program? YES NO
- SDT-11 Are there written procedures for dye testing? YES NO
- SDT-12 Does the utility have a goal for the percent of the system dye tested each year? YES NO

SDT-13 What percent of the main collection system has been dye tested over the past year? 0/0

- SDT-14 Does the utility share smoke and dye testing equipment with another utility? YES NO

Hydrogen Sulfide Monitoring and Control (HSMC)

HSCM-01 How would you rate the system's vulnerability for hydrogen sulfide corrosion? (Check only one)

Not a problem
 Only in a few isolated areas
 A major problem

HSCM-02 Does the utility have a corrosion control program? YES NO

HSCM-03 Does the utility take hydrogen sulfide corrosion into consideration when designing new or replacement sewers? YES NO

HSCM-04 Does the utility have written procedures for the application of chemical dosages? YES NO

HSCM-05 Are the chemical dosages, dates, and locations documented? YES NO

HSCM-06 Does the utility document where odor is a continual problem in the system? YES NO

HSCM-07 Does the utility have a program in place for renewing or replacing severely corroded sewer lines to prevent collapse? YES NO

HSCM-08 Are the following methods used for hydrogen sulfide control? (Check all that apply)

<input type="checkbox"/> Aeration	<input type="checkbox"/> Chlorine	<input type="checkbox"/> Potassium permanganate
<input type="checkbox"/> Iron salt	<input type="checkbox"/> Sulfur dioxide	<input type="checkbox"/> Sulfonamide
<input type="checkbox"/> Enzymes	<input type="checkbox"/> Hydrogen peroxide	<input type="checkbox"/> Other
<input type="checkbox"/> Activated charcoal canisters		

HSCM-09 Does the system contain air relief valves at the high points of the force main system? YES NO

HSCM-10 How often are the valves maintained and inspected? (Weekly, Monthly, etc.)

HSCM-11 Does the utility enforce pretreatment requirements? YES NO

Infrastructure Security

Although outside the scope of a CMOM program, municipal wastewater utilities should also consider security vulnerabilities. To reduce the threat of both intentional and natural disasters, the utility should take steps to implement appropriate countermeasures and develop or update emergency response plans.