City of Duvall

Sewer Utility Capital Improvement Program Update

October 2021

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ABBREVIATIONS

ATS: Automatic Transfer Switch
BOD: Biochemical Oxygen Demand
$CBOD_5$: Carbonaceous Biochemical Oxygen Demand
CCI: Cost Construction Index
CIP: Capital Improvement Program
CIPP: Cured-In-Place-Pipe
City: City of Duvall
CY: Cubic Yard
DO: Dissolved Oxygen
DMC: Duvall Municipal Code
DMRs: Discharge Monitoring Reports
Ecology: Washington State Department of Ecology
EPA: Environmental Protection Agency
EQ: Equalization
ERU: Equivalent Residential Unit
FOG: Fats, Oils, and Grease
FTE: Full-Time Equivalent
FY: Fiscal Year
GFC: General Facility Charge
GFCI: Ground Fault Circuit Interrupter
GIS: Geographic Information System
GMA: Growth Management Act
gpad: Gallons per Acre-Day
hp: Horsepower
HVAC: Heating, Ventilation, and Air Conditioning
I/I: Infiltration and Inflow
KCBLR: King County Buildable Lands Report
LED: light-emitting diode
MBR: Membrane Bioreactor
MCC: Motor Control Center
mgd: Million Gallons per Day
mm: Millimeter
MMDF: Maximum Month Daily Flow
NBOD: Nitrogenous Biological Oxygen Demand
NEC: National Electric Code
NPDES: National Pollutant Discharge Elimination System
O&M: Operation and Maintenance
OFM: Washington State Office of Financial Management
OSS: On-Site Sewage System

Permit: NPDES Permit #WA0029513
PPM: Parts Per Million
PRV: Pump Skid Pressure Reducing Valve
PVC: Polyvinyl Chloride
RCW: Revised Code of Washington
RTU: Remote Telemetry Unit
SF: Square Feet
SFR: Single Family Residence
SPD: Surge Suppression Device
TKN: Total Kjeldahl Nitrogen
THIRA: Threat and Hazard Identification and Risk Assessments
TMDL: Total Maximum Daily Load
TSS: Total Suspended Solids
UGA: Urban Growth Area
UGAR: Urban Growth Area Reserve
ULID: Utility Local Improvement District
UV: Ultraviolet
VFD: Variable Frequency Drive
WAC: Washington Administrative Code
WWTP: Wastewater Treatment Plant

1. INTRODUCTION

1.1 BACKGROUND

The City of Duvall (City) has worked with Parametrix to complete a Capital Improvement Program (CIP), Efficiency, and General Facility Charge Update study for the City's Sewer Utility. This Plan has been developed in accordance with the City's 2015 Comprehensive Plan and the Washington State Department of Ecology's (Ecology) Wastewater Treatment Plant National Pollution Discharge Elimination System (NPDES) Permit #WA0029513 (Permit). This plan supplements, but does not supersede, the 2001 Duvall Wastewater Facility Plan (Parametrix, 2001) as adopted and approved by Ecology in October 2001.

The City has evolved from a sparsely populated area of homes and businesses, concentrated around the Old Town center with surrounding farms and rural forest lands, to a developed (and still developing) suburban community in northeastern King County. The Sewer Utility has grown with the City and has adapted to changing regulations and environmental conditions and requirements. These changes are most notably tracked with Ecology's required discharge permit.

1.2 WHY UPDATE THE SEWER CAPITAL IMPROVEMENT PROGRAM?

No substantive changes to the 2001 Wastewater Facility Plan are included within this update. However, the City's 2015 Comprehensive Plan includes goals and policies that are directly relevant to the management of the Sewer Utility (City of Duvall, 2015). These goals and policies, along with Permit requirements, guide long-range planning as well as day-to-day operation of the Sewer Utility. The primary goal and associated policies for Sewer Utility management is included in the Capital Facilities Element - Chapter 7:

> **GOAL CF-7:** An effective and efficient wastewater treatment plant and collection system meets the needs of Duvall's present and future population.

Additional relevant goals and policies are included in the Land Use Element (Chapter 2) and the Environment and Sustainability Element (Chapter 8) of the 2015 Comprehensive Plan.

The 2001 Wastewater Facility Plan and 2003 FCS Group Sewer Rate and General Facilities Charge Analysis (FCS Group, INC., 2003) were based on forecasted growth estimates within the City at that time. Periodic updates with respect to current development forecasts provide for a more robust understanding of system operation and CIP project needs. Updated growth forecasts and CIP projects also provide a basis for updating the financial analysis and General Facilities Charge analysis to ensure long-term financial viability of the Sewer Utility.

1.3 TIMELINE FOR UPDATES AND AMENDMENTS

The City has experienced rapid growth since the effort to update this Sewer Utility CIP began. Because of the variation in growth, the "existing" conditions under which certain analyses were prepared vary slightly depending on the year in which the effort was completed. As such, for clarity, certain analyses are identified by the year in which the work was completed or amended (e.g., sewer system modeling in 2018, WWTP Capacity Evaluation updated in 2021).

1.4 REGULATORY REQUIREMENTS

Wastewater Treatment Systems, and associated Wastewater Facility Plans, are regulated under Revised Code of Washington (RCW) 90.48.110, Washington Administrative Code (WAC) 463-60-195, and WAC 173-240. The 2001 Wastewater Facility Plan includes provisions for full buildout of the system that exceeds the development forecasts contained within the 2015 Comprehensive Plan and subsequent forecasts within this CIP update and appendices. As such, a full update of the Facility Plan is not required at this time. Information contained in this report is intended to supplement the 2001 Facility Plan and provide an updated 20-year CIP that will be used as a basis for the annual 6-year Sewer Utility CIP Update. This CIP update also includes an overall evaluation of wastewater treatment plant (WWTP) operations and provides recommendations for possible efficiency improvements. Some of these recommended improvements are included as projects within the Sewer Utility CIP Update.

2. EXISTING CONDITIONS (2018)

2.1 SYSTEM DESCRIPTION

2.1.1 GENERAL DESCRIPTION OF CITY

Founded in 1913, the City of Duvall has grown from a small timber town to a well sought-after bedroom community. In the last 50 years, expanding suburban development from Seattle and Bellevue has led to growth in the City and throughout the Snoqualmie Valley. Agricultural activities are an important component of the economy and land use, with cattle and dairy operations, produce and crop farms, and greenhouse operations extending up and down the Valley. These activities have increased residential housing and associated businesses that have come to characterize the City and other surrounding urbanized areas.

2.1.2 WASTEWATER UTILITY HISTORY

Planning for the City's Sewer Utility began in 1967. On-site sewage systems (OSS), commonly known as "septic" systems were common in the City at that time. Planning continued through 1971, when a Utility Local Improvement District (ULID) was formed to fund construction of the sanitary sewer collections system and WWTP. The sanitary sewer system and WWTP first came online in 1976. The original WWTP was an oxidation type ditch. The City completed an update of the facility to a Membrane Bioreactor (MBR) in 2005.

2.2 PERMITTING

2.2.1 WWTP NPDES PERMIT

The NPDES permit program, promulgated by the Clean Water Act in 1972, regulates point sources that discharge into water of the United States. The City maintains a Municipal NPDES permit (WA0029513) for the WWTP discharge into the Snoqualmie River. The most recent permit was issued January 18, 2018, and is effective from March 1, 2018 through February 28, 2023. The City continues to meet current NPDES permit requirements for WWTP discharge.

2.2.2 PUGET SOUND NUTRIENTS GENERAL PERMIT

Ecology has conducted modeling ("Salish Sea Model") that shows nutrients discharged from domestic WWTPs contribute to low dissolved oxygen levels, below state water quality criteria, in the Puget Sound. As such, Ecology is planning to require that WWTPs control nutrients consistent with the Clean Water Act and Washington State's Pollution Control Act through a "Puget Sound Nutrients General Permit." This permit will trigger additional action tiers if certain treatment targets are not met, which may require a WWTP to conduct optimization studies/modeling, perform additional sampling and testing, implement additional equipment, or plan for and implement process upgrades. The first term (anticipated

January 2022 through December 2027) of the general permit will be applicable only to facilities that discharge directly to Puget Sound.

While the Salish Sea Model predicts that the aggregated nutrient load from watersheds that flow into the Puget Sound contributes to impairment, it does not contain sufficient information to estimate the watershed load attributable to a particular treatment plant in that watershed. Since additional analysis is needed to establish contributions of treatment plants located in the watersheds, those facilities are not included in the general permit at this time. This includes the City of Duvall's WWTP, which is currently excluded from coverage under the general permit.

Ecology will evaluate required nutrient reductions from excluded facilities as part of the Nutrient Source Reduction Plan during the first permit term. Future permit coverage requirements will be addressed during permit renewal. Therefore, while the City will not be subject to additional requirements as part of the general permit at this time, the City should consider it likely that sometime in the future (as early as 2028, after the first term of the general permit), similar permit requirements may be implemented that will potentially impact the monitoring, maintenance, and upkeep of the City's treatment facility.

2.3 LAND USE SUMMARY

2.3.1 LAND USE

The City limits encompass an area of approximately 1,590 acres (2.5 square miles), with an urban growth area (UGA) of approximately 127 acres and UGA reserve (UGAR) of approximately 343 acres (0.73 square miles). Since the 2001 Wastewater Facility Plan adoption, land use continues to include residential, commercial, and industrial development, as shown in the Figure 2-1 zoning map. Land use has typically trended toward more residential use, exemplified by several housing developments with planned construction through 2022, and several more developments currently in review for approval.

2.3.2 EXISTING POPULATION

The Washington State Office of Financial Management (OFM) annually determines and publishes the population of all cities and towns in the state. In 2018, the population of Duvall was published as 7,655. This is only residential population and does not account for "equivalent population" from commercial and light industrial uses. There was approximately 370,000 square feet of commercial and 56,200 square feet of light industrial land use as of the year 2015 (cited in the 2017 Transportation Analysis update to the 2015 Comprehensive Plan).

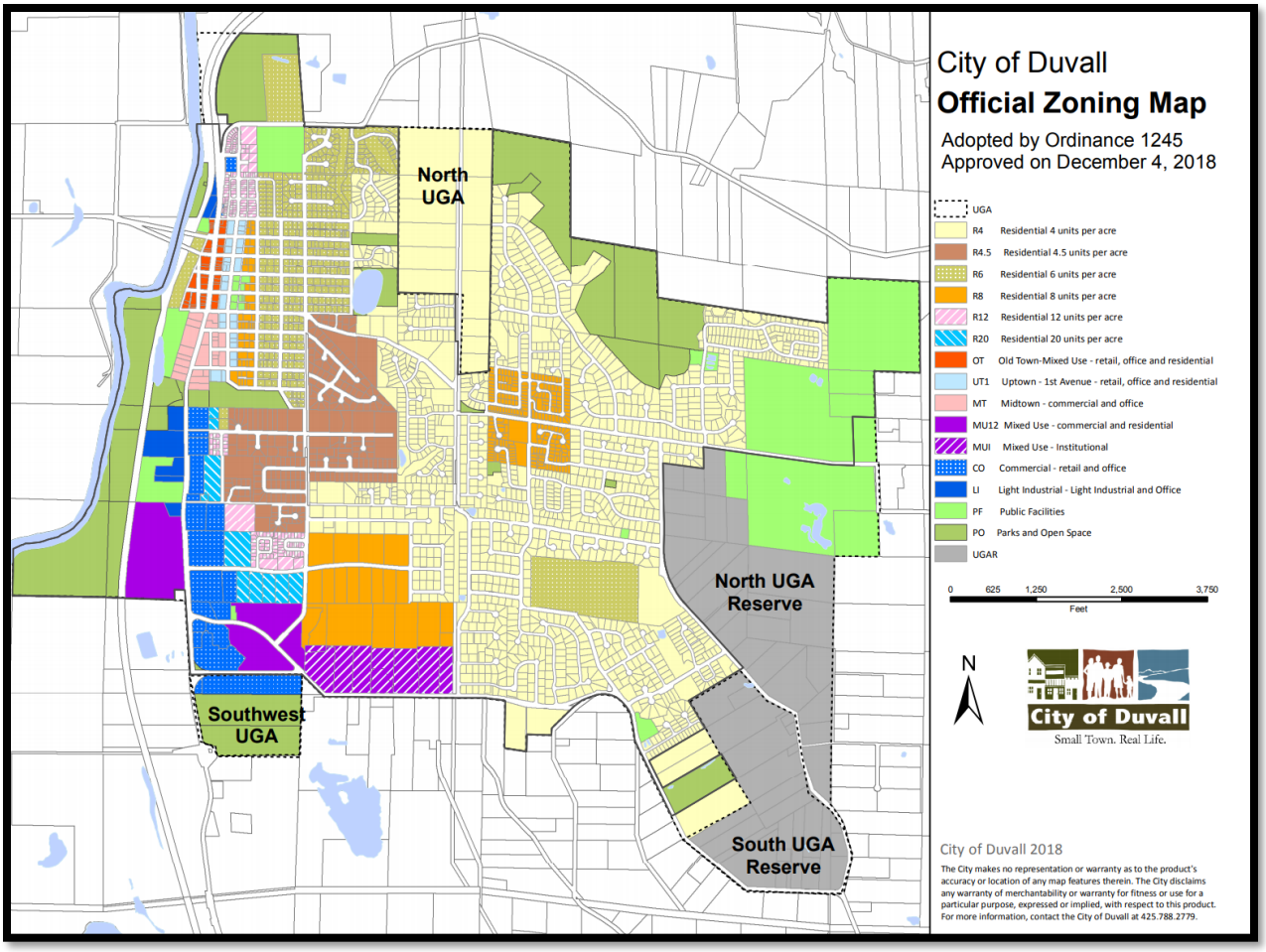


Figure 2-1. 2018 Zoning Map

The City provided a conversion of approximately three people per household; thus, one ERU is equivalent to an effective population of three people. The City also provided a conversion of one equivalent residential unit (ERU) per 3,000 square feet of commercial and light industrial space (effectively one additional residential connection worth of flow per every 3,000 square feet).

Therefore, 2015 commercial and light industrial spaces add approximately 142 ERU, or 426 equivalent population. Commercial space and light industrial space are forecasted to be 964,760 and 89,685 square feet, respectively. Averaging this expansion over the 20-year period (2015-2035) adds an additional 10.5 ERU per year, or approximately 31.4 equivalent population per year (94 equivalent population between 2016 and 2018). Adding the commercial and light industrial equivalent populations to the OFM population estimate, the total 2018 population estimate is 8,175.

The 2001 Wastewater Facility Plan forecasted a City population of 12,516 through 2020. This was based on historical population growth data that suggested a growth rate of approximately 4.8 percent per year (5 percent was ultimately adopted by the City's Planning Department). This growth rate was very conservative; actual residential growth rate over the years 2010 through 2018 ranged from 0.3 to 3.19 percent, averaging 1.7 percent annually.

Additional population information and projections are provided in Section 3.1.2.

2.4 CONVEYANCE SYSTEM

2.4.1 SYSTEM DESCRIPTION

The existing wastewater collection system consists of approximately 32 miles of sewer pipe spread across the City's 19 sewer basins, totaling over 1,000 acres of service area. The system also consists of five duplex submersible pump stations and associated force mains. An overview of the City's pump stations and collection system is presented in Table 2-1, Table 2-2, and Figure 2-2. All sewers ultimately drain to the City's WWTP located at the intersection of Carnation Duvall Road (Highway 203) and NE 145th Street.

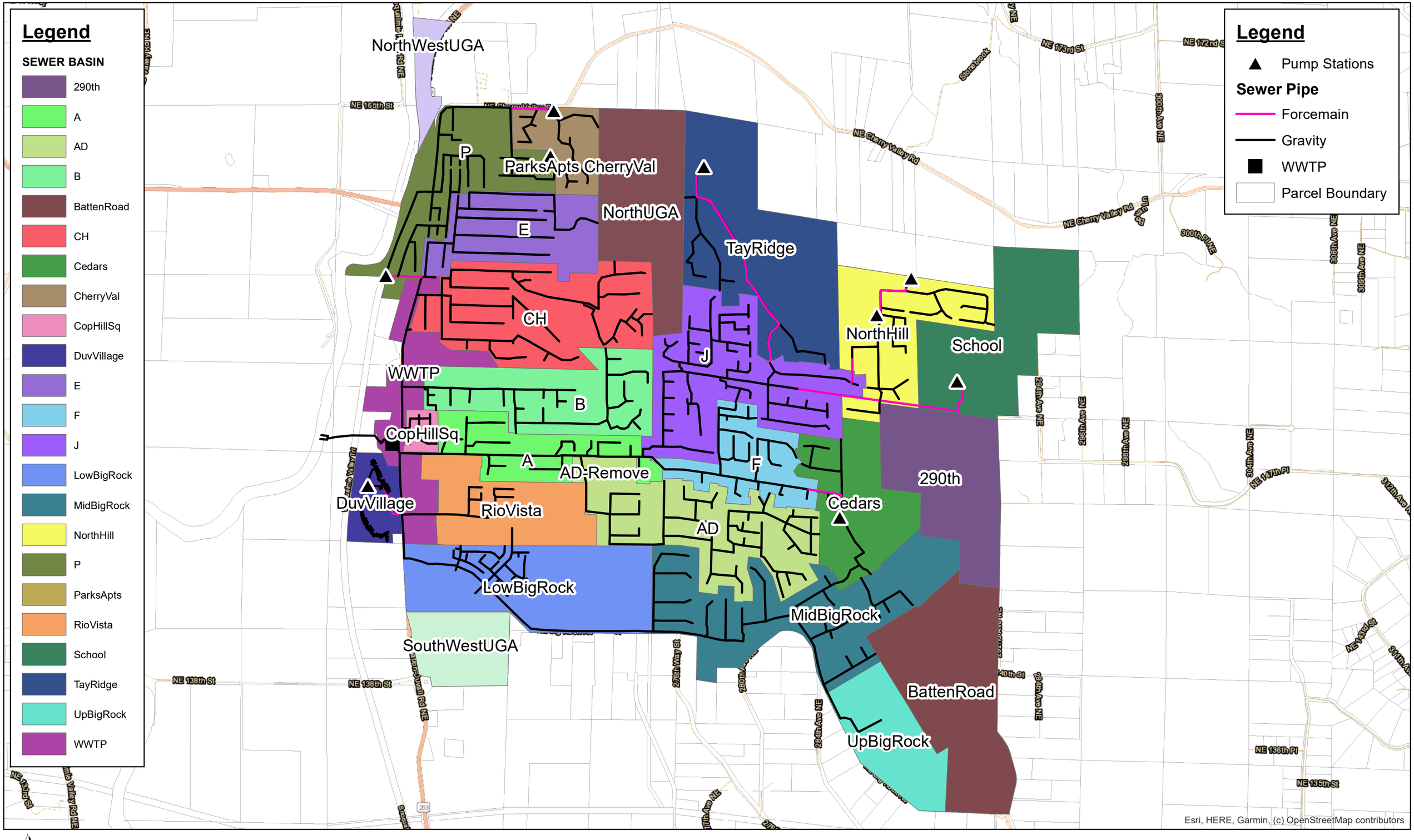
Table 2-1. Existing Pump Stations Summary

Pump Station	Location	Year of Construction	Rated Capacity (per pump)
Cherry Brooke	NE Cherry Valley Rd and 4th Ave NE	1993	240 gpm 66 ft TDH
Railroad	NE Stephens Street and Riverside Ave NE	1974	510 gpm 79 ft TDH
Taylors Ridge	277th Pl NE	1995	375 gpm 180 ft TDH
North Hill	NE 156th St	2016	227 gpm 21 feet TDH
Duvall Village	Railroad Circle NE	2020	162 gpm 70 ft TDH

gpm = gallons per minute; TDH = total dynamic head

Table 2-2. Summary of Conveyance System Attributes

Type	Count	Unit
Gravity Main (8-inch)	32.4	Miles
Force Main (4- and 6-inch)	1.7	Miles
Manhole	918	Each
Lift Station	5	Each



0 0.125 0.25 0.5 Miles

N

Figure 2-2
2021 Existing Wastewater Collection System
City of Duvall

2.5 TREATMENT SYSTEM

2.5.1 GENERAL DESCRIPTION

The City owns and operates a MBR WWTP. The primary processes at the WWTP include a headworks with screening and grit removal, equalization, activated sludge MBR, ultraviolet (UV) light disinfection, and solids handling. An overview of the WWTP configuration is depicted in Figure 2-3. The MBR facility is designed for four treatment trains, with three currently equipped and in use. A summary of the facility's permitted treatment capacity in terms of maximum month daily flow (MMDF), biochemical oxygen demand (BOD), and total suspended solids (TSS) is presented in Table 2-3.

Table 2-3. City of Duvall WWTP NPDES Permit Capacity

Number of Treatment Trains	Parameter	Capacity	Units
Three Trains (Existing)	MMDF	1.3	million gallons per day (mgd)
	BOD	1,909	pounds per day
	TSS	1,845	pounds per day
Four Trains (Future)	MMDF	1.75	mgd
	BOD	2,545	pounds per day
	TSS	2,460	pounds per day

RAMP ACCESS
FENCE WITH ENTRANCE GATE, WIDTH 12 FEET
2' HIGH ROCK WALL
EXISTING ROCK WALL
PAVING LIMITS
CMU WALL, 3 SIDES, 18'-8"x12'-8"x6'-0" HIGH SEE SHEET C00-1 FOR TRANSFORMER ENCLOSURE DE
TRANSFORMER
N 269586.10
E 1356158.00
BOLLARD
LABORATORY BUILDING
GENERATOR
MBR EQUIPMENT BUILDING
MBR No. 1
MBR No. 2
MBR No. 3
MBR No. 4
AERATION TANK No. 1
AERATION TANK No. 2
ANOXIC TANK No. 1
ANOXIC TANK No. 2
DIGESTER No. 1
EXISTING GENERATOR BUILDING
N 269520.11
E 1356156.90
PUBLIC WORKS BUILDING
MAIN STREET NE
UV AND PUMP BUILDING
STORMWATER WET POND
REUSE WATER TANK
N 269450.69
E 1356156.40
N 269449.16
E 1356248.38
BIOFILTER
DIGESTER No. 2
SLOPE
SOLIDS BUILDING
N 269398.68
E 1356166.77
N 269374.11
E 1356230.46
BOLLARD
N 269374.85
E 1356186.46
PSE EASEMENT
BOLLARD
EXISTING SLUDGE LOAD OUT AREA
N 269407.58
E 1356277.46
PAVING LIMITS
EXISTING EDGE OF PAVEMENT
HEADWORKS, SEE SHEET C20-4
PROPERTY LINE
PLAN
1"=20'

Figure 2-3
WWTP Overview

2.5.2 OPERATING PARAMETERS

The City's NPDES permit sets effluent limits for two periods of the year: (1) August through October and (2) November through July. Effluent limits are set by Ecology to ensure the water quality standards are met in the Snoqualmie River. Parameters of the effluent limits of the permit include carbonaceous biochemical oxygen demand ($CBOD_5$), TSS, pH, fecal coliform bacteria, and nitrogenous biological oxygen demand (NBOD) + CBOD (August through October only). The tables below show effluent limits for both the dry and wet seasons in Table 2-4 and Table 2-5, respectively.

Table 2-4. Effluent Limits – Dry Season (August through October)

Parameter	Average Monthly	Average Weekly
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	25 milligrams/liter 85% removal of influent $CBOD_5$	40 milligrams/liter
Total Suspended Solids (TSS)	30 milligrams/liter 325 pounds/day 85% removal of influent TSS	45 milligrams/liter 488 pounds/day
Parameter	**Minimum**	**Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**7-Day Geometric Mean**
Fecal Coliform Bacteria	100/100 milliliter	200/100 milliliter
Parameter	**Average Monthly**	**Maximum Daily**
Nitrogenous Biological Oxygen Demand (NBOD) + $CBOD_5$	69.3 pounds/day	172.3 pounds/day

Table 2-5. Effluent Limits – Wet Season (November through July)

Parameter	Average Monthly	Average Weekly
$CBOD_5$	25 milligrams/liter 271 milliliter/day 85% removal of influent $CBOD_5$	40 mg/L 434 milliliter/day
Total Suspended Solids (TSS)	30 mg/L 325 milliliter/day 85% removal of influent TSS	45 mg/L 488 milliliter/day
Parameter	Minimum	Maximum
pH	6.0 standard units	9.0 standard units
Parameter	Monthly Geometric Mean	7-Day Geometric Mean
Fecal Coliform Bacteria	100/100 milliliter	200/100 milliliter

2.5.3 WASTEWATER TREATMENT CAPACITY AND OUTFALL SYSTEM EVALUATIONS

Parametrix prepared a capacity evaluation for the City's WWTP in 2018 and updated the evaluation in 2021. The technical memorandum documenting the 2021 capacity evaluation is found in Appendix A. In summary, this work included review and analysis of historic WWTP loading and flow data, the City's future development planning, and the City population growth forecast. Overall, the WWTP is operating at approximately 87 percent of current BOD capacity and 86 percent of TSS capacity (with three MBR treatment trains in use). Based on the City's growth projections, the WWTP is projected to reach 100 percent of three-train capacity at the end of 2025.

The plant is already permitted to additional four-train capacity. As such, a Department of Ecology Engineering Report to expand capacity is not needed. Instead, design of plant expansion to four-train capacity should begin in 2021 or early 2022. Based on the City's population projections, the four-train treatment MBR facility should handle City wastewater flows and loads beyond 2040 (the 2040 population projection is anticipated to be approximately 87 percent of four-train WWTP capacity).

The WWTP discharges treated, disinfected effluent into the Snoqualmie River through Outfall 001. The outfall is located at approximately river mile 10.4 of the Snoqualmie River. The outfall consists of a 24-inch pipe that splits into two 18-inch outfall ports. In 2019 the City's NPDES permit required an outfall mixing study to be performed. The WWTP Outfall Evaluation and Mixing Zone Study results can be found in Appendix B.

3. WASTEWATER FLOW PROJECTIONS

3.1 FORECASTED LAND USE

3.1.1 BUILDABLE LANDS ANALYSIS

The following planning documents were examined to ensure this Plan is consistent with the City's land use policies and other related plans.

- Growth Management Act
- City of Duvall Comprehensive Plan

Growth Management Act (GMA)

The State of Washington GMA was passed in 1990 and amended as required over the years. It defines four goals relevant to wastewater system planning:

1. Focus growth in urban areas and reduce sprawl
2. Ensure consistency between land use and utility plans
3. Ensure adequate public facilities and services, concurrent with growth
4. Designate and protect critical areas

Through the GMA all counties, cities and towns were required to develop comprehensive plans, which address issues of land use, transportation, housing, capital facilities, utilities, and rural lands.

The GMA requires that King County (County) and the City cooperate in designating a UGA. As part of the development of its Comprehensive Plan, the City designated UGAs that would accommodate the City's projected population growth and facilitate resource conservation.

The GMA also requires that critical areas be designated and protected. Critical areas include areas at high risk for erosion, landslides, earthquakes or flooding; coal mines; wetlands or lands adjoining streams, rivers and other water bodies.

City of Duvall Comprehensive Plan

The City's most recent Comprehensive Plan was published in 2015, adopted in June of 2016, and amended in December of 2017. The Land Use Element of this Comprehensive Plan states the City's vision of how growth and development should occur over a 20-year horizon and includes goals and policies to achieve this vision. The Land Use Map, presented in Figure 3-1, shows the different types of land uses that are planned throughout the City.

City of Duvall
Future Land Use Map

Adopted by **Resolution No. 18-18**
Approved on **December 4, 2018**

- R4-4.5 Residential 4-4.5 Units Per Acre
- R6 Residential 6 Units Per Acre
- R8 Residential 8 Units Per Acre
- R12 Residential 12 Units Per Acre
- R20 Residential 20 Units Per Acre
- MU Mixed Use Commercial and Residential
- CO Commerical
- LI Light Industrial
- PF Public Facilities
- PO Parks and Open Space
- UGAR Urban Growth Area Reserve
- City Limits

N

City of Duvall
Small Town. Real Life.

City of Duvall Comprehensive Plan
SOURCE: ESA 2015, City of Duvall 2018

Figure 3-1 Land Use Map

The Land Use Element of the Comprehensive Plan articulates many of the same goals and concerns of the GMA. Like the GMA, the Land Use Element seeks to accommodate growth while maintaining the City's residential but rural character and protecting environmentally sensitive areas. It seeks to promote a strong local economy and vital commercial and industrial districts by focusing economic development within them and establishing development guidelines. The Transportation and Capital Facilities Elements ensure that new development will be adequately serviced without compromising existing levels of service, similar to the principal of concurrency as defined in the GMA.

The City's Comprehensive Plan also states its City Limits and updates its UGA and UGAR boundaries. Some undeveloped lots still exist within the City and infilling is expected and encouraged. The City will also consider annexing some of its UGA in order to accommodate future growth and development.

3.1.2 PROJECTED POPULATIONS BASED ON RESIDENTIAL DEVELOPMENT (2021)

To evaluate the City's future growth, a population estimate was developed to account for significant planned short-term growth and maintain consistency with the City's Comprehensive Plan/Transportation Plan and the OFM population data.

OFM annually determines and publishes the population of all cities and towns in the state. In 2020, the population of Duvall was published as 7,950. This is only residential population and does not account for "equivalent population" from commercial and light industrial uses. There was approximately 370,650 square feet of commercial and 78,800 square feet of light industrial land use as of the year 2020 (data provided by City and consistent with that cited in the 2017 Transportation Analysis update to the 2015 Comprehensive Plan plus growth since the publication of the update). Furthermore, consistent with King County Buildable Lands Report (KCBLR), an additional approximately 19,300 square feet of light industrial and 197,700 square feet of commercial are anticipated to be added over the period of 2020 to 2040 (data provided by City).

The City provided a conversion of one ERU per 3,000 square feet of commercial and light industrial space (effectively one additional residential connection worth of flow per every 3,000 square feet). The City also provided a conversion of approximately three people per household, meaning one ERU is equivalent to a population of three people.

Therefore, commercial and light industrial spaces add approximately 161 ERU, or 461 equivalent population, as of 2020. Adding the commercial and light industrial equivalent populations to the OFM population estimate, brings the total 2020 population estimate to 8,411.

The 2001 Wastewater Facility Plan forecasted a City population of 12,516 through 2020. This was based on historical population growth data which suggested a growth rate of approximately 4.8 percent per year (5 percent was ultimately adopted by the City's Planning Department). Actual residential growth rate over the years 2010 through 2020 ranged from 0.3 to 3.19 percent, averaging 1.7 percent per year, which is approximately 150 population per year based on current 2020 population estimate.

In the 5-year planning period 2021 through 2025, large developments are anticipated to be completed and are expected to increase population at approximately twice the historic rate of annual growth. The City provided a rate of 300 population per year residential plus 11 population per year from nonresidential growth for the period of 2021 through 2025. Lastly, for 2026 through 2040, the City provided a growth rate of 101 population per year (about 1 percent increase based on 2026 forecasted population) for remaining housing plats as well as commercial and industrial equivalent population. The yearly forecasted population estimate is summarized in Table 3-1.

Table 3-1. Population Projection Yearly Summary

Year	Population Projection
2020	8,411
2021	8,722
2022	9,033
2023	9,344
2024	9,655
2025	9,966
2026	10,067
2027	10,168
2028	10,269
2029	10,370
2030	10,471
2031	10,572
2032	10,673
2033	10,774
2034	10,875
2035	10,976
2036	11,077
2037	11,178
2038	11,279
2039	11,380
2040	11,481

3.2 WASTEWATER FLOW PROJECTIONS (2018)

3.2.1 WASTEWATER

Parametrix estimated the average dry weather wastewater flow using existing (year 2018) unit counts provided by the City for each sewer basin. Parametrix supplemented the unit counts with spot check counts from aerial imagery and record drawings. The total unit count within the City resulted in approximately 2,865 units; a summary of the unit counts for each basin is found in Appendix C.

A flow per unit was calculated based on 2018 unit counts such that the total flow in the system equaled approximately that of the average monthly dry weather flow to the WWTP. Based on inspection of WWTP discharge monitoring data between 2014 through 2018, the average monthly dry weather flows were approximately 0.4 million gallons per day (mgd). Therefore, with a unit count of 2,865, the resulting average dry weather flow per unit is approximately 140 gallons per day. This flow was considered to be the base ERU flow value under dry weather (no infiltration and inflow), non-peaked conditions.

3.2.2 INFLOW AND INFILTRATION

Parametrix determined a system-wide rate of infiltration and inflow (I/I) using WWTP discharge monitoring data between 2014 through 2018 by subtracting the lowest dry weather flow (0.347 mgd) recorded from a peak day flow (1.453 mgd). This was then divided by the total delineated acreage of the current sewer system basin extents (1,062 acres) to determine the total gallons of I/I per acre introduced to the system in 1 day (gallons per acre-day [gpad]). This rate was calculated to be approximately 1,042 gpad. King County has historically used 1,100 gpad as the benchmark I/I rate. Therefore, given that the calculated rate was close to the benchmark rate, an I/I rate of 1,100 gpad was used as a conservative estimate.

3.3 COLLECTION SYSTEM MODELING (2018)

3.3.1 MODEL PREPARATION

Parametrix developed a partial collection system hydraulic model in InfoSewer 7.6, a steady state hydraulic modeling software integrated with ESRI ArcGIS. The model was limited to the trunk sewer lines as defined by the City. The trunk system modeled includes 118 gravity pipes, 117 manholes, and two pump stations with associated force mains. The provided data also contained information such as pipe diameters, lengths, invert elevations, and pipe material. This information was supplemented and/or corrected by using best available record drawings provided by the City, field survey data collected by Parametrix, aerial imagery and contours, and engineering judgment in cases where information was missing or inconsistent. For example, many pipe inverts were corrected (or collected during survey) to NAVD88 datum, and pipe diameters were updated in locations where cured-in-place pipe had been installed. The overall system flows were calibrated to influent flow data from the WWTP, but flow is not recorded at other locations in the City system, and no flow monitoring was conducted to calibrate the model. It is therefore recommended that temporary flow monitoring be conducted in the lines identified as overcapacity prior to implementing any pipe capacity improvement projects.

An overview of the model is found in Appendix D. The model was used to analyze both existing and future conditions to determine if any areas within the City's sewer collection system exceed capacity. The flows applied to each scenario and results of the modeling are described in the following sections.

3.3.2 EXISTING CONDITIONS

For existing conditions, the dry weather ERU wastewater flow, described in Section 3.2.1, was distributed in the model based on 2018 unit counts within each basin. Wastewater flows within each basin were applied to nodes in the model in the following manner:

- Where flow from specific developments could be confirmed to flow into a specific node (either from record drawing inspection or review of City Geographic Information System [GIS] data), the flow from that development was applied to the identified node.
- If a basin was outside of any direct connection to the trunk system, the flow for the basin was applied to the most upstream node in the model to which the basin ultimately flowed.
- If it was unclear where remaining units within a basin flowed, the flow was applied to the most upstream node in the basin to allow for a conservative estimate of pipe capacity.

Stormwater I/I was applied at the most upstream node in each basin to produce a conservative estimate of pipe capacity. A summary detailing the wastewater and I/I flow applied to each node within each basin is found in Appendix C.

The existing conditions scenario modeling also included a peaking factor of 3.0 applied to dry weather ERU flow values. This peaking factor was determined from the Ecology Criteria for Sewage Works Design based on the City's approximate population of 8,000 residents and was consistent with the WWTP discharge monitoring data between 2014 through 2018.

Results of the modeling are depicted in Figure 3-2 and reveal that in general, most pipes within the system are operating at less than 50 percent of full capacity. It was identified, however, that one pipe (ID 616) was at 75 to 100 percent capacity and two pipes (IDs 195 and 196) were exceeding 100 percent capacity. These pipes are located on NE 145th Street between 267th Ct NE and 270th Place NE. Detailed model results of pipe capacity for existing conditions are found in Appendix D.

3.3.3 FUTURE CONDITIONS

Modeling of future conditions included all flows applied under existing conditions as well as flows from the following sources:

- City-approved developments with anticipated buildout through 2022
- Future developments in review but not yet approved
- Anticipated future development within the City's UGAs and UGAR

The City provided lot counts for each of the approved developments and developments in review, as seen in Appendix E. The North UGA was assumed to have approximately 50 percent buildable land at an R-4 density (4-units per acre). The North and South UGAR was forecasted to have approximately 20 ERU and the Southwest UGA with 3 ERU. The location of the anticipated developments and the UGA locations are also found in Appendix E.

The process for applying the additional future flows to the model was the same as described for existing conditions. A summary detailing the wastewater and I/I flow applied to each node for future conditions is found in Appendix C.

Results of the modeling are depicted in Figure 3-3 and reveal that again most pipes in the system are operating at less than 50 percent of full capacity. Compared to existing conditions, the modeling showed that nine pipes which previously operated at less than 50 percent capacity now operated at 50 to 75 percent capacity. One pipe (ID 616) still operates at 75 to 100 percent capacity as well as two pipes (IDs 195 and 196) operating above 100 percent capacity. Detailed model results of pipe capacity for future conditions are found in Appendix D.

3.3.3.1 2021 Revision

The City informed Parametrix that a sewer system modification diverted flow originally flowing down NE 145th St to connect into a sewer trunk flowing down NE 143rd Pl. This change diverted approximately 46,500 gpd from NE 145th St to NE 143rd Pl. This reduced the number of pipe segments exceeding 100 percent capacity on NE 145th St. This reduction is reflected in a revision to CIP project CS-1.

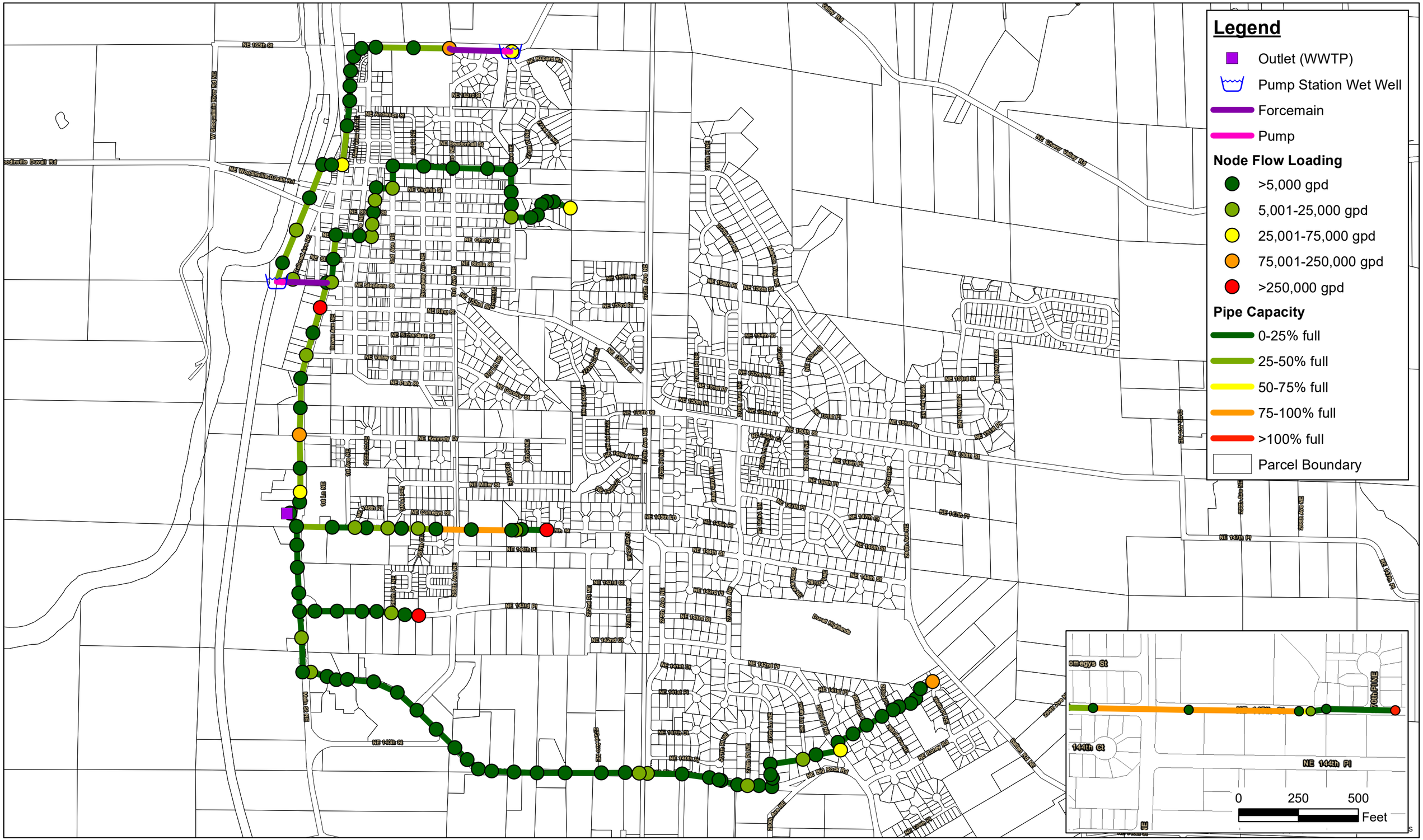


Figure 3-2
Existing Conditions Pipe Capacity
ERU=140 gpd, peaked x3
I/I=1,100 gpad

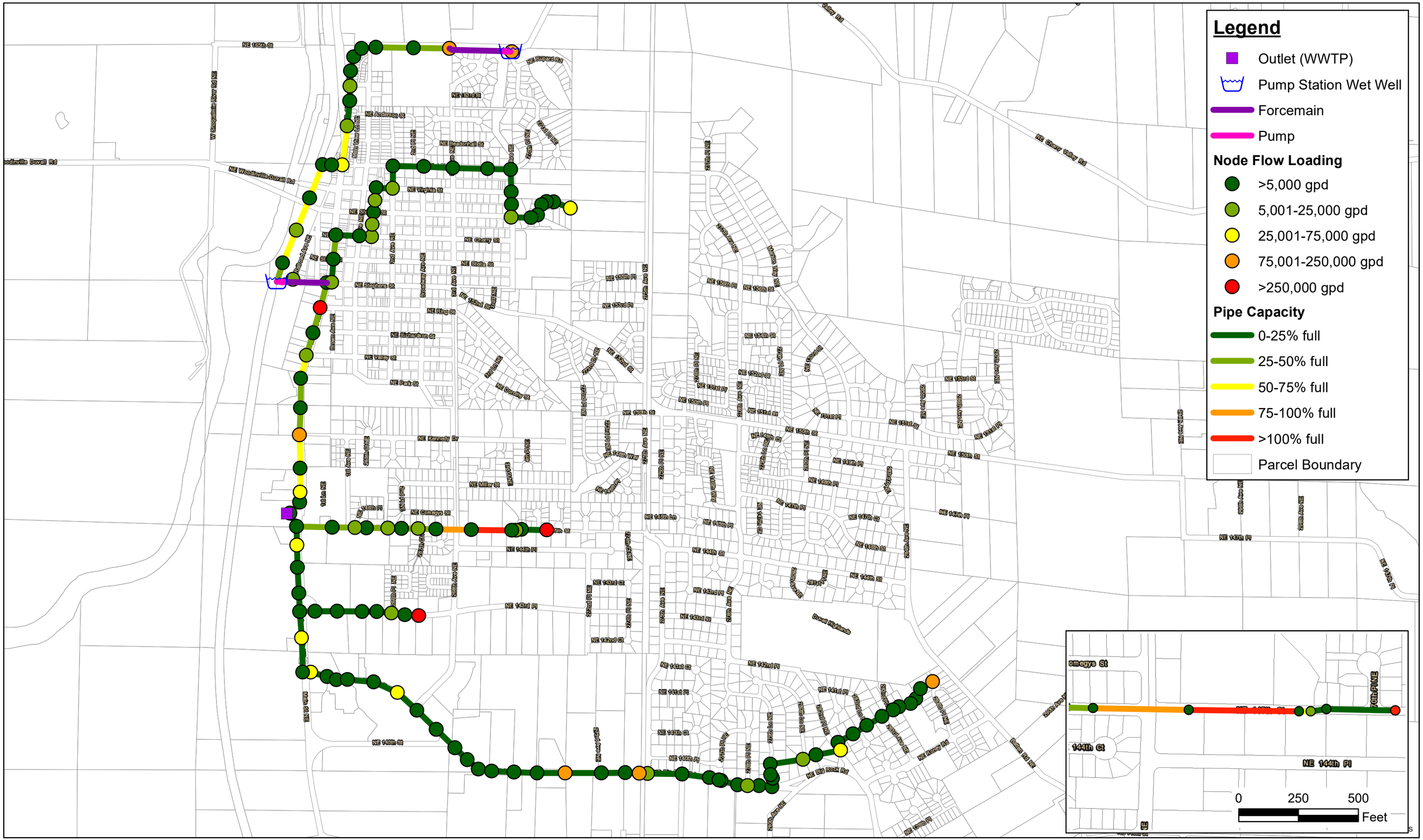


Figure 3-3
Future Conditions Pipe Capacity
ERU=140 gpd, peaked x3
I/I=1,100 gpad

4. PUMP STATION AND WWTP EVALUATION

4.1 INTRODUCTION

Parametrix performed on-site reviews and evaluations of equipment and infrastructure at four City pump stations and the WWTP. Evaluations also included talking with City operators regarding their observations on equipment operation and maintenance (O&M). General notes and findings of the evaluations are presented in this chapter, with resulting recommended CIP and O&M projects presented in the following chapter.

4.1.1 PUMP STATIONS

Parametrix staff performed on-site reviews of four of the City's sewer pump stations, including Taylor's Ridge, Cherry Brooke, Railroad (aka Stephens/Depot Village), and Cedars (Crestview) stations. On-site review was not conducted for the North Hill and Duvall Village stations because these stations were recently constructed and therefore assumed to be in good condition and operating as designed. In general, each station has a wet well with submersible pumps and includes a valve vault, electrical panels, and a standby diesel generator. Drawdown testing for each of the four pump stations was also conducted during the on-site reviews to determine current pumping capacity. Subsequent to the on-site inspections and drawdown testing, the Cedars station was decommissioned and replaced with a gravity sewer line. The following summarizes the findings of the evaluations and results of pump performance from the drawdown testing. Projects to correct the deficiencies noted below are included in Chapter 5.

Mechanical

In general, the pumps at each station evaluated appear to be underperforming based on the drawdown testing. There are a variety of factors that may be causing this issue including solids buildup in the force main, partially clogged pumps, worn impellers, increased recirculation in the pump from clearances above what is specified by the manufacturer, and from operating conditions different from the pumps' rated duty point. Each pump station's rated capacity as well as current pump performance based on drawdown testing is summarized in Table 4-1.

Table 4-1. Pump Performance Based on Drawdown Testing

Station	Cherry Brooke		Railroad		Taylors Ridge	
Pump Number	**Pump 1**	**Pump 2**	**Pump 1**	**Pump 2**	**Pump 1**	**Pump 2**
Rated Flow (gpm)	240	240	510	510	375	375
Tested Flow (gpm)	151	136	185	141	131	129
Rated Head (ft)	66	66	79	79	180	180
Tested Head (ft)	NA	NA	NA	NA	180	180
Rated Horsepower	10		20		35	
Pump Model	Flygt NP-3127		Flygt NP-3153		Flygt NP-3171	

gpm = gallons per minute; ft = feet; NA = not applicable

In all of the evaluated pump stations, discharge piping and fittings are showing signs of corrosion in the wet wells. Some stations also had piping within valve vaults showing signs of coating failure and corrosion. Grease buildup was identified at the Taylor's Ridge Pump Station which can cause odor issues, level sensing failure, and pump clogs. The air release valve at Cherry Brooke was identified as a model not intended for use with fluids that contain suspended solids such as wastewater. It was also identified at Cherry Brooke that the potable water backflow preventer is located below grade and should be relocated above grade.

Structural

No critical structural deficiencies were identified at the pump stations evaluated. However, it was noted that fall protection is not currently provided around the entrances to the wet wells. WAC 296-809-60004 requires "a railing, temporary cover, or other temporary barrier to prevent any accidental falls" when a permit-required confined space entrance cover is removed. It was also noted that the shelter over the generator at the Railroad Pump Station has span beams resting on support beams, which should be secured with brackets and screws.

Electrical and Controls

The existing telemetry system was identified as aging and will soon be obsolete due to cellular communication upgrades. The generators had also not been tested recently. Several National Electric Code (NEC) violations were noted in the various control panels. Additional control panel deficiencies were identified including missing panel-mounted alarm lights, seals and air gaps, and general damaged equipment.

At the Cherry Brooke Pump Station, the "lead pump on" float was not working properly. At the Railroad Pump Station, it was noted that the diesel generator exhausts into the existing shelter. This could be improved by venting outside of the shelter.

Civil/Other

At all pump stations evaluated, the site fencing was noted to be lacking or showing signs of damage and wear, which poses pump station access and security risks.

4.1.2 WASTEWATER TREATMENT PLANT

Parametrix staff performed an on-site review of the City's WWTP. Overall, the WWTP is operating well and reliably achieving permit limits, but it is showing signs of normal wear. The following summarizes the mechanical, electrical, and structural findings of the evaluation. Projects to correct the deficiencies noted below are included in Chapter 5.

Mechanical

At the WWTP headworks, it was noted that the concrete flow channel upstream of the Hycor 3-millimeter (mm) screen is sometimes filled with approximately 5 inches of heavy settled grit and solids. Grease also accumulates in the channels upstream and downstream of the headworks band screen. These issues at the headworks require significant staff time to clean and maintain.

Also noted is that the existing 3-cubic yard screenings and grit dumpster is too small to be considered effective by the City. The existing Hycor 3-mm screen is approximately 14 years old and is showing signs of wear. The existing influent sampler and cabinet are also showing signs of wear.

In the anoxic tank, the operators noted that there is a constant layer of grease and foam. The aluminum slide gates at the anoxic and aeration tanks are corroding and not operating smoothly. After high-flow events that require use of the equalization (EQ) tank next to the anoxic tanks, significant operator time is required to manually control the EQ pumps that pump wastewater stored in the EQ tank back into the process. In the aeration tanks, the operators believe the large 75 horsepower (hp) blowers do not have adequate turndown to accommodate the low flows and loads that typically occur late at night.

At the Disinfection and Reuse Building, operators have noted that refurbishing the reuse water pump impeller stack and seals is becoming a significant cost every few years. Insufficient air cooling was noted in the area where the UV system control panels are located. The existing effluent sampler and cabinet is old and showing signs of wear. The AUMA valve actuator on the reuse water system does not reset automatically when power is restored after a power outage. The UV system is aging, replacement parts are no longer available, and the units are not very energy efficient nor can they meet future WWTP four-train capacity.

In the Solids Handling Building, the existing belt press is operating efficiently but is limited to processing 35 gallons per minute of digested solids. The operators will soon need to work overtime in order to keep up with the solids output of the WWTP.

Electrical

Across the WWTP, it was noted that much of the lighting consists of fluorescent light fixtures which are less efficient than newer light-emitting diode (LED) lighting. More lighting should be added to the anoxic and MBR tank areas to improve safety.

Regarding electrical service to the WWTP, there have been some issues with brown-out power conditions. The motor control center (MCC) 20 panel, which provides power for the headworks, shows signs of corrosion. The standby generator has not had a load test for a number of years. It was also noted that the automatic transfer switch (ATS) does not have a bypass feature to allow for ATS maintenance without requiring a WWTP shutdown. Furthermore, there is no tap box between the generator and ATS connections. Providing a tap box would eliminate wear on the generator main breaker terminations (due to disconnection and reconnection) and make generator testing easier.

Due to safety concerns, code compliance, and general equipment age, some electrical panels and heat trace wires require replacement. At the aeration tanks, the dissolved oxygen (DO) analyzer displays have failed due to exposure to sun and UV light. At the MBR, there have been problems with nuisance alarms caused by the surge suppression device (SPD). There have also been issues with the blower breakers tripping during brown-out or facility power loss which could impact the reliability of the treatment process.

Structural

Overall, the structures at the WWTP appear to be in good condition. It was noted that across the facility grounds, there were patches of broken, damaged, or spalling concrete such as on stairs and tank walls. It was also noted that seismic bracing was missing on filtrate piping between the ceiling and wall of the Solids Handling Building. Handrails were noted to be missing around certain hatches and overlooking the screening dumpster facility. Some safety chains were also identified as missing at handrail openings. The storage shed was noted to have some rot at the bottom of the siding and a mossy roof.

5. SYSTEM IMPROVEMENTS

5.1 CAPITAL IMPROVEMENT PROGRAM (CIP)

5.1.1 CIP PROJECT DEVELOPMENT

The CIP is a priority list of Sewer Utility improvement projects and programs that the City hopes to undertake by 2035. Each project in the CIP includes a description, estimate of total project cost, funding approach (proportions of City Sewer Fund allocations and development share), and an identified timeframe for implementation. This list was developed by Public Works staff based on: (1) the systemwide evaluation and analysis summarized in Chapter 3; (2) additional consideration of current and anticipated maintenance practices; and (3) system improvement needs. The identified improvement projects and programs will help staff to implement the overall 2015 Comprehensive Plan goals and policies of the City.

The CIP includes the following categories for Citywide system improvements and program strategies:

- Wastewater Treatment Plant Improvement Projects
- Conveyance Improvement Projects
- Pump Station Improvement and Replacement Projects
- Other Citywide Sewer Utility Programs

The projects are described in the following sections, with project costs summarized in Table 5-1 and detailed in Appendix F.

Table 5-1. Capital Improvement Project List and Cost Summary

Project Group	Project ID	Project Name	Project Description	Total Project Cost Estimated ($)	Repair and Replacement	Upgrade	Capacity Expansion	Current Capacity Share (%)	Current Capacity Cost ($)	Future Capacity Share (%)	Future Capacity Cost ($)	Time Frame	Estimated Project Year
Wastewater Treatment Plant Improvement Projects	WWTP-1	UV System Upgrades	Replace Ultraviolet (UV) system with energy efficient components and to facilitate future plant expansion.	$786,000		X	X	65%	$510,900	35%	$275,100	Short	2021-2022
	WWTP-2	Generator Inspection and Testing	Inspect and service the WWTP standby generator and ATS. This inspection and service should be repeated every five (5) years.	$18,800	X			100%	$18,800	0%	$0	Short	2023
	WWTP-3	Headworks Improvements and Capacity Upgrades	Install Type II manhole or equivalent in the influent flow stream before the channel to collect grit and solids. Pilot test ozone digester system for grease removal upstream of headworks band screen. Upgrades to 10-cubic yard dumpster. Replace 3-millimeter Hycor Screen with drum screen. Replace anoxic basin pumps (see Plan Section 5.2 for details).	$999,600		X	X	10%	$99,960	90%	$899,640	Short	2023
	WWTP-4	Electrical Upgrades	Conduct arc-flash study, replace heat trace systems, upgrade headworks power panel and replace Headworks panel H (see Plan Section 5.2 for details).	$306,000		X		65%	$198,900	35%	$107,100	Short	2023
	WWTP-5	Capacity Upgrades - Phase 1	Based on the WWTP Capacity evaluation (as described in Section 2.5.3 of the Plan), this project is the planning and detailed design for upgrading the facility to the four-train capacity.	$720,200			X	0%	$0	100%	$720,200	Short	2021-2022
	WWTP-6	Capacity Upgrades - Phase 2	Upgrade the facility based on planning and design from Phase 1 (see Plan Section 5.2 for details).	$6,820,200			X	0%	$0	100%	$6,820,200	Mid	2024
	WWTP-7	Anoxic Tank Foam	Install sprayers or telescoping skimmer valves to remove anoxic basin foam layer.	$53,800		X		65%	$34,970	35%	$18,830	Long	2030

Project Group	Project ID	Project Name	Project Description	Total Project Cost Estimated ($)	Repair and Replacement	Upgrade	Capacity Expansion	Current Capacity Share (%)	Current Capacity Cost ($)	Future Capacity Share (%)	Future Capacity Cost ($)	Time Frame	Estimated Project Year
Pump Station Projects	PS-1	Combined Pump Station Improvements	Pump Evaluations, fall protection, telemetry upgrades, generator replacement, fencing repairs, electrical upgrades (see Plan Section 5.2 and Table 5-2 for details).	$742,000		X		65%	$482,300	35%	$259,700	Short	2022
Conveyance Improvement Projects	CS-1	Infiltration and Inflow Repair	Address found I&I issues (CIPP, injection grouting, pipe replacement, lid replacement, etc.).	$400,000		X		65%	$260,000	35%	$140,000	Short	2021-22
	CS-2	Old Town Alleys	Clear alleys for access to sewer main and potential CIPP or slip lining due to I/I issues.	$140,000		X		65%	$91,000	35%	$49,000	Short	2021-22
	CS-3	NE 145th Street	Upsize approximately 460 LF of sewer main between 3rd Ave NE and 270th Pl NE from 8-inch to 12-inch to increase available capacity.	$388,900			X	55%	$213,895	45%	$175,005	Long	2030
Citywide Programs	CP-1	Infiltration and Inflow Program	On-going Citywide program to identify Infiltration/Inflow issues throughout the City's collection system (monitoring, inspection, etc.).	$150,000		X		65%	$97,500	35%	$52,500	Annual	Annual
	CP-2	Collection System Repair and Replacement	System maintenance, correction of issues found in the annual I&I program.	$200,000	X			80%	$160,000	20%	$40,000	Annual	Annual
	CP-3	Sewer Plan Update	On-going effort to keep goals, policies, and design standards current with Federal regulations.	$250,000			X	50%	$125,000	50%	$125,000	Mid	2027
	CP-4	Sewer Facility Building Maintenance	Building maintenance and repairs for treatment plant, pump stations, and sewer-related office spaces.	$25,000	X			100%	$25,000	0%	$0	Annual	Annual
	CP-5	Sewer Plan Update	Engineering report to document with Ecology that four-train WWTP Capacity will be adequate for buildout population.	$250,000			X	0%	$0	100%	$250,000	Long	2037

5.2 IMPROVEMENT PROJECTS AND PROGRAMS

5.2.1 WASTEWATER TREATMENT PLANT IMPROVEMENT PROJECTS

Based on the on-site assessment and evaluations, the following WWTP capital improvement projects were identified. Each project is also identified with a timeline of "Short-term", "Mid-term", and "Long-term" which corresponds to timelines of within 1 to 3 years, 4 to 6 years, and 6+ years, respectively.

WWTP-1: UV System Upgrades (Short-term)

- Replace the UV disinfection system with energy efficient components and capacity for future flows.
- Provide additional air cooling in the area where the UV system control panels are located. The cooling required will need to be based on the new replacement UV unit being installed by the City. This could be accomplished by installing a large fan to circulate a large amount of ambient air through the room or by installing an air conditioning unit. Include sizing and selection of heating, ventilation, and air conditioning (HVAC) equipment.

WWTP-2: Generator Inspection and Testing (Short-term)

- Inspect and service the WWTP standby generator ATS. This inspection and service should be repeated every 5 years.
- Conduct a 100 percent load bank test of the standby generator. The 100 percent load bank testing of the generators should be performed annually to remove exhaust wet stacking buildup and evaluate for equipment degradation. If the generator does not pass the 100 percent load test, consider replacement. If possible, schedule the generator replacement timeframe based on connected load requirements associated with plant improvements and upgrades.

WWTP-3: Headworks Improvements and Capacity Upgrades (Short-term)

- Evaluate and install a Type II manhole or equivalent sump in the influent flow stream before the screen channel to collect grit and solids and to provide better maintenance and cleaning access.
- Pilot test an ozone digester system upstream of the headworks band screen in the new influent manhole (bullet immediately above). If successful at reducing downstream grease, install a permanent ozone digester system.
- Replace or extend the existing screening/grit conveyor approximately 20 feet to the west, so it would discharge directly into the 10-cubic yard (CY) dumpster.
- Install a new rollup door at the dumpster enclosure to isolate the 10-CY dumpster and contain odors.

- Replace the existing 3-mm Hycor Screen with a high-reliability drum screen. To accommodate the drum screen, the existing channel will need to be widened.
- Replace the old anoxic basin pumps.

WWTP-4: Electrical Upgrades (Short-term)

- Conduct an arc-flash study to ensure electrical panels meet current code and properly label.
- Replace the heat trace system at the headworks and anoxic tank area.
- Upgrade the headworks power panel with a NEMA 12 rated MCC panel and seal all openings.
- Replace Headworks panel H with a NEMA 3R or 4X enclosure.

WWTP-5: WWTP Capacity Upgrades – Phase 1 (Short-term)

- Based on the WWTP Capacity evaluation as described in Section 2.5.3, planning and design to upgrade the facility to the four-train capacity should begin around 2021 to 2022. Incorporate the upgrades identified in Phase 2 below.

WWTP-6: WWTP Capacity Upgrades – Phase 2 (Mid-term)

- Upgrade the facility to the four-train capacity including permeate pump motor replacement.
- Evaluate replacement of aeration and MBR lobe air blowers with a more energy efficient blower type.
- Provide an option for low air demand at night by connecting the discharge lines between the blowers. The system could then provide air to both aeration tanks from one blower, reducing the amount of wasted air and power demand during the low flows and loads that typically occur at night.
- Install a variable frequency drive (VFD) for the pumps serving the equalization tank. This will allow staff to select a low-flow rate that the treatment process can better accommodate and require less operator time.
- Replace the belt filter press with a higher capacity screw press. Include a discharge conveyor that would more efficiently fill the bed of the sludge haul truck.
- Install appropriate fencing to secure the WWTP (automatic gate, card reader, etc.) and replace signage as necessary.
- Improve lighting in the anoxic and MBR tank areas.
- Repair damaged or broken concrete throughout the plant property.
- Install wall bracing for filtrate piping between the ceiling and wall in the Solids Handling Building.

- Replace the six aluminum slide gates at the aeration and anoxic tanks with motorized stainless-steel slide gates.
- Perform an engineering study and field measurements to determine the best corrective action for blower breakers tripping during brown-out or facility power loss.
- Replace the controls or actuator for the AUMA valve actuator for the reuse water system.
- Replace the existing influent and effluent samplers and cabinets with refrigerated samplers.
- Replace aeration and MBR lobe air blowers with a more energy efficient blower type.

WWTP 7: Anoxic Tank Foam (Long-term)

- Install a sprayer system and telescoping skimmer valves to remove the anoxic basin foam layer.

5.2.2 PUMP STATION IMPROVEMENT AND REPLACEMENT PROJECTS

Based on the on-site assessments and evaluations, the following pump station capital improvements projects (Table 5-2) were identified. All projects were identified with a "Short-term" project timeline to be completed within the next 1 to 3 years.

Table 5-2. Detailed Pump Station Project List

Project	Pump Station Name	Project Name	Project Cost ($)
1	All Pump Stations	Pump Evaluations	$155,900
2		Fall Protection	$22,300
3		Telemetry Upgrades	$34,200
4		Corrosion Repair/Protection	$74,000
5		Fencing	$65,200
6		Load Bank Testing	$31,200
7		Pump Station Generator Replacement	$170,900
8	Cherry Brooke	Mechanical Upgrades	$32,400
9		Electrical Upgrades	$9,000
10	Railroad	Electrical Upgrades	$14,300
11	Taylor's Ridge	Electrical Upgrades	$47,100
12		Generator Upgrades	$85,500
		Total:	**$742,000**

PS-1 All Pump Stations (Short-term):

1. Pump Evaluations

- An evaluation of the pumps at each station should be conducted to identify needs for repair, adjustment of parts, or replacement.

2. **Fall Protection**

   - Install fall protection at wet well access hatches as required by the WAC for permit confined spaces.

3. **Telemetry Upgrades**

   - Provide upgraded telemetry equipment for compatibility with current cellular communication technology.

4. **Corrosion Repair/Protection**

   - Clean, prepare, and recoat discharge piping and fittings in wet wells and vaults.

5. **Fencing**

   - Repair or replace site fencing as needed to accommodate pump station access and security.

6. **Load Bank Testing**

   - Conduct bi-annual 100 percent load bank testing of five pump station standby generators (Cedars Pump Station has been eliminated).

7. **Pump Station Generator Replacement**

   - Over the 6-year CIP period, replace the generators at Cherry Brooke and Railroad Pump Stations. Replace every other year in order of worst condition first.

Cherry Brooke Pump Station

8. **Mechanical Upgrades**

   - The existing air release valve (Val-Matic Model 22) is designed for clean water use and should be replaced with one that is intended for wastewater, such as the Val-Matic Model 48, which is the model in use at the Taylor's Ridge Pump Station.

   - The backflow preventer is located below ground. Relocate backflow preventer to an above-ground location and provide frost protection.

   - Replace the "lead pump on" float and confirm proper operation of the float system.

9. **Electrical Upgrades**

   - Provide a main disconnecting means that can operate with the internal panel cover closed.

   - Replace the failed panel-mounted ground fault circuit interrupter (GFCI) receptacle.

   - Increase the air gap between the wet well conduits and the control panel entry to meet the required minimum 18-inch distance. Provide expanded steel mesh protection around the exposed wet well cables.

- Provide conduit and conductors between the control panel and the generator enclosure for 120 Volt power feed of auxiliary equipment. Remove the existing exposed control panel receptacle and cord connection to generator equipment.

Railroad Pump Station

10. Electrical Upgrades

- Provide a separate panel-mounted alarm light labeled for transducer fail/backup float operation.
- Verify proper use of seal fittings or provide an adequate air gap preventing gases from entering the control panel.
- Replace the damaged grounding electrode conductor. Provide new crimp splice connections for terminating additional ground conductors.
- Replace the generator and ATS with a system properly sized to allow full duplex pump operation under standby power.
- Extend the generator exhaust to vent outside the equipment shelter to improve ventilation if the generator is not replaced.

Taylor's Ridge Pump Station

11. Electrical Upgrades

- Provide three separate conduits for the two wet well pump motor cables and float cables. Increase the air gap between the open conduit and junction boxes to the required minimum of 18 inches. Provide expanded steel mesh protection around the exposed wet well cables.
- Replace all control panel door components and back plate with equipment to provide wire management. Provide adequate separation for the intrinsically safe relays and consolidate the remote telemetry unit (RTU) communication terminations into one compartment. Confirm that the intrinsically safe conductors have adequate separation within the MCC and modify as necessary. Provide new RTU input conductors from the sources outside the control panel section to a new terminal strip.
- Replace both sets of motor starter equipment and MCC doors. Provide a complete back panel with new overcurrent protection, starters, associated equipment, and wire management. Provide a new intrinsically safe relay and new Low/Low-Level float for pump interlock. Provide new MCC doors with associated selector switches.

12. Generator Upgrade

- Replace the generator and ATS with a system properly sized to allow full duplex pump operation under standby power.

5.2.3 CONVEYANCE IMPROVEMENT PROJECTS

Based on the results of existing and future wastewater collection system modeling, one conveyance improvement project (CS-1) was identified below. Three additional projects were added:

CS-1: Infiltration and Inflow (Short-term)

- As discussed in the following section, the I/I Program accumulates funds to address known issues. Multiple issues are typically addressed by combining into a single project every few years. CS-1 is therefore an I/I project resulting from the I/I Program.

CS-2: Old Town Alleys (Short-term)

- Clear alleys for access to sewer main and potential CIPP or slip lining because of I/I issues. Old town alleys have been encroached on by adjacent property owners. Funding is necessary to reclaim sewer right-of-way.

CS-3: NE 145th Street (Long-term)

- Upsize pipes 195, 196, and 616 along NE 145th Street from 8-inch to 12-inch diameter to increase available capacity. Prior to commencing this project, 1 to 2 months of wet-season flow monitoring in the subject pipes is recommended to verify the model results.

5.2.4 CITYWIDE IMPROVEMENT PROGRAMS

The CIP includes the following Citywide improvement programs:

CP-1 Infiltration/Inflow Program (Annual)

This is an on-going Citywide program to address I/I issues throughout the City's collection system. These issues are mostly located in the Old Town area of the City where sewer main piping is concrete bell and spigot.

The City has recently started participating in flow data collection from Tolt Hawk monitors installed on the underside of sewer manhole lids. City staff intends to use this data to prioritize I/I projects throughout the City's collection system based on subbasins.

CP-2 System Repair and Replacement (Annual)

Collection System

Within CP-2 is the Annual Pipe Replacement/Cured-In-Place Pipe (CIPP) Program/Root Removal Program used to preserve and enhance the City's existing and planned sewer system. The program provides the City with a systematic approach for evaluating piped conveyance networks for condition, root intrusion, blockages, sediment accumulation, and other similar conveyance issues. The City will need to consider allocating a significant annual budget including funding for staff resources to administer the maintenance, operations, and capital programs to ensure that the sewer utility infrastructure is preserved in a cost-

effective manner. For regional improvements, staff resources will be used to prepare grants and coordinate with local and federal governing entities.

Facilities

The purpose of the Facility Infrastructure Upgrades Program is twofold: (1) periodically replace equipment when it reaches end of life or obsolescence, and (2) plan for upgrades as they relate to future, anticipated regulatory changes. Equipment such as pumps, mixers, blowers, valves, gauges, etc. at the WWTP or pump stations across the City's collection system require regular replacement when they reach end of life (e.g., typically, 20-year life planned for mechanical equipment). Other items may reach obsolescence before planned end of life, such as when a manufacturer discontinues a product line and ends production of spare parts. Funding for this program, therefore, supports regular replacement of equipment outside the scope of planned capital improvement projects. Furthermore, regulations periodically change and typically become more stringent; thus, this program also provides funding for upgrades to facilities to ensure local, state, and federal regulations are consistently achieved.

CP-3 Sewer Plan Update (2027)

This is an on-going effort to keep goals, policies, and design standards current with federal regulations. This program also provides future planning for WWTP updates or upgrades that would trigger a review and approval process with Ecology.

CP-4 Sewer CP-4 Facility Building Maintenance (Annual)

Buildings that are related to and support the sewer system functionality (but are not directly facilities that convey or process sewage) require periodic upkeep. City staff, including those dedicated to sewer operations, are currently housed at several City facilities. Over time, there will need to be upgrades, expansions, major maintenance, etc. to said facilities. This program provides funds for the upkeep of these facilities.

Typically, City buildings that house staff supported by multiple funds have split costs proportionally based on the comingled full-time equivalent (FTE) breakout. We expect this funding strategy to continue over time. Shared costs to building improvements should be charged accordingly.

CP-5 Sewer Plan Update

As discussed in the 2021 WWTP Capacity Evaluation (Appendix A) and summarized in Section 2.5, the WWTP is forecasted to reach 100 percent of three-train capacity in 2025. The WWTP is already permitted for expansion to four-train capacity. However, the plant is forecasted to reach 85 percent of four-train capacity prior to 2040, but not exceed 100 percent capacity by future buildout population as forecasted in the 2001 Facility Plan and the 2017 update to the 2015 Comprehensive Plan. Because the plant is forecasted to reach 85 percent four-train capacity (an action level triggered in the NPDES permit) within the planning period of this update (through 2040), but not exceed 100 percent capacity by buildout, an

Engineering Report will need to be prepared to document with Ecology that four-train WWTP Capacity will be adequate for buildout population. CP-5 captures the effort required for this Engineering Report.

5.3 PROJECT COST ESTIMATES

Planning level cost opinions were prepared by Parametrix in January 2019, for each of the CIP projects developed in this work (see Appendix F). The cost opinions incorporated capital costing information from RSMeans CostWorks, vendor quotes, and historic project bids. Mechanical and electrical installation costs were assumed to be 45 percent and 35 percent of equipment cost, respectively. A tax of 8.9 percent is included, as well as administration and construction engineering services which ranged from 5 to 20 percent depending on the project needs. A contingency of 30 percent was applied to each project. The costs were updated to August 2021 dollars using a Construction Cost Index increase of 12 percent.

5.4 OPERATIONS AND MAINTENANCE

As the sewer system network and facilities age, the ability of the system to perform as designed deteriorates if left unchecked. Therefore, the City implements a sewer O&M Program which has two primary functions:

- Maintain the functional use of the public sewerage system; and
- Maintain and achieve permitted regulations for effluent quality.

Routine maintenance reduces the potential for unexpected equipment shutdowns, ensures reliability of the system, reduces overall costs by correcting minor problems before they become major problems, provides data on the usable service life remaining of equipment, and predicts need for replacement. Key maintenance tasks include:

- Regular observation of equipment for sound, vibration, or other signs of abnormal operation, and performing basic maintenance and repair tasks.
- Weekly tasks include inspection of pump stations, hosing down collected solids, and refilling lubrication oil reservoirs.
- Additional periodic maintenance tasks include rebuild and repair of equipment, replacement of process filters (air, oil, etc.), replacement of lubricant, and replacement of belts.
- Maintaining a log of maintenance performed.
- Maintaining an adequate supply of spare parts and other necessary supplies.

Key operations tasks include:

- Daily recording of meter readings and sampling and testing of wastewater and sludge.
- Calibration of monitoring equipment and sensors as recommended by manufacturer.

- Adjusting the operation of facilities in response to season, influent changes, biological issues, or other factors.
- Maintaining a safe and clean operating environment.
- Periodic checks to verify alarms, controls, and backup equipment are functioning properly and will start up as required.

Additional operations, maintenance, and inspection duties performed by WWTP staff include:

- Daily inspections – Plant walkthrough, biosolids dewatering, digester transfer when needed, Biosolids Specific Oxygen Uptake Rate test when needed, address any issues found in walkthrough, and record MBR data.
- Weekly inspections of pump stations – Generator test run and inspection, manually test pumps, visual well inspection (grease, debris, etc.), record pump hours and start cycles, and inspect fencing.
- Lab testing – Flow, Ph, Temperature, CBOD, BOD, Solids, Volatile Solids, Fecal, DO, and collect samples for outside testing of NH/3, Total Kjeldahl Nitrogen (TKN), Nitrate Nitrite, Total Phosphorus, Ortho Phosphates, performance evaluation testing for lab accreditation (twice annually), Biosolids Classification testing (annually), Biosolids 503 Testing (annually).
- Plant checks – Plant walkthrough, Record pH, Flow, and weather conditions.
- Other – MBR recovery cleans, MBR inspections and repairs, remove and replace electric motors, blowers, pumps (lift stations and plant), belts, air filters, oil, wear parts, plumbing parts, sampler cleaning, UV cleaning, grounds/vegetation maintenance (lift stations and plant), lift station cleaning (grease and debris removal), vehicle maintenance, building maintenance, winterize plant, general plant repair, lift station rodent control, pressure washing, scheduling biosolids haul off, procurement of lab supplies, scheduling of fuel deliveries (lift stations and plant), on-call response, scheduling calibration of flow meters, pressure transducers, level transducers, balances, scheduling MBR cleaning chemical deliveries, monitor and transfer of grit and headworks screenings, schedule removal of grit and headworks screenings, procurement of biosolids dewatering chemicals.

5.4.1 TREATMENT PLANT

During the on-site evaluation, Parametrix identified some items which, in discussion with City staff, were determined to not be significant enough to warrant incorporation into a CIP project. Those general items, and other recommendations are:

- Corrosion prevention on painted surfaces
- Replace safety chains and other metals material with rust-resistant alternatives as required
- Continue evaluation and installation of safety equipment or PPE (handrails, safety chains, etc.)
- Installing stainless steel weather/sun shields at displays with high exposure to the sun and UV light

- Continue checks and monitoring of air valves for potential replacement or maintenance
- Evaluate existing lighting fixtures for maintenance, repair or replacement
- Replace PVC conduit with galvanized steel or aluminum conduit where applicable
- Evaluate pull boxes liquid-tight seals and replace as required
- Routinely evaluate and inspect all liquid-tight conduit is in-tact, repair or replace as necessary

5.4.2 CONVEYANCE SYSTEM

As described in Section 4.1.1, the shelter over the generator at the Railroad Pump Station has span beams resting on support beams. These should be secured together with brackets and screws.

City WWTP staff also complete pipe cleaning, vactoring, and line jetting periodically throughout the City's conveyance network. This maintenance activity can also include video inspection of pipes to check for root intrusion, pipe displacement, I/I, or other failures.

5.4.3 FATS, OILS, AND GREASE (FOG)

Fats, oils, and grease (FOG) enter the sewer system mainly through improper disposal of cooking oils and grease poured down drains and from fats dissolved in residential and commercial dishwashers and garbage disposals. FOG typically congeals at it cools after cooking or dishwashing and can lead to many issues in a sanitary sewer system including blocked side sewers, reduced conveyance pipe capacity, odor issues, level sensing failure and pump clogs in pump stations, and foaming and fouling in the WWTP. City staff has indicated that the collection and treatment systems have ongoing issues with FOG, particularly in the commercial area of the City. During the pump station and WWTP plant site visits conducted for this Plan, Parametrix noted FOG buildup in several pump stations, and FOG is likely responsible for the foaming issues in the anoxic tank at the WWTP.

While FOG can be addressed at pump stations and the WWTP by certain treatment processes such as ozone digestion, it is best eliminated at the source. The largest contributors of FOG to the system are typically restaurants, commercial kitchens (including grocery stores and some schools), and dairy production facilities. Significant reductions in FOG can be achieved by requiring pretreatment at these types of sources. Pretreatment typically consists of a grease interceptor, which detains the grey water discharged from the kitchen to allow the water to cool and the FOG to float or settle out of the grey water before it is discharged to the collections system. FOG is periodically pumped from the grease interceptor and disposed of or used in industry. When appropriately sized for the flow and grease loading and properly maintained, a grease interceptor is a very effective method of preventing FOG from entering the sewer system. Disadvantages to grease interceptors are the need to separate the grey and black water plumbing in the building served, the relatively high cost of installation, and the need for periodic maintenance.

Duvall Municipal Code Section 9.04.080 currently includes prohibitions and limitations on discharge of deleterious substances to the sanitary sewer, including a limit of 100 parts per million (ppm) on FOG. This limit is typical of jurisdictions around the country. The code is currently lacking specific pretreatment requirements for new and existing FOG-generating businesses, and there are no provisions for monitoring

to determine if customers are in violation. Violation of the code is a civil infraction, enforced by the Code Enforcement Officer, with a fixed fine of $500 per day for violation.

To address the FOG issues in the system, the following three steps are recommended:

1. Perform a significant public education campaign. This campaign should include detailed flyers in utility bills aimed at residential customers. The campaign should also include visits to restaurants, stores, and commercial kitchens to explain the importance of FOG management and recommend kitchen best management practices that can significantly reduce FOG discharge to the sewer system. The education campaign can also be used to explain the code updates recommended in Step 2 below.

2. Revise the Sanitary Sewer Utility Code to require installation of appropriate FOG management systems, such as grease traps and grease interceptors, for new and existing businesses that generate FOG, and to require periodic self-monitoring and reporting of FOG discharge to the City's sewer system. The City Council may also wish to increase the financial penalties for violations to be more consistent with the high maintenance costs associated with FOG violations. There are numerous examples of such regulations in the codes from surrounding jurisdictions in Western Washington.

3. Enforce the revised code through the self-monitoring process to ensure that FOG management systems are properly operated and maintained.

The high costs of installing FOG management systems such as grease interceptors, particularly at existing businesses, can be seen as a hindrance to making the code revisions recommended above. To help address this issue, the City Council could elect to implement a loan program to assist business owners with the costs. As an example, Pierce County has a program called the Commercial Sewer Conservation Loan Program that will loan up to $50,000 to qualifying businesses to cover up to 90 percent of the cost of pretreatment installation.

5.4.4 MAINTENANCE AND OPERATIONS STAFFING

To achieve the City's operations and maintenance program, the City employs three full-time staff. All three staff share the maintenance duties outlined in Section 5.4.1. As the City's sewer system has seen rapid expansion in recent years, and continues to expand, additional staff are needed to maintain the growing system. As shown in Table 5-3, the City has identified the need for at least one additional full-time staff, classified as a Maintenance 1 position. All three current staff are licensed WWTP operators and spend the majority of their time maintaining and operating the WWTP. Therefore, the new full-time position would be largely handling maintenance of the collection system and pump stations, including the maintenance of pumps and valves, and clearing vegetation in alleys and near sewer system facilities to allow access for maintenance.

Table 5-3. Sewer Operations FTE Workload Summary

Sewer Operations FTE Workload Summary Description	Maintenance Period	Frequency (Times/Year)	Time/Unit (Hours)	No. of Staff	Time/Year (Hours)
Preventative Maintenance					
Equipment Observation	Daily	260	1	1	260
Inspect and Clean Pump Stations	Weekly	52	8	1	416
Systemwide vactoring (Lift Stations, WWTP Incoming Line, Ring St)	Quarterly	4	16	1	64
Systemwide flushing of flat sewer lines	Semi-Annually	2	8	2	32
Safety work/support	Monthly	12	8	1	96
Check Plant	Daily	260	2	2	1,040
Check Plant – Weekends and Holidays	Daily	105	2	1	210
Rebuild/Repair Equipment	As Needed	1	120	2	240
Replace Lubricants	Semi-Annually	2	20	2	80
Replace Process Filters	Quarterly	4	8	1	32
Replace Belts	Annually	1	20	2	40
Documenting Maintenance	Weekly	52	2	1	104
Inventory/Stocking/Parts	Quarterly	4	4	1	16
Alley Maintenance (needed)	Weekly	52	16	1	832
				Maintenance Total	3,462
Operations					
Sampling, Testing, and Monitoring	Daily	260	4	1	1,040
Calibrating of Monitoring Equipment and Sensors	Weekly	52	1	1	52
Adjusting Facility Operations	Daily	260	2	1	520
Biosolids Management - Cleaning, Testing, Haul Away	Daily	260	1	1	260
Groundskeeping – Plant	2x/Month	24	8	1	192
Groundskeeping – Pump stations	2x/Month	24	8	1	192
Inspection and Cleaning of Membranes	Semi-Annually	2	40	3	240
Draining and Cleaning Tanks and Diffusers	Semi-Annually	2	40	2	160
Check Alarms, Controls, Backup Equipment	Daily	260	3	1	780
Regulatory Reports	Monthly	12	4	1	48
Filling out DMRs	Daily	260	0.5	1	130
Miscellaneous Projects	Quarterly	4	15	2	120
Management Support for Public Works Director and Work Planning	Monthly	12	0.5	1	6
				Operations Total	3,740
Does not include after-hours call outs					
Total Hours Required					7,202
Total Full Time Employees Required (based on 1,560 hours per year per person)					4.62

FTE = full-time equivalent; DMRs = discharge monitoring reports

5.4.5 CONSTRUCTION SITE INSPECTION

City inspectors and sewer utility staff ensure proper installation and function of Sewer Utility Collection and Conveyance systems. Inspections make sure new sewer construction, typically as part of new developments, follows approved plans and meets applicable codes. The City's inspection capacity covers most civil site and building work. However, when inspections for specialty areas such as electrical, mechanical, and structural/seismic are required, the City contracts with a third party – typically an engineering firm – to participate in the inspections.

5.4.6 EMERGENCY MANAGEMENT

To ensure a more secure and resilient nation, the Federal Emergency Management Agency created the National Preparedness Goal to help communities prepare for, withstand, and recover from an emergency or disaster. The primary method used to prepare for various emergencies and disasters is through the use of Threat and Hazard Identification and Risk Assessments (THIRA). The THIRA is an all-hazards capability-based assessment tool used by communities to help understand its most likely threats and hazards and how their impacts may vary according to time of occurrence, season, locations, and community factors.

A THIRA was proposed as part of the sewer utility CIP update; however, on further evaluation, it was determined that a THIRA is best suited as a community and multi-systemwide analysis, not just for the sewer system, and therefore, was not conducted. While a THIRA was not conducted, threats to the sewer system infrastructure can still be identified. Threats which may impact the sewer collection system and WWTP include:

- Earthquake
- Flood
- Levee Failure
- Human-caused attacks (biological, chemical, cyber, etc.)

The WWTP discharges into the nearby Snoqualmie River; the outfall could be impacted by flooding and levee failure. An earthquake could impact many facets of the sewer system including buried pipes, pump station structures, and WWTP infrastructure.

The City participates in WAWARN, the Washington Water/Wastewater Agency Response Network, which is a system that allows other water and wastewater utilities to receive rapid mutual aid and assistance from other systems in an emergency.

6. PROJECT FUNDING, RATE STUDY

6.1 GRANTS

In past years, the City has secured grants and low-interest loans for constructing sewer infrastructure. Notably, the 2001 WWTP upgrades were grant funded. While the City has secured additional grant and loan funding for more recent past projects, there are currently no ongoing grant or loan pursuits. The City may consider applying for funding for upcoming CIP projects. Grants the City could apply for include:

- WA Ecology Integrated Water Quality Funding Program (Loan)
    - Eligible Projects: Design and construction projects associated with publicly-owned wastewater facilities.
- Public Works Board – Preconstruction and Construction Loan Programs
    - Eligible Projects:
        - Preconstruction activities including design, engineering, permit acquisition, and environmental review.
        - Construction activities that focus on repair, replacement, or creation of a wastewater facility.

6.2 SEWER UTILITY RATE STUDY

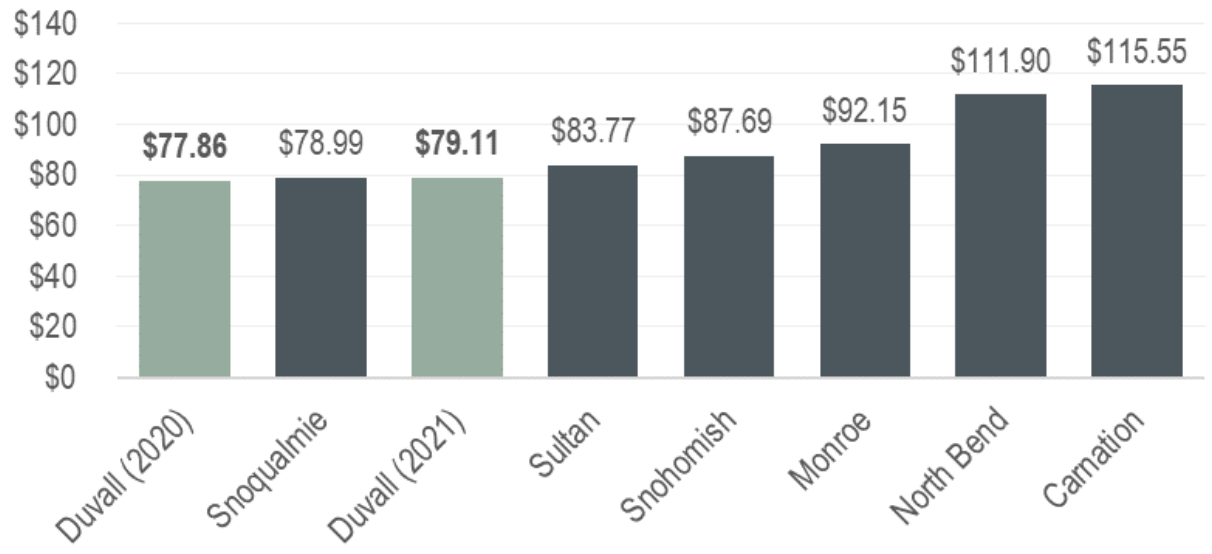
As part of this CIP Update, a sewer utility rate study was conducted by FCS Group. This study documents the sewer utility revenue requirement and general facilities charge (GFC) recommended updates. The full report is provided in Appendix G, with key results of the study summarized below.

6.2.1 402 OPERATING SEWER FUND

City funds for sewer improvements come from the City's 402 Sewer Utility Fund. The 402 Sewer Utility Fund charges are billed as monthly rates to customers and contribute to operations and maintenance activities along with minor system improvements. These funds pay for staff, equipment, services, and other resources required for day-to-day operation of the Sewer Utility.

FSC Group documented the 2020 Sewer Utility rates of seven eastern Puget Sound Cities, which ranged from $77.86 (Duvall) to $115.55 (Carnation) with an average rate of $92.56. The City's 2020 rate of $77.86 was below the average studied per month as illustrated in Figure 6-1.

Figure 6-1. Summary of 2020 Single Family Residential Monthly Sewer Utility Rates



Annual 402 Sewer Utility Operations Fund rate revenue and expenses associated with operations and maintenance were well balanced, with a balance of approximately $3.5M beginning January 1, 2021, suggesting appropriate rate amounts.

6.2.2 408 Sewer Capital Improvement Fund

The City's 408 Sewer Capital Improvement Fund revenues are reserved for Citywide replacement projects, conveyance and capacity improvements, and other general system improvements. Improvement projects may be partially or wholly funded by GFCs paid at time of building permit in accordance with Duvall Municipal Code (DMC) 9.04.110 and are intended to recover a share of the cost of system capacity needed to serve growth. Existing cash balance of the 408 Fund is approximately $2.45M.

Revenue to this Fund comes from General Facility Charges (GFC) for construction projects including commercial construction or residential/multi-family home developments charged at final plat or commercial building permit approval. The existing GFC is $11,953/ERU; the rate study calculated a revised maximum future GFC of $14,087/ERU as detailed in Table 6-1, Table 6-2, and Table 6-3.

Table 6-1: Total Cost of Existing Facilities Serving Customers

Cost Basis	Amount
Utility Plant-in-Service (through 2019)	$28,839,922
Less: Contributed Capital (through 2019)	(18,226,658)
Plus: Interest on Non-Contributed Plant (through 2019)	4,814,521
Plus: Cost of Planned Future Upgrade Facilities (through 2037)	4,077,175
Plus: Construction-Work-in-Progress (end of 2019)	672,000
Total Cost of facilities serving all customers	**$20,176,959**

Description	Amount
Total Cost of Facilities Serving All Customers	$20,176,959
System Capacity (ERUs)	3,928 ERUs
GFC Component 1 of 2	**$5,136.26 / ERU**

Table 6-2: Total Cost of Facilities Serving Growth

Cost Basis	Amount
Total Projects in Capital Plan (not inflated)	$18,526,292
Less: Non-Capacity Upgrade CIP from Component 1	(4,077,175)
Less: Repair & Replacement Projects (mostly mains)	(3,884,592)
Less: Developer Contribution & Grants	0
Total Cost of Facilities Serving Growth Only	**$10,564,525**

Description	Amount
Total Cost of Facilities Serving Growth	$10,564,525
ERUs Added by Buildout	1,180 ERUs
GFC Component 2 of 2	**$8,950.46 / ERU**

Table 6-3: GFC Calculation

Cost Basis	Amount
Component 1 general facilities charge	$5,136 / ERU
Component 2 general facilities charge	$8,950 / ERU
Total Calculated GFC (rounded)	**$14,087 / ERU**
Existing GFC (as of 2021)	$11,953 / ERU
Increase	$2,134 / ERU

7. REFERENCES

City of Duvall. (2015). *Comprehensive Plan.* Retrieved from Duvall, WA - Official Website: http://www.duvallwa.gov/297/Comprehensive-Planning

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APPENDIX A

2021 WWTP CAPACITY EVALUATION

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

1019 39TH AVENUE SE, SUITE 100 | PUYALLUP, WA 98374 | P 253.604.6600

TECHNICAL MEMORANDUM

DATE:	October 22, 2021
TO:	City of Duvall
FROM:	Brandon Moss, PE; Allan Maas, PE
SUBJECT:	WWTP Capacity Analysis 2021 Update
CC:	Randy Raymond, PE
PROJECT NUMBER:	216-3240-018
PROJECT NAME:	WWTP Capacity Analysis Update

10/22/2021

1. OVERVIEW

This technical memorandum presents and summarizes the Wastewater Treatment Plant (WWTP) capacity evaluation for the City of Duvall (City). This work included review and analysis of historic WWTP loading and flow data and forecasts City population growth. The WWTP is currently operating at approximately 87 percent of its biochemical oxygen demand (BOD) capacity and 86 percent total suspended solids (TSS) capacity with three membrane bioreactor (MBR) treatment trains in use. When 85 percent capacity is reached, planning for permit and plant capacity expansion is recommended to begin (and required per National Pollutant Discharge Elimination System (NPDES) discharge permit) to maintain adequate capacity for expected growth. However, because the City's WWTP is already NPDES permitted for additional four-train MBR capacity, a plan for expanding plant capacity is not needed. Instead, it is recommended that design of the fourth MBR train upgrades begin in 2021 or early 2022. The four-train MBR capacity is not projected to be reached until after 2038.

A more comprehensive evaluation of the City WWTP facility was completed as part of a separate task. This technical memorandum is focused on an evaluation of the flow and load capacity of the biological treatment part of the WWTP and is provided as an attachment to the City's 2021 Capital Improvement Plan Update. This technical memorandum only includes a brief discussion of headworks, ultraviolet (UV) disinfection, and solids handling systems.

2. BACKGROUND AND DATA COLLECTION

WWTP Design Capacity

Only three trains of a four-train MBR WWTP are equipped and operating with Suez membranes. The three-train maximum month average design flow (MMDF) is 1.3 million gallons per day (mgd). The current NPDES-approved permit includes capacity for the WWTP allowing expansion up to four treatment trains, equating to a MMDF of 1.75 mgd. This evaluation used the three-train and four-train permit capacity for BOD and TSS removal to evaluate WWTP biological capacity; the NDPES permit capacities are detailed in Table 2-1.

Table 2-1: City of Duvall WWTP NPDES Permit Capacity

Number of Treatment Trains	Parameter	Capacity	Units
Three Trains	MMDF	1.3	mgd
	BOD	1,909	pounds per day
	TSS	1,845	pounds per day
Four Trains	MMDF	1.75	mgd
	BOD	2,545	pounds per day
	TSS	2,460	pounds per day

Notes: WWTP = wastewater treatment plant; NPDES = National Pollutant Discharge Elimination System; MMDF = maximum month average design flow; mgd = million gallons per day; BOD = biochemical oxygen demand; TSS = total suspended solids.

A Note on Four-Train Capacity

The existing MBR trains were modified in 2016. Three of the four MBR cassettes in each of the three trains were replaced with cassettes that have 33 percent more capacity. The existing fourth cassette in each train was disconnected and does not operate. The plant capacity was effectively not changed, because the three new cassettes in each train equal the capacity of four of the old cassettes. Upgrading the existing MBR trains could be done by installing new cassettes in the fourth train or installing the fourth cassette in each of the existing three trains. Adding a fourth cassette to each existing train would upgrade the WWTP hydraulic capacity. However, upgrading the plant to the permitted four-train load capacity (2,545 pounds per day [lbs/day] BOD) would require operation of the fourth MBR train aeration and membrane equipment.

Current WWTP Flow and Loadings

The City provided discharge monitoring reports (DMRs) for the three years of WWTP operation (data set ranges from approximately January 2017 through May 2021). The DMRs include information on influent flow rates, BOD loading, and TSS loading. The data set was evaluated for the aforementioned parameters (see Attachment A). Influent flow is generally consistent across the data set with higher flows in the winter/spring and lower flow in the summer/fall and was generally not a limiting factor for capacity evaluation.

The data set revealed some uncharacteristically high monthly loadings for BOD and TSS. The individual data points contributing to these elevated loadings were inspected and did not reveal any apparent connection to holidays or unusual wet weather events where additional loading may be expected. Inconsistencies and/or inaccuracies with biological tests such as the 5-day BOD test are not entirely uncommon as biological tests can be impacted by sample toxicity (e.g., BOD sample with incomplete nitrification occurring during treatment) which can lead to uncharacteristically high results. This is further compounded by the fact that BOD and TSS are monitored by a composite sampler only one and two times a week, respectively.

Additionally, after October 2018 sampling, results became more variable and showed an overall increase in loading. Based on discussion with the City, it was suspected that new businesses such as a brewery and distillery may have had unauthorized discharges to the sewer, causing periodic loading spikes. The City investigated these potential contributors and determined that the new businesses were likely not impacting sampling because the brewery had limited production amounts and the distillery was just a show room. Further investigation revealed that the composite sampler location was moved to a different location at the WWTP headworks in October 2018. The sampler location was returned to the original location in March 2021, and additional samples were monitored via testing at the WWTP and a third-party testing lab. Analysis of these results indicated that the 2018 sampler move resulted in unusual testing results. The samples taken between October 2018 and February 2020 are from a

poorly mixed and sometimes stagnant flow area. Once the sampler was moved back to a better-mixed area, results have been more consistent.

As such, some outliers in the BOD data were omitted and the data for BOD and TSS was evaluated at a 95th percentile. This resulted in approximate loading of 1,657 lb/day BOD and 1,585 lb/day TSS. A summary of the loading and percent of WWTP capacity utilized is presented in Table 2-2.

Table 2-2: Existing WWTP Loading

	Existing (Year 2021)
Equivalent Sewer Population	8,722
BOD	
BOD Loading (lb/day)	1,657
Percent of NPDES Permit Max. Month Limit (Current Three-Train Capacity)	87%
Percent of Future Four-Train Capacity	65%
TSS	
TSS Loading (lb/day)	1,584
Percent of NPDES Permit Max. Month Limit (Current Three-Train Capacity)	86%
Percent of Future Four-Train Capacity	64%

Notes: WWTP = wastewater treatment plant; BOD = biochemical oxygen demand; lb/day = pounds per day; NPDES = National Pollutant Discharge Elimination System; % = percent; TSS = total suspended solids.

A comprehensive evaluation of the Duvall WWTP facility was not included in this technical memorandum (see the 2021 CIP Plan Update for a more comprehensive evaluation), but most of the WWTP facilities were designed to match the four-train capacity. Based on discussions with the WWTP staff, there are no issues with WWTP hydraulic capacity; staff believe that the BOD capacity should be the focus of this evaluation. The headworks screens, grit removal, and flow measurement were designed for a peak hour flow of 5.25 mgd or greater. The facility has capacity for influent equalization via approximately 300,000 gallons of influent storage (downstream of headworks) allowing peak flows to be processed over a longer duration and stay within plant capacity. The MBR chemical systems and solids systems were designed to handle the four-train maximum month and average day loadings. It is anticipated that as part of the future four-train WWTP capacity upgrade, a new UV system will be installed to adequately handle the upgraded flow capacity.

Existing Population and Expected Growth

To evaluate the City's future growth and how and when it will impact the WWTP loading capacity, a population estimate was developed to account for significant planned short-term growth and maintain consistency with the City's Comprehensive Plan/Transportation Plan and the Washington State Office of Financial Management (OFM) population data.

OFM annually determines and publishes the population of all cities and towns in the state. In 2020, the population of Duvall was published as 7,950. This is only residential population and does not account for "equivalent population" from commercial and light industrial uses. There was approximately 370,650 square feet of commercial and 78,800 square feet of light industrial land use as of the year 2020 (data provided by City and consistent with that cited in the 2017 Transportation Analysis update to the 2015 Comprehensive Plan plus

growth since the publication of the update). Furthermore, consistent with King County Buildable Lands Report (KCBLR), an additional approximately 19,300 square feet of light industrial and 197,700 square feet of commercial is anticipated to be added over the 2020 to 2040 period (data provided by City).

The City provided a conversion of one equivalent residential unit (ERU) per 3,000 square feet of commercial and light industrial space (effectively one additional residential connection worth of flow per every 3,000 square feet). The City also provided a conversion of approximately three people per household, meaning one ERU is equivalent to a population of three people.

Therefore, commercial and light industrial spaces add approximately 161 ERU or 461 equivalent population as of 2020. Adding the commercial and light industrial equivalent populations to the OFM population estimate, brings the total 2020 population estimate to 8,411.

The 2001 Wastewater Facility Plan forecasted a City population of 12,516 through 2020. This was based on historical population growth data which suggested a growth rate of approximately 4.8 percent per year (5.0 percent was ultimately adopted by the City's Planning Department). Actual residential growth rate over the years 2010 through 2020 ranged from 0.3 to 3.19 percent, averaging 1.7 percent per year, which is approximately 150 population per year based on current 2020 population estimate.

In the 5-year planning period 2021 through 2025, large developments are anticipated to be completed and are expected to increase population at approximately twice the historic rate of annual growth. The City provided a rate of 300 population per year residential plus 11 population per year from nonresidential growth for the 2021 through 2025 period. Lastly, for 2026 through 2040, the City provided a growth rate of 101 population per year (about 1 percent increase based on 2026 forecasted population) for remaining housing plats as well as commercial and industrial equivalent population. The yearly forecasted population estimate is summarized in Table 2-3.

Table 2-3: Population Projection Yearly Summary

Year	Population Projection
2020	8,411
2021	8,722
2022	9,033
2023	9,344
2024	9,655
2025	9,966
2026	10,067
2027	10,168
2028	10,269
2029	10,370
2030	10,471
2031	10,572
2032	10,673
2033	10,774
2034	10,875
2035	10,976

Year	Population Projection
2036	11,077
2037	11,178
2038	11,279
2039	11,380
2040	11,481

2. CAPACITY EVALUATION RESULTS

Assumptions/Basis of Design

The following assumptions and initial data are used in the WWTP capacity evaluation:

- Existing and projected population as previously described, summarized in Table 2-3.
- 1,657 lb/day BOD current (year 2021) 95th percentile WWTP loading.
  - Equates to approximately 0.19 pounds per capita per day (ppcd) BOD.
- 1,584 lb/day TSS current (year 2021) 95th percentile WWTP loading.
  - Equates to approximately 0.18 ppcd TSS.

Two intervals of projected population were used to evaluate WWTP capacity. The intervals include:

- 2020 equivalent population + near-term rapid expansion.
  - Covers population through 2025.
- 2020 equivalent population + near-term rapid expansion + long-term growth.
  - Covers population through 2040.

Projected Loading per Capita

For this evaluation, all future estimated populations (described in the following section) are assumed to contribute 0.20 ppcd to the WWTP for both BOD and TSS. This loading is a conservative estimate for BOD and TSS per capita contributions (compared to the City's current loading of 0.19 ppcd BOD and 0.18 ppcd TSS (see section above). The 0.20 ppcd is cited in the Washington State Department of Ecology's *Criteria for Sewage Works Design* (Orange Book) as a basis of design for dwellings, schools, and other facilities which produce wastewater and was included in the 2018 Duvall WWTP capacity evaluation in Attachment B.

Projected WWTP Capacity

The projected loadings per capita for BOD and TSS and the projected populations were used to determine the percentage of WWTP capacity "used" for each interval, presented in Table 2-1.

Table 2-1: WWTP Capacity Usage

	Existing (2021)	Projected Through 2025	Projected Through 2040
Equivalent Sewer Population	8,722	9,966	11,481
BOD			
BOD Loading (lb/day)	1,657	1,906	2,209
Percent of NPDES Permit Max. Month Limit (Current Three-Train Capacity)	87%	100%	116%
Percent of Future Four-Train Capacity	65%	75%	87%
TSS			
TSS Loading (lb/day)	1,584	1,833	2,136
Percent of NPDES Permit Max. Month Limit (Current Three-Train Capacity)	86%	99%	116%
Percent of Future Four-Train Capacity	64%	75%	87%

Notes: WWTP = wastewater treatment plant; BOD = biochemical oxygen demand; lb/day = pounds per day; NPDES = National Pollutant Discharge Elimination System; % = percent; TSS = total suspended solids.

Based on current (year 2021) equivalent population and loadings, plant capacity is at approximately 87 percent of BOD and 86 percent for TSS capacities. After near-term rapid expansion for permitted developments is completed (anticipated through year 2025), the plant will be approximately 100 percent of BOD and TSS three train capacity.

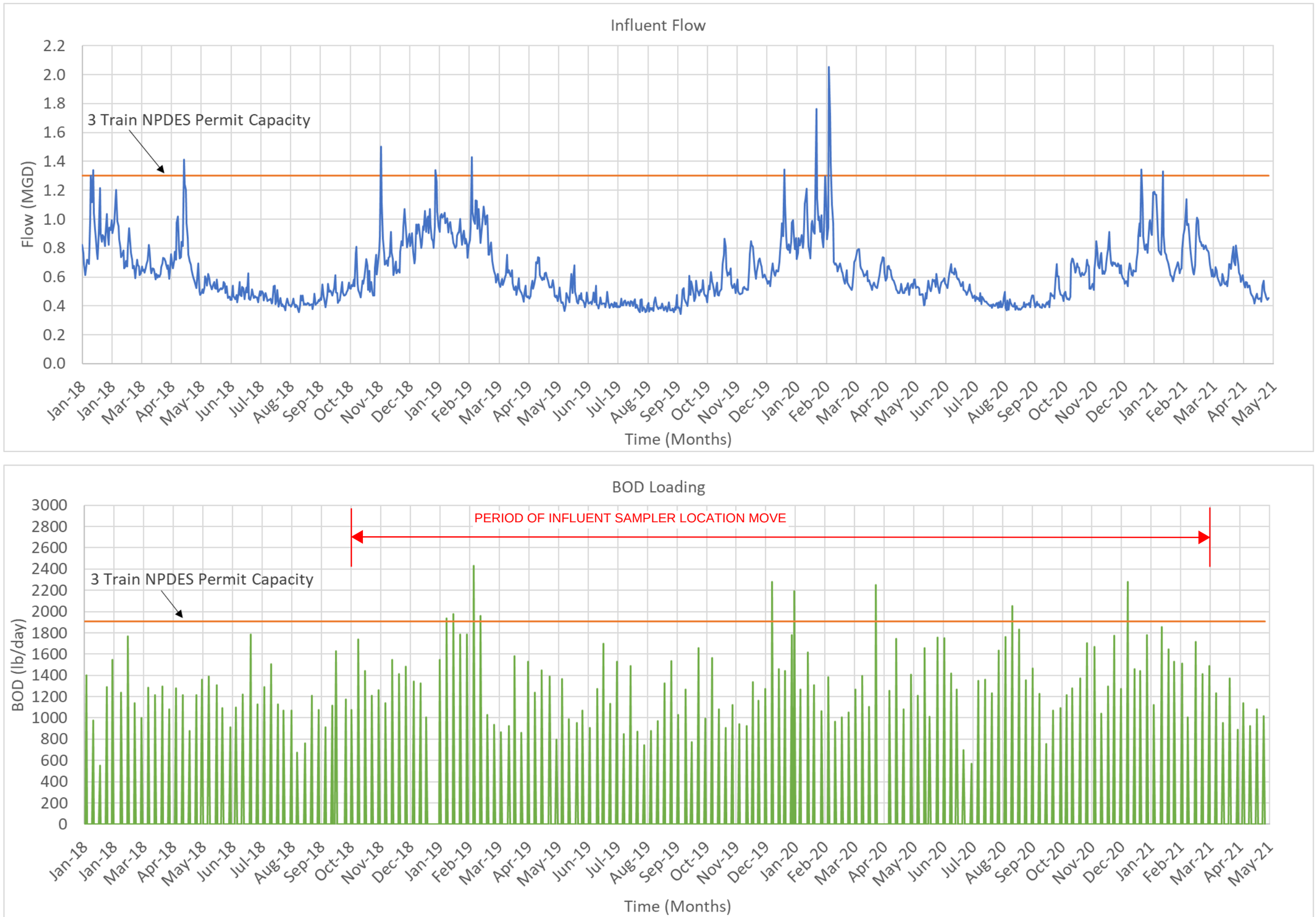
Projections through 2040 show WWTP three-train BOD and TSS capacity being exceeded after 2025. Because of variances in WWTP flow and loading, a conservative approach would be to have the four-train upgrade completed before influent loading reached 90 percent of three-train capacity.

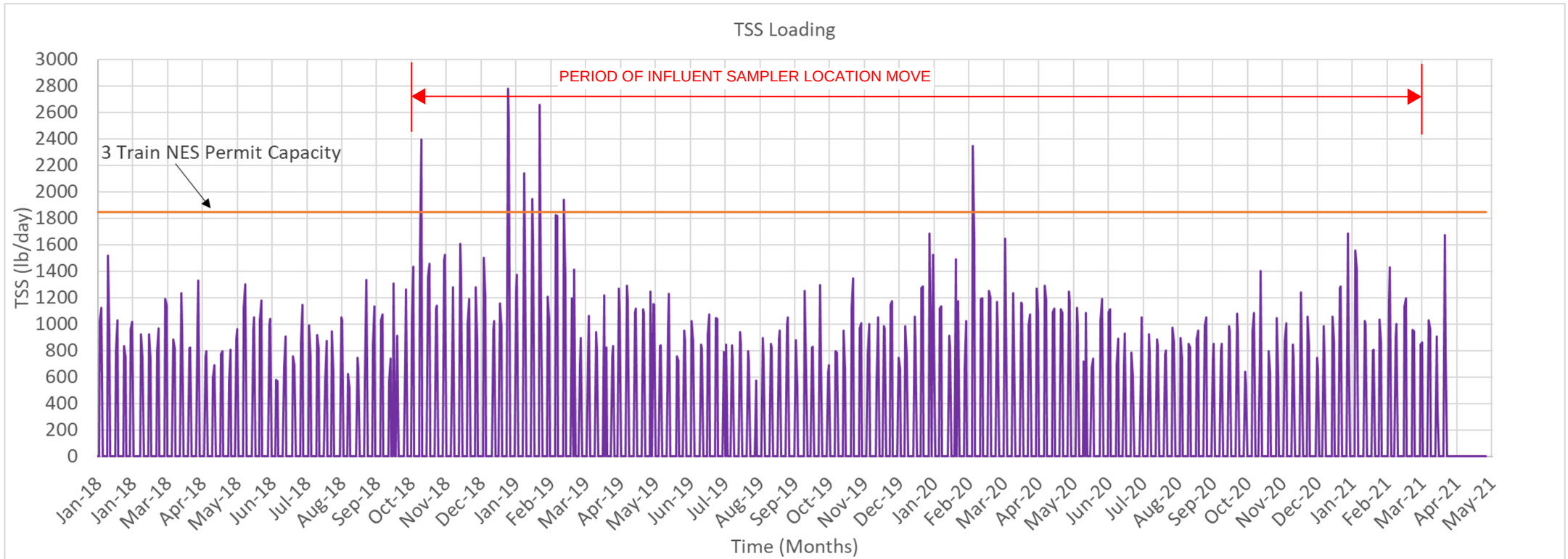
3. CONCLUSION/SUMMARY

The City's WWTP capacity was evaluated at existing conditions with anticipated population growth conditions. The evaluation used a combination of historic WWTP loading and flow data as well as population growth forecast using growth rates provided by the City to assess WWTP capacity. Currently (year 2021), the three treatment trains are at approximately 87 percent of BOD capacity. Per the City's NPDES permit (WA0029513), while waste loading has not had 3 consecutive months above 85 percent the loading, projection shows the plant will reach 100 percent capacity within 5 years. Per section S4.B of the NPDES permit, this triggers the requirement of planning for plant expansion; however, the plant is already permitted to additional four-train capacity. As such, a plan to expand capacity is not needed. Instead, design of plant expansion to four-train capacity should begin in 2021 or early 2022. Based on the City's population projections, the four-train treatment MBR facility should handle City wastewater flows and loads beyond 2038 (at which point, 85 percent capacity is expected to be reached again).

Attachment A

Discharge Monitoring Report Graphs


Influent Flow
Flow (MGD)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3 Train NPDES Permit Capacity
Jan-18
Jan-18
Mar-18
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Feb-19
Mar-19
Apr-19
May-19
Jun-19
Jul-19
Aug-19
Sep-19
Oct-19
Nov-19
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Time (Months)
BOD Loading
BOD (lb/day)
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
PERIOD OF INFLUENT SAMPLER LOCATION MOVE
3 Train NPDES Permit Capacity
Time (Months)


TSS Loading
PERIOD OF INFLUENT SAMPLER LOCATION MOVE
3 Train NES Permit Capacity
TSS (lb/day)
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan-18
Jan-18
Mar-18
Apr-18
May-18
Jun-18
Jul-18
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Feb-19
Mar-19
Apr-19
May-19
Jun-19
Jul-19
Aug-19
Sep-19
Oct-19
Nov-19
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Time (Months)

Attachment B

2018 WWTP Capacity Evaluation
Draft Technical Memorandum,
Parametrix

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

1019 39TH AVENUE SE, SUITE 100 | PUYALLUP, WA 98374 | P 253.604.6600

DRAFT TECHNICAL MEMORANDUM

DATE: October 2, 2018
TO: City of Duvall
FROM: Brandon Moss, EIT; Allan Maas, P.E., Parametrix
SUBJECT: WWTP Capacity Evaluation
CC: Doug Berschauer, P.E., Parametrix
PROJECT NUMBER: 216-3240-015
PROJECT NAME: Wastewater Treatment Plant Capacity Evaluation

OVERVIEW

This technical memorandum presents and summarizes the Wastewater Treatment Plant (WWTP) capacity evaluation for the City of Duvall (City). This work included review and analysis of historic WWTP loading and flow data, the City's future development planning, and City population growth forecast. Overall, the WWTP is operating at approximately 76 percent of current biochemical oxygen demand (BOD) capacity (with three membrane bioreactor [MBR] treatment trains in use). Based on the City's growth projections, the WWTP is projected to reach 85 percent capacity around the years 2021-2022. At that time, it is recommended that design and construction of the fourth MBR train upgrades begin. After the four-train upgrade is made, the four-train capacity is not projected to reach 85 percent of BOD capacity until after the year 2035.

A more comprehensive evaluation of the City WWTP facility is being done as part of a separate task. This technical memorandum is focused on an evaluation of the flow and load capacity of the biological treatment part of the WWTP. This memo only includes a brief discussion of the capacity of headworks, ultraviolet (UV) disinfection, and solids systems.

BACKGROUND AND DATA COLLECTION

WWTP Design Capacity

The City operates three trains of a four-train MBR WWTP with a three-train maximum month average design flow (MMDF) of 1.3 million gallons per day (mgd). The current National Pollutant Discharge Elimination System (NPDES) approved permit includes capacity for the WWTP allowing expansion up to four treatment trains, equating to a MMDF of 1.75 mgd. This evaluation used the three-train and four-train permit capacity for BOD and total suspended solids (TSS) to evaluate WWTP biological capacity; the NDPES permit capacities are detailed in Table 1.

Table 1: City of Duvall WWTP NPDES Permit Capacity

Number of Treatment Trains	Parameter	Capacity	Units
Three Trains	MMDF	1.3	mgd
	BOD	1,909	pounds per day
	TSS	1,845	pounds per day
Four Trains	MMDF	1.75	mgd
	BOD	2,545	pounds per day
	TSS	2,460	pounds per day

A Note on Four-Train Capacity

The existing MBR trains were upgraded in 2016. Three of the four MBR cassettes in each of the three trains were replaced with cassettes that have 33 percent more capacity. The existing fourth cassette in each train was disconnected and does not operate. The plant capacity was effectively not changed, because the three new cassettes in each train equal the capacity of four of the old cassettes. Upgrading the existing MBR trains could be done by installing new cassettes in the fourth train or installing the fourth cassette in each of the existing three trains. Adding a fourth cassette to each existing train would upgrade the WWTP capacity to the four-train capacity shown on the WWTP design drawings and the NPDES permit. Although this would likely be the most cost-effective method to upgrade, the term used throughout this document is “four train capacity”. This was done to simplify the text, but note that four train original documented capacity = three train capacity with the new Zenon cassettes (four new cassettes per train).

Current WWTP Flow and Loadings

The City provided discharge monitoring reports (DMRs) for the past four and a half years of WWTP operation (data set ranges from January 2014 through April 2018). The DMRs include information on influent flow rates, BOD loading, and TSS loading. The data set was evaluated on a monthly average for the aforementioned parameters (see Attachment A). Influent flow is generally consistent across the data set with higher flows in the winter and lower flow in the summer, but was not a limiting factor for capacity evaluation. However, the results revealed some uncharacteristically high monthly loadings for BOD and TSS (e.g. February 2015 for BOD and October 2016 for TSS). The individual data points contributing to these elevated loadings were inspected and did not reveal any apparent connection to holidays or unusual wet weather events where additional loading may be expected.

Inconsistencies and/or inaccuracies with biological tests such as the 5-day BOD test are not entirely uncommon as biological tests can be impacted by sample toxicity (e.g. BOD sample with incomplete nitrification occurring during treatment) which can lead to uncharacteristic high results. This is further compounded by the fact that BOD and TSS are monitored, by a composite sampler only 1 or 2 times a week. Therefore 95th percentile values of 30-day average influent BOD and TSS pounds per day (lb/day) values were used to determine current influent BOD and TSS loadings. The 95th percentile values are 1,459 lb/day for BOD and 1,295 lb/day for TSS (see Attachment A).

A comprehensive evaluation of the Duvall WWTP facility was not included in this memo, but most of the WWTP facilities were designed to match the four-train capacity. Based on discussions with the WWTP staff, there are no issues with WWTP hydraulic capacity; staff believe that the BOD capacity should be the focus of this evaluation. The headworks screens, grit removal and flow measurement were designed for a peak hour flow of 5.25 mgd or greater. The MBR chemical systems and solids systems were designed to handle the four-train maximum month and average day loadings. The UV system will require an evaluation to determine what its capacity is and when an upgrade of this system should be constructed.

To evaluate the City's future growth and how/when it will impact the WWTP loading capacity, existing planned developments (from City Planning Department) and 20-year population projections (from the City's Comprehensive Plan and Transportation Plan) were used to project future wastewater flows and loads.

Current and Future City Developments

The City provided a list of all current permitted developments (extending through the year 2022) and developments still under review (see Attachment B). Each list contained a variety of information including the number of lots, remaining building permits, and zoning. The list of those currently approved contained 12 developments; the City anticipates approximately 369 additional building permits from the currently approved developments including R-4, R-12, and MU12 zoning. The list of developments under review contains three developments, totaling approximately 271 lots including zoning R-8, R-12, R-20, and MUI zoning. As described in the *Capacity Evaluation Results* section below, the number of additional building permits, lots, and zoning density was used to estimate impact on WWTP for these future loads.

Two Urban Growth Areas (UGAs) also border the existing city limits (see Attachment B). It is anticipated that the UGAs may be incorporated into the City at some point in the future. The UGAs contain approximately 234 lots.

Existing Population and Expected Growth

Per the 2017 Transportation Analysis update to the 2015 Comprehensive Plan, the estimated residential 2018 population of the City is 7,813 residents. Again, based on the 2017 Transportation Analysis update, there are also approximately 370,000 square feet of commercial and 56,200 square feet of light industrial land use as of the year 2015. The City provided a conversion of one equivalent residential unit (ERU) per 3,000 square feet (effectively one additional "resident" worth of flow per every 3,000 square feet). Based on the 2017 Transportation Analysis update, a population growth rate of approximately 1.77 percent per year is anticipated and has been confirmed by the City to be used in this analysis. Therefore, using the conversion and expected population growth (since 2015) the commercial and light industrial adds approximately 449 "equivalent" residents, bringing the 2018 total to 8,262 equivalent population.

CAPACITY EVALUATION RESULTS

Assumptions/Basis of Design

The following assumptions and initial data are used in the WWTP capacity evaluation:

- A 2018 equivalent population of 8,262
- Yearly population growth of 1.77 percent (not compounded)
- Population growth projected to the year 2035, consistent with the City's projected growth in the Transportation Plan
- 3.00 ERU per building lot permit or future development lot for residential zoning
- 30.00 ERU per building permit or future development lot for restaurants/business with kitchens (where high strength waste is expected)
- 1,459 lb/day BOD current (year 2015 to 2018) 95th percentile WWTP loading
  - 1,459 lb./day ÷ 8,262 equivalent population = 0.177 pounds per capita per day (ppcd) BOD
- 1,295 lb/day TSS current (year 2015 to 2018) 95th percentile WWTP loading
  - 1,295 lb/day ÷ 8,262 equivalent population = 0.157 ppcd TSS

Projected Loading per Capita

For this evaluation, all future estimated populations (described in the following section) are assumed to contribute 0.200 ppcd to the WWTP for both BOD and TSS. This loading is a conservative estimate for BOD and TSS per capita contributions (compared to the City's current loading of 0.177 ppcd BOD and 0.157 ppcd TSS based on estimated equivalent population and existing WWTP loading, see section above) and has been used by Parametrix in previous facility planning. The 0.2 ppcd is also cited in the Washington State Department of Ecology *Criteria for Sewage Works Design* (Orange Book) as a basis of design for dwellings, schools, and other facilities which produce wastewater.

Projected Populations

Three intervals of projected population were prepared to evaluate WWTP capacity, the intervals include:

1. 2018 equivalent population + current permitted developments
2. 2018 equivalent population + current permitted developments + under review developments
3. 2018 equivalent population + current permitted developments + under review developments + annexation of UGA

The calculated equivalent population for each interval is presented in Table 2. The first interval includes both the current population and expected future population from only current permitted developments; this interval has an estimated equivalent population of 9,396. The second interval includes the additional population from developments under review and has an equivalent population estimate of 10,269. The third interval includes annexation of the UGA resulting in a total estimated 10,971 equivalent population.

Table 2. Projected Population for Each Development Interval

Projection Intervals	Developments	Lots	ERU	Equivalent Population
(1)	**2018 Equivalent Population + Currently Permitted Developments**			
	Currently Permitted	Total: 369	–	-
		368 Residential	3	1,104
		1 Restaurant	30	30
			Currently Permitted Subtotal:	*1,134*
			2018 Equivalent Population:	8,262
			Total:	**9,396**
(2)	**2018 Equivalent Population + Currently Permitted Development + Under Review Developments**			
	Under Review	Total: 271	–	-
		270 Residential [a]	3	843
		1 Restaurant	30	30
			Under Review Subtotal:	*873*
			Total:	**10,269**
(3)	**2018 Equivalent Population + Currently Permitted Development + Under Review Developments + UGA**			
	UGA	Total: 234	3	702
			Total:	**10,971**

[a] Includes one lot as a 12-unit condo (12 units x 3 ERU = 36 equiv. pop.),

Projected WWTP Capacity

The projected loadings per capita for BOD and TSS and the projected populations were used to determine the percentage of WWTP capacity "used" for each interval, presented in Table 3. Based on current (year 2018) equivalent population and loadings, plant capacity is approximately 76 percent utilized for BOD and 70 percent for TSS with three treatment trains. After all current permitted developments are completed (anticipated through year 2022), plant capacity will be approximately 88 percent for BOD and 82 percent for TSS (again with three treatment trains). When loading reaches about 85 percent capacity, this is an indication that planning and design should begin to expand treatment capacity; therefore, the City should consider planning for plant expansion to four treatment trains near the completion of all current permitted developments.

Projections which include all future developments currently under review show WWTP three-train capacity at approximately 97 percent for BOD and 92 percent for TSS. Because of variances in WWTP flow and loading, a conservative approach would be to have the four-train upgrade completed before influent loading reached 90 or 95 percent of three-train capacity. The three-train configuration does not have enough capacity for all expected population growth and annexation of the UGA; this requires at least four treatment trains, which would use approximately 79 percent of BOD and 75 percent TSS capacity.

Table 3. Project WWTP BOD and TSS Loadings for Each Population Projection Compared to WWTP Capacity with Three and Four Treatment Trains

	Existing [a] (year 2018)	Projected [b] (1)	Projected [b] (2)	Projected [b] (3)
Equivalent Sewer Population	8,262	9,396	10,269	10,971
BOD				
BOD Loading (lb/day)	1,475	1,678	1,834	1,959
Percent of NPDES Permit Max. Month Limit (Current Three-Train Capacity)	76%	88%	97%	105%
Percent of Future Four-Train Capacity	57%	66%	73%	79%
TSS				
TSS Loading (lb/day)	1,289	1465	1,602	1711
Percent of NPDES Permit Max. Month Limit (Current Three-Train Capacity)	70%	82%	92%	100%
Percent of Future Four-Train Capacity	53%	62%	69%	75%

[a] Based on January 2014 - April 2018 WWTP Discharge Monitoring Reports and 2018 estimated population (0.177 ppcd BOD, 0.157 ppcd TSS).

[b] Assumes 0.200 ppcd BOD and TSS loading for any future population growth.

While the projection interval and the capacity usage presented in Table 3 are based on current and future development planning, the years in which 85 percent capacity will be reached for both three and four treatment trains can also be assessed based on an overall 1.77 percent population growth estimate as presented in Table 4 on the following page (see Attachment C for projection calculations). BOD loading is a clear limiting factor in WWTP capacity, with 85 percent BOD capacity for three-train treatment being reached about four years earlier than TSS capacity and about three years sooner for four-train treatment.

It should be noted that while the 1.77 percent growth rate method results in 85 percent three-train WWTP capacity being reached in approximately 2023-2024, the large volume of current permitted development will result in more loading on the WWTP in the short term; thus, 85 percent of three-train capacity is more likely to be met by 2021-2022. However, long-term outlook for four-train treatment reveals potential capacity beyond all projection intervals (see Table 3) assessed in this evaluation.

Table 4: Expected Year WWTP Capacity Reaches 85% for Three and Four Treatment Trains

	Loading [a] Parameter	Population	Potential Year Population is Reached
85% Capacity 3 Train	BOD	9,082	2021-2022
	TSS	9,628	2027-2028
85% Capacity 4 Train	BOD	11,785	Beyond 2035
	TSS	12,242	Beyond 2035

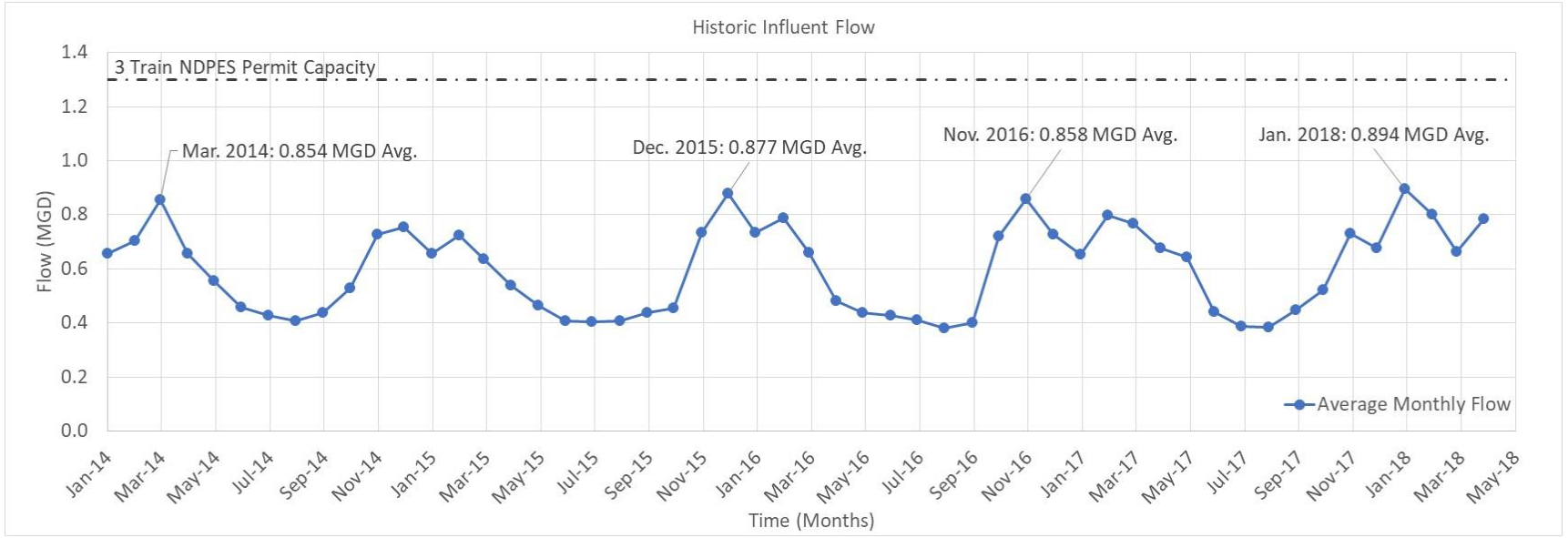
[a] As noted earlier in this memo, the flow values are consistently less of a capacity concern than influent BOD loading.

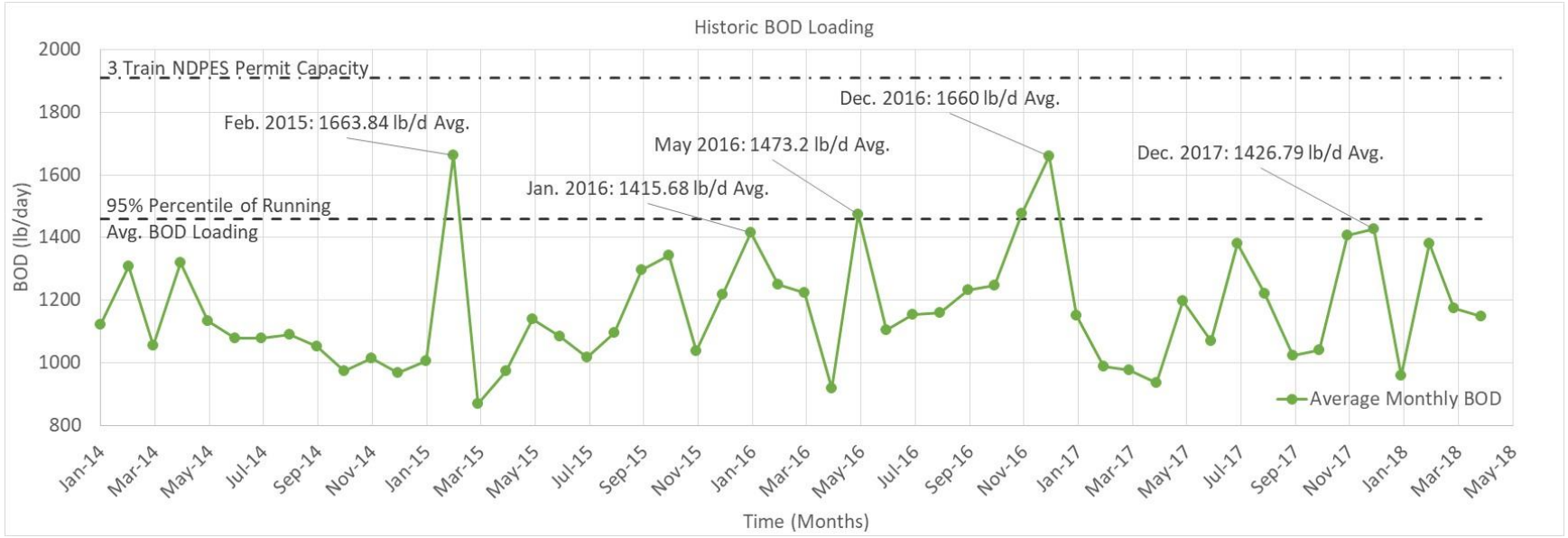
SUMMARY

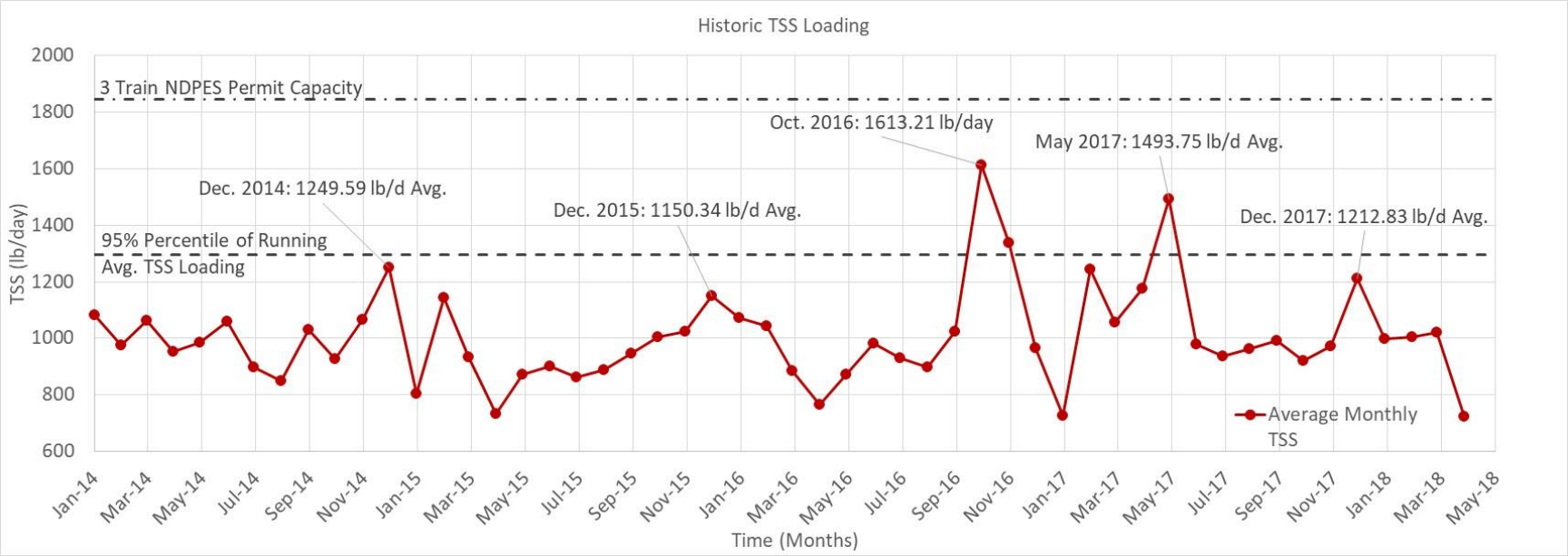
The City's WWTP capacity was evaluated at existing conditions with anticipated population growth. The evaluation used a combination of historic WWTP loading and flow data, the City's future development planning, and City population growth forecast to assess WWTP capacity. Current operation of three treatment trains is at approximately 76 percent of current BOD capacity. A large number of currently permitted developments within the City results in increased loading on the WWTP in the short term, thus the WWTP is expected to reach 85 percent capacity around the years 2021-2022. At 85 percent capacity, planning and design should begin to increase the WWTP to its ultimate NPDES permitted treatment capacity using four treatment trains. The four-treatment train BOD capacity will reach 85 percent sometime after the year 2035 (beyond the population forecast period of this evaluation), at which time planning and design of WWTP upgrades and an increase in the NPDES permit capacity should occur.

Attachment A

Historic Flow and Loading Analysis


Historic Influent Flow
3 Train NDPES Permit Capacity
Mar. 2014: 0.854 MGD Avg.
Dec. 2015: 0.877 MGD Avg.
Nov. 2016: 0.858 MGD Avg.
Jan. 2018: 0.894 MGD Avg.
Flow (MGD)
Average Monthly Flow
Time (Months)


Historic BOD Loading
3 Train NDPES Permit Capacity
Feb. 2015: 1663.84 lb/d Avg.
Dec. 2016: 1660 lb/d Avg.
May 2016: 1473.2 lb/d Avg.
Dec. 2017: 1426.79 lb/d Avg.
Jan. 2016: 1415.68 lb/d Avg.
95% Percentile of Running Avg. BOD Loading
BOD (lb/day)
Average Monthly BOD
Time (Months)


Historic TSS Loading
2000
1800
1600
1400
1200
1000
800
600
TSS (lb/day)
3 Train NDPES Permit Capacity
95% Percentile of Running Avg. TSS Loading
Dec. 2014: 1249.59 lb/d Avg.
Dec. 2015: 1150.34 lb/d Avg.
Oct. 2016: 1613.21 lb/day
May 2017: 1493.75 lb/d Avg.
Dec. 2017: 1212.83 lb/d Avg.
Average Monthly TSS
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
Sep-16
Nov-16
Jan-17
Mar-17
May-17
Jul-17
Sep-17
Nov-17
Jan-18
Mar-18
May-18
Time (Months)

Attachment B

Current and Future Development Planning

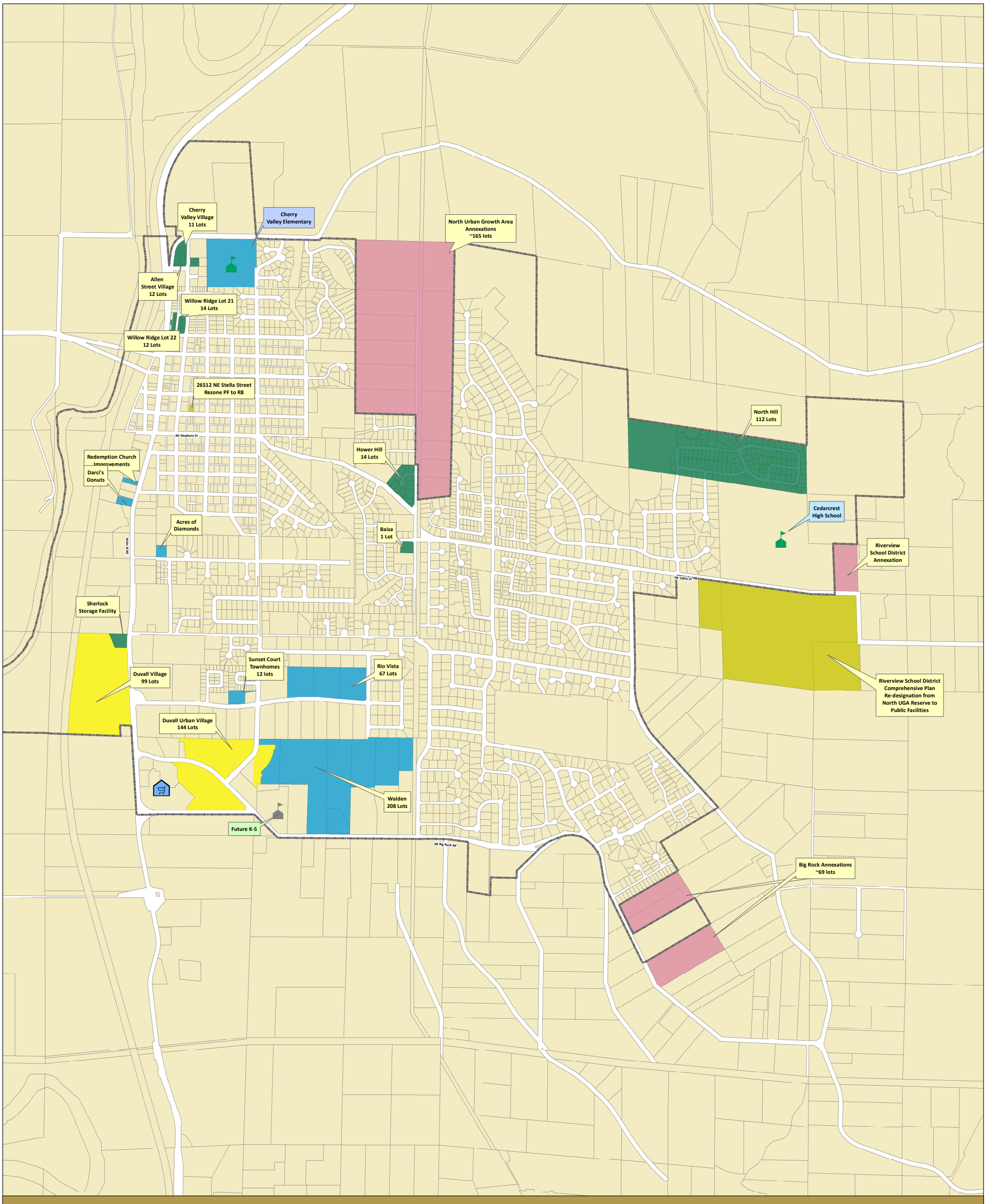
Current Development Summary

Development	Current Status	Current Zoning	Application/ DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat (Years, Ave= 10.3)	Size (Acres)	Total Lots	Building Permits Issued	Building Permits Remaining (7/13/18)	2018 Anticipated (remaining)	2019 Anticipated	2020 Anticipated	2021 Anticipated	2022 Anticipated
Allen Street Village	Legal Lots	R-12 (12 Units/Acre)	11/16/2006	6/15/2007	3/21/2017	10.3	1.04	12	10	2	2				
Cherry Valley Village	Legal Lots	R-12 (12 Units/Acre)	3/20/2006	12/11/2006	3/21/2017	11	1.04	11	9	2	2				
Bowe Court	Legal Lots	R-6 (6 Units/Acre)	BLA June 2015	NA	NA	NA	0.9	6	6	0	0				
Hower Hill	Legal Lots	R-4 (4 Units/Acre)	7/27/2015	1/4/2016	9/6/2016	1.2	3.6	14	14	0	0				
North Hill	Legal Lots	R-4 (4 Units/Acre)	7/19/2007	7/16/2009, 2/3/2014 Amended	1/7/2017	9.5	40	112	70	42	22	20			
Willow Ridge - Lot 21	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	10/24/2013	16	0.55	14	14	0	0				
Willow Ridge - Lot 22	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	11/14/2013	16	0.62	12	0	12	12				
Ring Street Cottages	Legal Lots	R-4 (4 Units/Acre)	BLA 2016	NA	NA	NA	0.23	2	2	0	0				
Baisa	Legal Lots	R-4 (4 Units/Acre)	39287	39514	42521	8.8	0.62	1	0	1	0	1			
Duvall Village	Construction Drawings Approved	MU12	7/6/2015	7/6/2015	Fall 2018*	3.2*	30.8	99		99	0	24	25	25	25
DUV1 Toll	Construction Drawing Review	MU12	1/20/2009	40345	June 2018*	8.5	23.3	144		144	0	34	34	38	38
Rio Vista	Construction Drawings Submittal	R-12 (12 Units/Acre)	42171	8/12/2016	September 2018??	2.1*	12.72	67		67	0	16	17	17	17
Permits To Date (7/13/2018)															
										Total	38	95	76	80	80

Residential Developments Under Review (more process before ready to build homes)

Development Name	Current Status	Current Zoning	Application/DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat	Size (Acres)	Total Lots	Building Permits Issued
Sunset Court	Pending Preliminary Plat	R12 (12 Units/Acre)	3/22/2016	Under Review	Future Submittal	>0.25 Years	1.02	12	NA
Walden	Pending Preliminary Plat	R-8 (8 Units/Acre) & MUI (Mixed Use Institutional)	Agreement - 12/14/2007	Under Review	Future Submittal	>10.5 Years	38.54	208	NA
65 Degrees	Pending Preliminary Plat	R-20 (20 Units/Acre)	TBD	Under Review	Future Submittal	TBD	4.53	51	NA
						Total	**44.09**	**271**	**NA**

one of the 65 Degrees lot is a 12 unit condo



2018 Current Development Map

Residential Developments Under Review (more process before ready to build homes)

Development Name	Current Status	Current Zoning	Application/DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat	Size (Acres)	Total Lots	Building Permits Issued
Duvall Urban Village	Clearing & Grading	MU-12 (12 Units/Acre)	12/22/2008	6/16/2010	Future Submittal	>9.5 Years	23.3	144	NA
Duvall Village	Clearing & Grading	MU-12 (12 Units/Acre)	2001 Agreement - 4/18/2014	7/6/2015	Future Submittal	>17.5 Years	34.3	99	NA
Rio Vista	Pending Construction Submitta	R-8 (8 Units/Acre)	6/16/2015	8/12/2016	Future Submittal	>2 Years	12.7	67	NA
Sunset Court	Pending Preliminary Plat	R12 (12 Units/Acre)	3/22/2016	Under Review	Future Submittal	>0.25 Years	1.02	12	NA
Walden	Pending Preliminary Plat	R-8 (8 Units/Acre) & MUI (Mixed Use Institution	Agreement - 12/14/2007	Under Review	Future Submittal	>10.5 Years	38.54	208	NA
						Total	109.86	530	NA

Legal Lots (Ready to Build Homes)

Development	Current Status	Current Zoning	Application/DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat (Years, Ave= 10.3)	Size (Acres)	Total Lots	Building Permits Issued
Allen Street Village	Legal Lots	R-12 (12 Units/Acre)	11/16/2006	6/15/2007	2/9/2018	10.3	1.04	12	9
Cherry Valley Village	Legal Lots	R-12 (12 Units/Acre)	3/20/2006	12/11/2006	2/9/2018	11	1.04	11	9
Bowe Court	Legal Lots	R-6 (6 Units/Acre)	BLA June 2015	NA	NA	NA	0.9	6	6
Hower Hill	Legal Lots	R-4 (4 Units/Acre)	7/27/2015	1/4/2016	9/6/2016	1.2	3.6	14	14
North Hill	Legal Lots	R-4 (4 Units/Acre)	7/19/2007	7/16/2009, 2/3/14 Amended	1/7/2017	9.5	40	112	71
Willow Ridge - Lot 21	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	10/24/2013	16	0.55	14	14
Willow Ridge - Lot 22	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	11/14/2013	16	0.62	12	0
Baisa	Legal Lots	R-4 (4 Units/Acre)	7/24/2007	3/7/2008	5/31/2016	8.8	0.62	1	0
						Total	48.37	182	123

Legend

- City Limits

Residential Pipeline

- Legal Lot (Home construction in 0 to 2 years)
- Plat Construction (Home construction in 1 to 3 years)
- Construction Drawing Review (Home construction in 2 to 4 years)
- DA/P-Plat (Home construction in 3 to 10 years)
- Annexation (Home construction unknown)
- CPA
- Parcels

N W E S

City of Duvall
Small Town. Real Life.

Attachment C

Population Growth Estimate

Year	Residential Population	Commercial FA Population	Light Industrial FA Population	Total Equivalent Population
2015	-	369	57	-
2016	-	376	58	-
2017	-	382	59	-
2018	7813	389	60	8262
2019	7951	395	61	8407
2020	8090	402	62	8553
2021	8228	408	63	8699
2022	8366	415	64	8845
2023	8504	421	65	8991
2024	8643	428	66	9137
2025	8781	434	67	9282
2026	8919	441	68	9428
2027	9058	447	69	9574
2028	9196	454	70	9720
2029	9334	460	71	9866
2030	9472	467	72	10012
2031	9611	474	73	10157
2032	9749	480	74	10303
2033	9887	487	75	10449
2034	10026	493	76	10595
2035	10164	500	77	10741

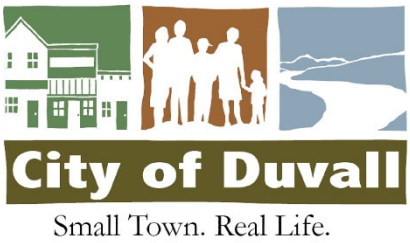
Approximate Growth/year using 1.77% population growth rate (non-compounding)	
Households	138.3
Commercial FA	6.5
Light Industrail FA	1.0

APPENDIX B

2019 WWTP OUTFALL EVALUATION AND MIXING ZONE STUDY

Duvall WWTP Updates to Mixing Zone Study

Prepared for



January 2019

Prepared by

Parametrix

Duvall WWTP Updates to Mixing Zone Study

Prepared for

City of Duvall
14525 Main Street NE
Duvall, WA 98019

Prepared by

Parametrix
1019 39th Avenue SE, Suite 100
Puyallup, WA 98374
T. 253.604.6600 F. 1.855.542.6353
www.parametrix.com

January 2019 | 216-3240-016

CITATION

Parametrix. 2019. Duvall WWTP Updates to Mixing Zone Study. Prepared by Parametrix, Puyallup, WA. January 2019.

CERTIFICATION

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

Prepared by Clara Olson, EIT

Checked by Brian Pippin, P.E.

1/23/2019

Approved by Allan Maas, P.E.

TABLE OF CONTENTS

KEY TERMS

$CBOD_5$	Carbonaceous biochemical oxygen demand
cfs	cubic feet per second
City	City of Duvall
DMRs	discharge monitoring reports
Ecology	Washington State Department of Ecology
HHC	Human Health Criteria
mgd	million gallons per day
NPDES	National Pollutant Discharge Elimination System
State	Washington State
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
UV	ultraviolet
WAC	Washington Administrative Code
WWTP	wastewater treatment plant

1. INTRODUCTION

In 2012, Washington State (State) revised the Human Health Criteria (HHC) for water bodies in the state. The HHC are used to set limits on discharge of wastewater to rivers in order to protect people who consume significant amounts of fish or shellfish. The purpose of this report is to determine the dilution factors for wastewater treatment plant (WWTP) effluent related to HHC. The State has set the criteria for how much area of the river can be used as a mixing zone, where WWTP effluent mixes with river water. At the edge of this mixing zone is where the chemicals and metals present in the diluted effluent must be less concentrated than the HHC values. The dilution values presented in this report (in addition to effluent testing data) will be used by the Washington State Department of Ecology (Ecology) to determine if there is a potential for WWTP effluent to exceed HHC at the edges of the river mixing zone.

The City of Duvall (City) owns and operates a WWTP that serves approximately 7,700 permanent residents, according to the 2016 Census estimate. Duvall is located approximately 10 miles upstream of the confluence of the Snoqualmie and Skykomish Rivers. Outfall 001 is the primary discharge point and consists of an upstream and downstream port. It is located at approximately river mile 10.4 of the Snoqualmie River.

National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit No. WA0029513 (Ecology 2018) defines effluent limitations and mixing zones for the WWTP discharge. Effluent limits are set by Ecology after determining the potential for exceeding water quality standards or HHC at the edge of the mixing zones.

The City's current NPDES permit requires a mixing study to be performed by April 1, 2019. The water quality criteria dilution factors included in the current permit were calculated based on dilution modeling at the 7Q10 river flow. The 7Q10 river flow is the lowest average 7-day flow with a recurrence interval of 10 years. This river flow is required for determining aquatic life water quality criteria, but HHC is modeled at different river flows. This is because the HHC are related to long-term exposure for people eating fish from a river or lake. For HHC evaluations, 30Q5 river flow applies to effluent-borne non-carcinogens, and harmonic mean flow applies to carcinogens. Through dialog with Ecology, it was determined that mixing calculations related to human health needed to be performed in accordance with Ecology's Water Quality Standards: Human Health Criteria and Implementation Tools (Ecology 2015).

1.1 Facility Description

The Duvall WWTP is a membrane bioreactor facility with a maximum monthly design flow of 1.75 million gallons per day (mgd), and maximum daily flow of 3.3 mgd.

The permit sets and describes effluent limits for two periods of the year: 1) August through October and 2) November through July. Effluent limits (monitored just downstream of the ultraviolet [UV] disinfection system) are set by Ecology to ensure the water quality standards are met at the edge of the effluent mixing zone in the Snoqualmie River. Parameters of the effluent limits of the permit include Carbonaceous biochemical oxygen demand ($CBOD_5$), Total Suspended Solids (TSS), pH, fecal coliform bacteria, and NBOD + CBOD (August through October only). The effluent limits are included in Table 1 and Table 2 below. The WWTP has not violated these limits.

Table 1. Effluent Limits – Dry Season (August through October)

Parameter	**Average Monthly**	**Average Weekly**
$CBOD_5$	25 mg/L	40 mg/L
	85% removal of influent $CBOD_5$	
TSS	30 mg/L	45 mg/L
	325 lbs/day	488 lbs/day
	85% removal of influent TSS	
Parameter	**Minimum**	**Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**7-Day Geometric Mean**
Fecal Coliform Bacteria	100/100 mL	200/100 mL
Parameter	**Average Monthly**	**Maximum Daily**
NBOD + CBOD	69.3 lbs/day	172.3 lbs/day

Table 2. Effluent Limits – Wet Season (November through July)

Parameter	**Average Monthly**	**Average Weekly**
$CBOD_5$	25 mg/L	40 mg/L
	271 lbs/day	434 lbs/day
	85% removal of influent $CBOD_5$	
TSS	30 mg/L	40 mg/L
	325 lbs/day	488 lbs/day
	85% removal of influent TSS	
Parameter	**Minimum**	**Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**7-Day Geometric Mean**
Fecal Coliform Bacteria	100/100 mL	200/100 mL

Outfall 001 is located at approximately river mile 10.4 of the Snoqualmie River. The outfall has two 18-inch-diameter ports, one 65 feet downstream from the other to minimize effluent plume width. The location of the upstream port is 47.733097 N, 121.992477 W. The downstream port is located at 47.733290 N, -121.992477 W. The ports are fitted with duck-bill-style elastomer valves which provide for more consistent effluent velocity over a range of flows, thus improving mixing. Further information on the two-port outfall is included in the original mixing study. The City confirmed the integrity of the two-port outfall after routine inspections by divers were completed in October 2017.

Figures 5-1, 6-1, and 6-2 from the original mixing study show the two-port outfall configuration, profile, and detail, and are included at the end of this report.

1.2 Description of Previous Studies

Dilution factors associated with acute and chronic mixing zones for the protection of aquatic life were evaluated for the Outfall 001 diffuser original mixing study completed in the City of Duvall Wastewater

Treatment Plant Outfall Improvements Engineering Report in April 2000 (Parametrix 2000). The dilution factors were amended in 2001 to account for constraints on volumetric mixing ratios and, for the acute mixing zone, the effects of the upstream port on the downstream port. The original mixing study included a bathymetric survey, which was also used in this update. The original mixing study also contains HEC-RAS calculations of river depth and velocity at the 7Q10 and 7Q20 Snoqualmie River flows calibrated to the outfall location. Although 7Q10 receiving water flow remains applicable for mixing zones related to aquatic life, the harmonic mean and 30Q5 flows are now applicable for mixing related to human health (Ecology 2015). The original mixing study and amendment are still applicable and require no further evaluation related to aquatic life. Because the Duvall WWTP was shown to meet water quality criteria for aquatic life, only human health dilution factors needs to be addressed in this report.

2. OUTFALL AND MIXING ZONE CHARACTERIZATION

The figures included at the end of this report show the outfall consists of 24-inch ductile iron pipe that splits into two 18-inch-diameter outfall ports. The 18-inch outfall ports are each 109-foot long, ductile iron carrier pipes with 30-inch steel casings, 0.375 inches thick. The ports extend from the west bank of the Snoqualmie River, 60 feet past the previous single outfall structure which was abandoned in 2001.

The two 18-inch outfall ports are separated by 65 feet from one another to minimize effluent plume width. The ports are fitted with duck-bill-style elastomer valves which provide for more consistent effluent velocity over a range of flows, thus improving mixing. The City recently discovered and cleared debris that had covered one of the ports. During routine inspections in September and October of 2017, the City confirmed the integrity of the two-port outfall after discovering and clearing debris that was present.

The mixing zone is the defined area in the Snoqualmie River where the effluent from Outfall 001 (both ports) mixes with the river water. Mixing zones are defined by Ecology to protect the river biota and water quality. Effluent limits are set by Ecology to ensure the water quality standards are met at the edge of the mixing zone. Ecology defined the maximum boundaries of the acute and chronic mixing zones in the permit. The horizontal boundaries of the permitted chronic mixing zone are 27.5 feet wide (25 percent of the river width at 7Q10 flow), 100 feet long upstream of the outfall, and 310 feet long downstream of the outfall. The mixing zone extends vertically from the discharge ports to the water surface. The permitted dilution factors for aquatic life are constrained by the regulatory limitation of mixing with up to 25 percent of the river flow (Washington Administrative Code [WAC] 173-201A-400(7)(a)(ii)). For evaluation of human health mixing zones, the 30Q5 flow was used for non-carcinogens and the harmonic mean flow was used for carcinogens in accordance with current guidelines (Ecology 2015).

The concentration of pollutants at the edge of the chronic zone must meet chronic aquatic life criteria and human health criteria. The current permitted chronic dilution factors were calculated based on dilution modeling at the 7Q10 river flow.

3. RECEIVING WATER CONDITIONS

Snoqualmie River flows for modeling were obtained from the U.S. Geological Survey (USGS) gaging station (12149000) on the Snoqualmie River near Carnation. This gage is at river mile 23.0, 12.6 miles upstream of the outfall and is the nearest Snoqualmie River gaging station with real-time flow data. For

evaluation of human health mixing zones, the 30Q5 flow was used for non-carcinogens and the harmonic mean flow was used for carcinogens in accordance with current guidelines (Ecology 2015). Based on over eight decades of river flow data, the harmonic mean flow at this station is 1,952 cubic feet per second (cfs). The 30Q5 flow is 574 cfs.

4. DISCHARGE CHARACTERISTICS

Guidelines for selecting effluent discharge rates for evaluation of human health mixing zones (Ecology 2015) are as follows:

- Annual average daily design flow for carcinogens.
- For plants operating below capacity, the highest monthly average maximum flow from the last 3 years during critical low stream flow for non-carcinogens (August through October for Duvall).

For the Duvall WWTP, these flows are as follows:

- The permitted annual average daily design flow capacity is 1.2 mgd.
- The monthly average maximum flow from the last 3 years during August through October was 0.721 mgd, calculated from discharge monitoring reports (DMRs).

The highest maximum monthly average influent flow rate overall (0.877 mgd) is just 50 percent of the WWTP capacity, so use of the actual monthly average maximum flow for non-carcinogens is appropriate.

5. MIXING ZONE MODELING ANALYSIS

The mixing zone modeling was performed with RiverPlume6 (Ecology 2012). Flux average dilution factors at the mixing zone boundary were calculated for critical river flows and effluent discharge rates. These were compared to 25 percent flow restricted dilution factors to determine the limiting dilution factor. Modeling methods, inputs, and results are discussed in detail below.

5.1 Modeling Inputs and Methods

Inputs necessary to conduct dilution modeling using RiverPlume6 include effluent discharge, receiving water stream depth, flow and velocity, channel width, Manning's roughness coefficient, discharge distance from nearest shoreline, distance downstream to point of interest, and transverse mixing coefficient constant.

As mentioned above, the stream flow (see Section 3) is 574 cfs for non-carcinogens and 1,952 cfs for carcinogens while the effluent discharge rate (see Section 4) is 0.721 mgd for non-carcinogens and 1.2 mgd for carcinogens.

The following modeling inputs were obtained directly from the original mixing study:

- Channel cross sections;
- Manning's roughness coefficient (0.05); and
- Transverse mixing coefficient (0.6) constant.

The stream width, depth, and velocity; channel width; and outfall distance from the nearest shoreline were calculated for the harmonic mean and 30Q5 stream flows using the HEC-RAS hydraulic river model following the same approach described in the original mixing study. HEC-RAS input and results are provided in Appendix A (Profile 1 for the 30Q5 flow, Profile 2 for the harmonic mean flow). The resulting depths, currents, channel widths, and outfall distances from shore are summarized in Table 3.

Table 3. Water Depth and Velocity at Station 3

River Flow Occurrence	Snoqualmie River Flow (cfs)	Water Depth above Outfall (feet)	River Current Velocity (feet/second)	Channel Width (feet)	Distance from Nearest Shoreline (feet)
30Q5 (Non-Carcinogens)	574	10.62	0.52	117	16.2
Harmonic Mean (Carcinogens)	1952	15.21	1.23	138	27.2

Based on the updated channel width of 138 feet for the harmonic mean flow, the maximum allowable human health mixing zone width (25 percent of the channel width) could potentially be 34.5 feet for carcinogens; however, allowable dilution is constrained by river volumetric flows as further described below.

5.2 Modeling Results

The modeling results are summarized in Table 4. Additionally, the RiverPlume6 modeling spreadsheet is provided in Appendix B. Modeling results for flux average dilution factor at the permitted chronic mixing zone boundary and the regulatory maximum dilution factor (i.e., well mixed with 25 percent of the critical stream flow) are shown. These compare to the existing permitted human health dilution factors of 136.9 and 851.2. In this case, the RiverPlume6 modeling shows the regulatory maximum dilution factors (130 for non-carcinogens, 264 for carcinogens) are the most restrictive. Ecology will be evaluating the WWTP potential to exceed the HHC based on these revised dilutions.

Table 4. Modeling Results

River Flow Occurrence	Snoqualmie River Flow (cfs)	Flux-Average Dilution Factor	Regulatory Maximum Dilution Factor
30Q5 (Non-carcinogens)	574	303	130
Harmonic Mean (Carcinogens)	1,952	801	264

6. REFERENCES

Ecology (Washington State Department of Ecology). 2012. Web Interface. Available at: https://ecology.wa.gov/Research-Data/Data-resources/Models-spreadsheets. PermitCalc link, RiverPlume6 tab in downloadable spreadsheet.

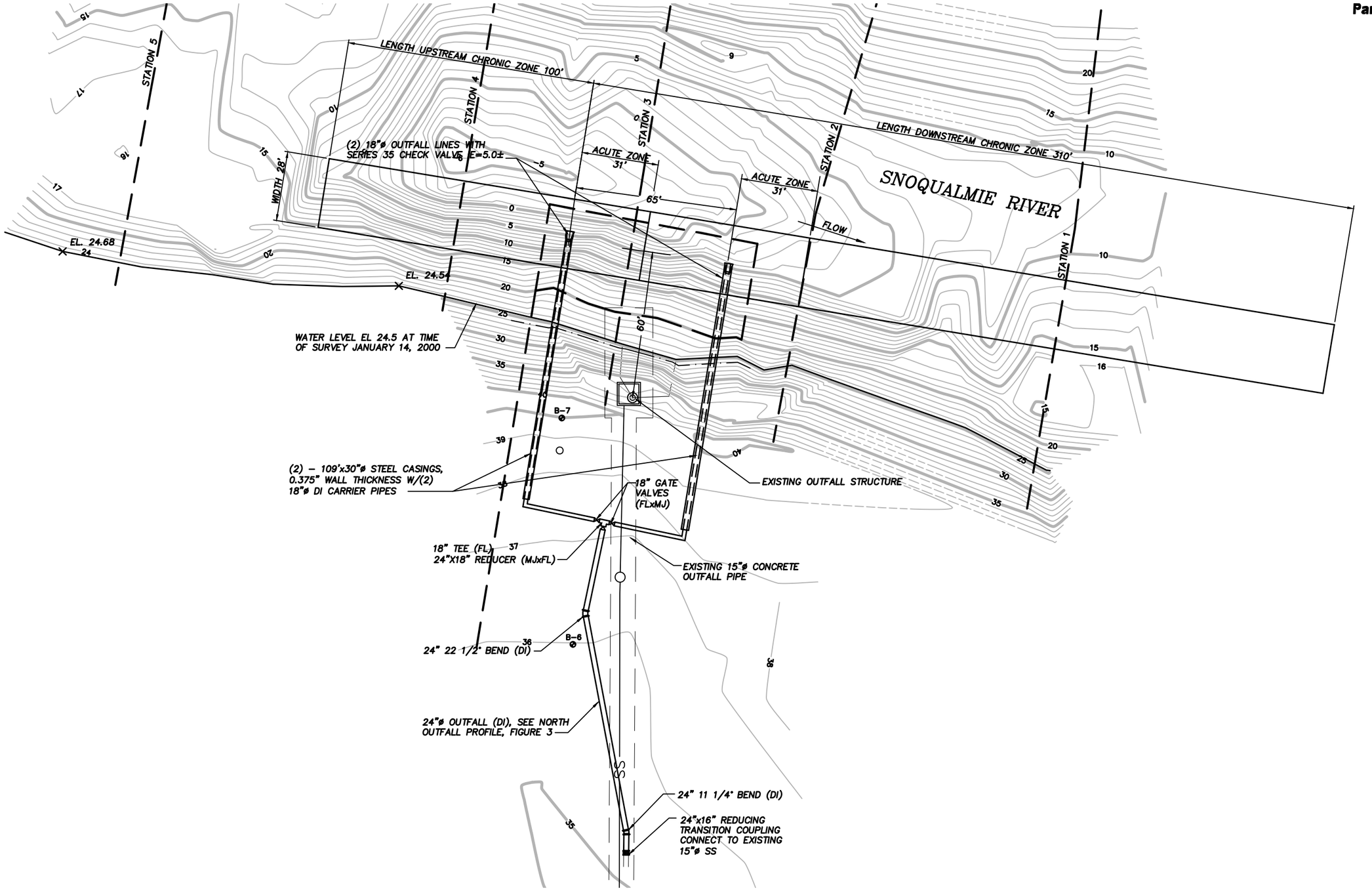
Ecology (Washington State Department of Ecology). 2015. Water Quality Program Permit Writer's Manual. Olympia, Washington.

Ecology (Washington State Department of Ecology). 2018. National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0029513. Northwest Regional Office – Bellevue, Washington.

Parametrix. 2000. The City of Duvall Wastewater Treatment Plant Outfall Improvements Engineering Report. Prepared for City of Duvall, Washington. April 2000. Amended in 2001.

USGS (U.S. Geological Service). 2017. National Water Information System: Web Interface. Available at: https://waterdata.usgs.gov/nwis/inventory/?site_no=12149000. February 2017.

Figures



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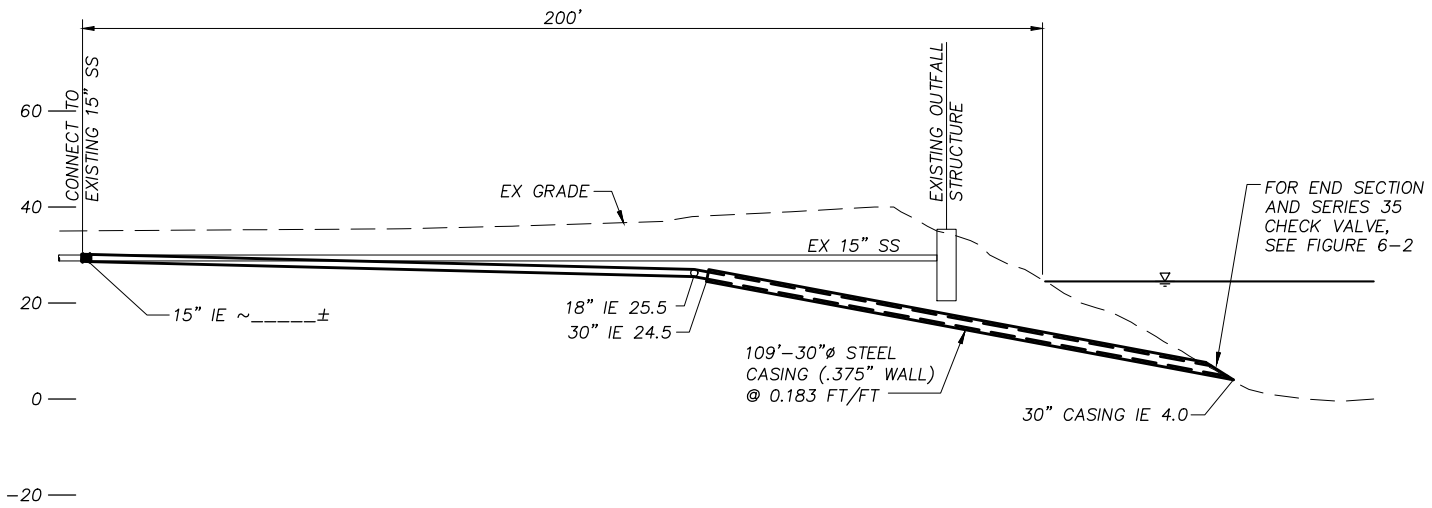
N

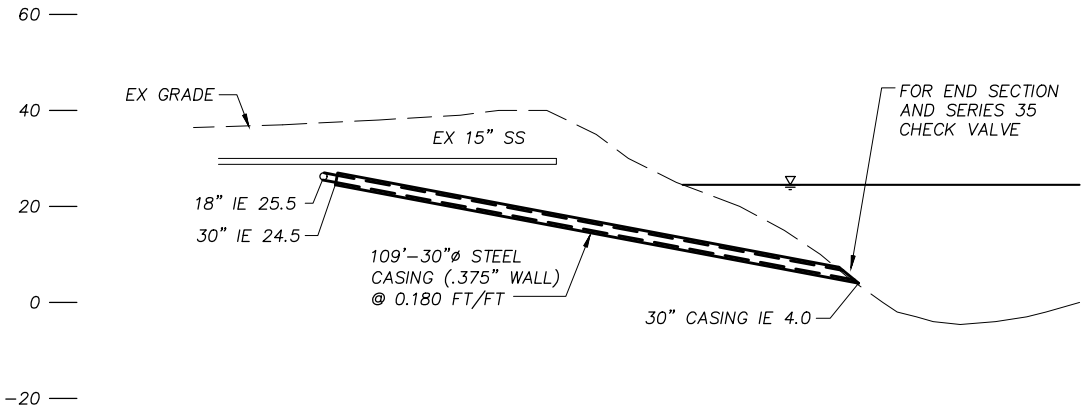
NOTES:
ELEVATIONS IN FEET BASED ON SURVEY BY PARAMETRIX, INC. 1/14/2000.
VERTICAL SURVEY DATUM BASED ON NVGD 29.

STATION TRANSECTS USED FOR HEC-RAS HYDRAULIC MODEL.

Figure 5-1
Proposed Two Port Outfall Configuration and Mixing Zone Sizes



NORTH OUTFALL PROFILE



SOUTH OUTFALL PROFILE

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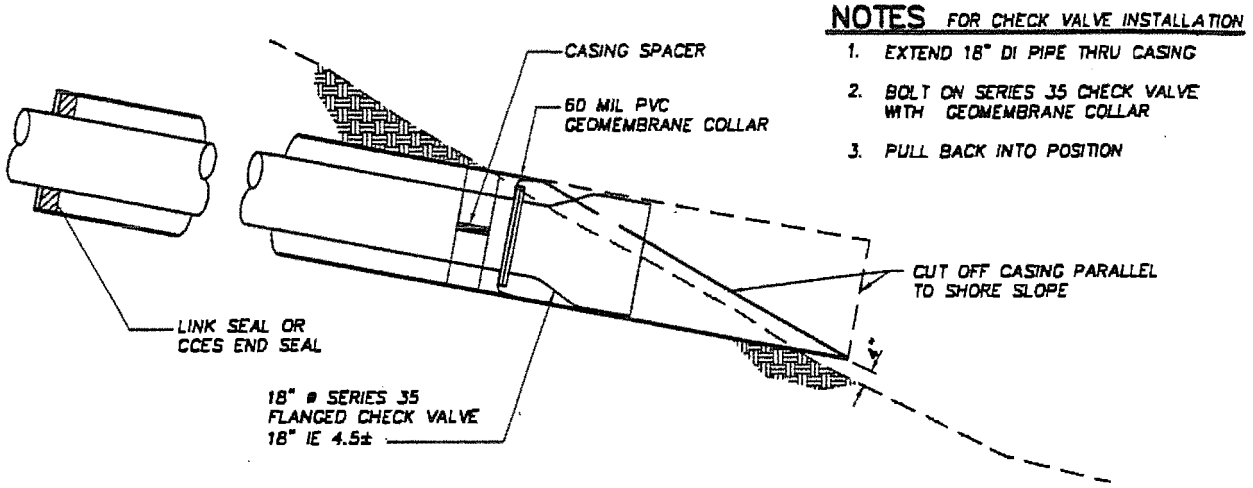
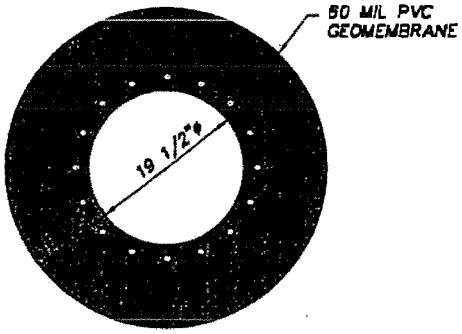
Figure 6-1
Proposed Outfall Profiles



OUTFALL CHECK VALVE



GEOMEMBRANE COLLAR

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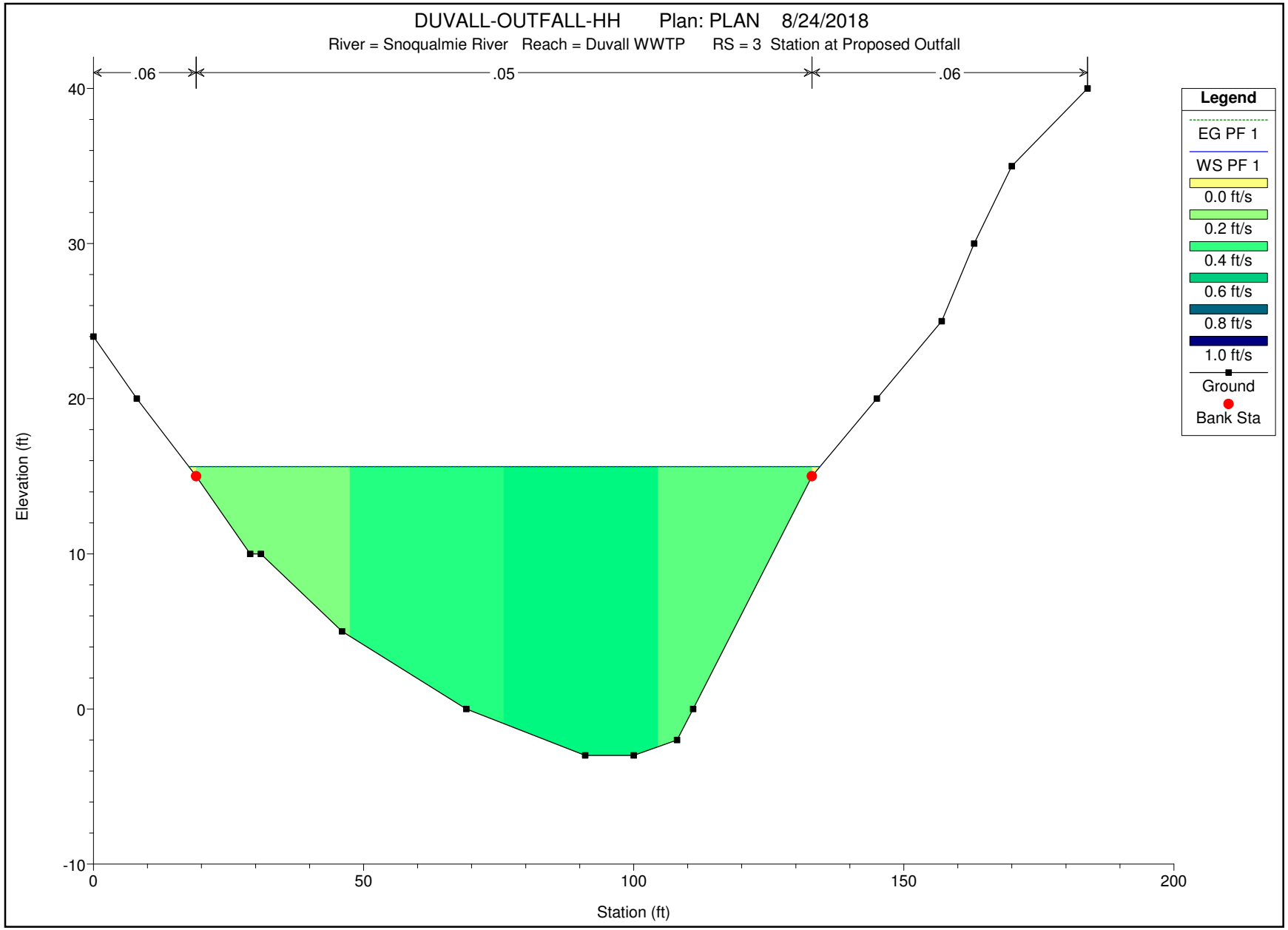
Figure 6-2
Proposed Outfall
Port Detail

Appendix A

HEC-RAS Input and Results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.05
.06
Legend
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WS PF 1
0.0 ft/s
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
Ground
Bank Sta
Elevation (ft)
Station (ft)
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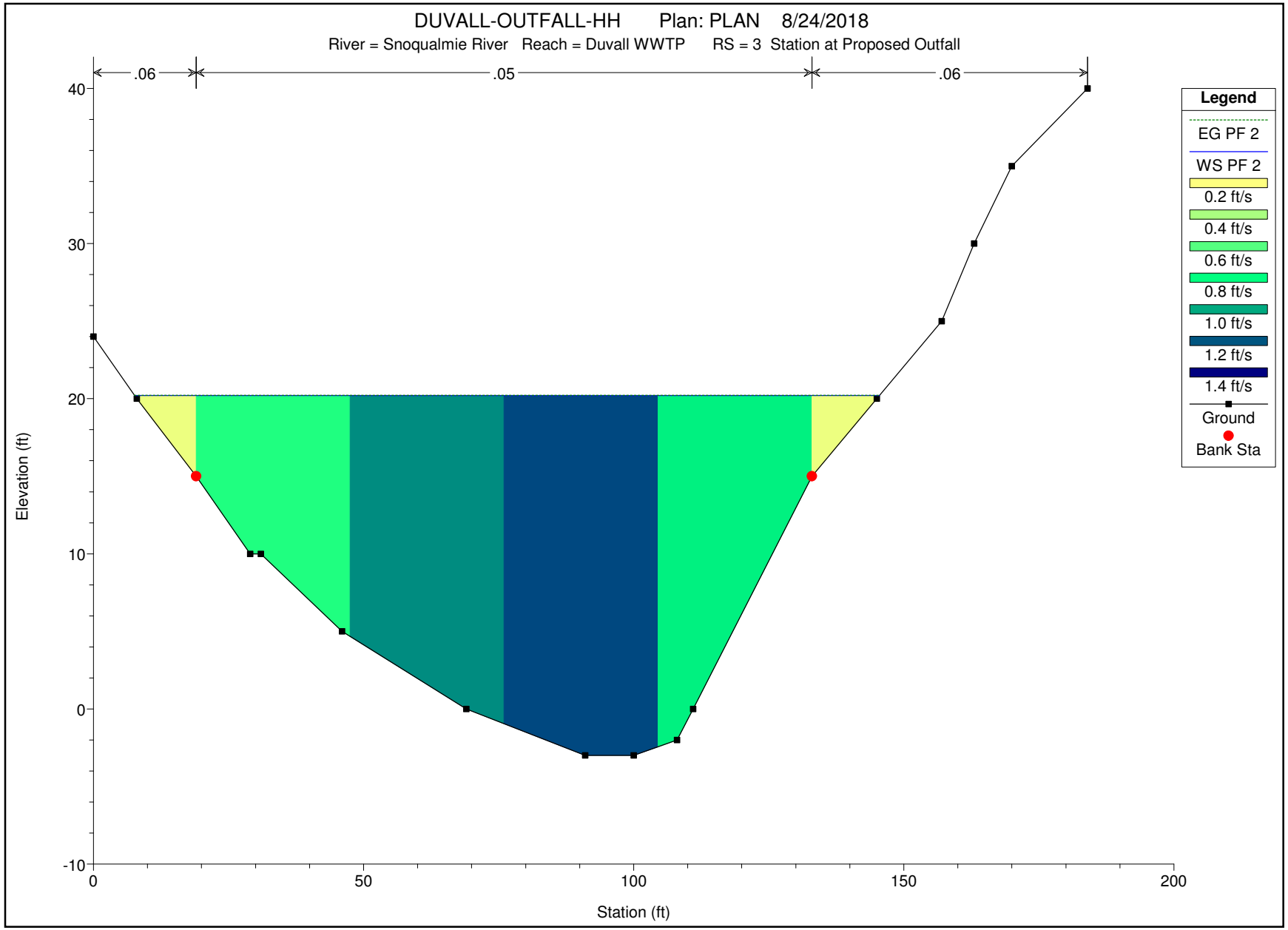
30
20
10
0
-10
0
50
100
150
200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River = Snoqualmie River Reach = Duvall WWTP RS = 3 Station at Proposed Outfall
.06
.05
.06
Elevation (ft)
40
30
20
10
0
-10
0
50
100
150
200
Station (ft)
Legend
EG PF 2
WS PF 2
0.2 ft/s
0.4 ft/s
0.6 ft/s
0.8 ft/s
1.0 ft/s
1.2 ft/s
1.4 ft/s
Ground
Bank Sta

Plan: 20180712 Snoqualmie River Duvall WWTP RS: 3 Profile: PF 1

E.G. Elev (ft)	15.62	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.00	Wt. n-Val.	0.060	0.050	0.060
W.S. Elev (ft)	15.62	Reach Len. (ft)	80.00	70.00	70.00
Crit W.S. (ft)		Flow Area (sq ft)	0.43	1383.92	0.46
E.G. Slope (ft/ft)	0.000008	Area (sq ft)	0.43	1383.92	0.46
Q Total (cfs)	574.00	Flow (cfs)	0.01	573.97	0.01
Top Width (ft)	116.86	Top Width (ft)	1.37	114.00	1.49
Vel Total (ft/s)	0.41	Avg. Vel. (ft/s)	0.03	0.41	0.03
Max Chl Dpth (ft)	18.62	Hydr. Depth (ft)	0.31	12.14	0.31
Conv. Total (cfs)	207614.0	Conv. (cfs)	4.5	207604.5	5.0
Length Wtd. (ft)	70.00	Wetted Per. (ft)	1.50	122.03	1.62
Min Ch El (ft)	-3.00	Shear (lb/sq ft)	0.00	0.01	0.00
Alpha	1.00	Stream Power (lb/ft s)	0.00	0.00	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.00	3.51	0.01
C & E Loss (ft)	0.00	Cum SA (acres)	0.01	0.42	0.03

Plan: 20180712 Snoqualmie River Duvall WWTP RS: 3 Profile: PF 2

E.G. Elev (ft)	20.22	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.02	Wt. n-Val.	0.060	0.050	0.060
W.S. Elev (ft)	20.21	Reach Len. (ft)	80.00	70.00	70.00
Crit W.S. (ft)		Flow Area (sq ft)	29.80	1906.44	32.52
E.G. Slope (ft/ft)	0.000030	Area (sq ft)	29.80	1906.44	32.52
Q Total (cfs)	1952.00	Flow (cfs)	7.19	1936.91	7.90
Top Width (ft)	137.90	Top Width (ft)	11.41	114.00	12.49
Vel Total (ft/s)	0.99	Avg. Vel. (ft/s)	0.24	1.02	0.24
Max Chl Dpth (ft)	23.21	Hydr. Depth (ft)	2.61	16.72	2.60
Conv. Total (cfs)	356832.1	Conv. (cfs)	1314.3	354073.1	1444.6
Length Wtd. (ft)	70.06	Wetted Per. (ft)	12.54	122.03	13.53
Min Ch El (ft)	-3.00	Shear (lb/sq ft)	0.00	0.03	0.00
Alpha	1.04	Stream Power (lb/ft s)	0.00	0.03	0.00
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	0.17	5.42	0.28
C & E Loss (ft)	0.00	Cum SA (acres)	0.06	0.42	0.08

Plan: 20180712 Snoqualmie River Duvall WWTP RS: 2 Profile: PF 1

E.G. Elev (ft)	15.62	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.01	Wt. n-Val.	0.060	0.050	0.060
W.S. Elev (ft)	15.62	Reach Len. (ft)	90.00	105.00	105.00
Crit W.S. (ft)		Flow Area (sq ft)	0.61	939.33	0.34
E.G. Slope (ft/ft)	0.000025	Area (sq ft)	0.61	939.33	0.34
Q Total (cfs)	574.00	Flow (cfs)	0.03	573.95	0.02
Top Width (ft)	112.09	Top Width (ft)	1.98	109.00	1.11
Vel Total (ft/s)	0.61	Avg. Vel. (ft/s)	0.05	0.61	0.05
Max Chl Dpth (ft)	12.62	Hydr. Depth (ft)	0.31	8.62	0.31
Conv. Total (cfs)	114504.1	Conv. (cfs)	6.7	114493.9	3.6
Length Wtd. (ft)	105.00	Wetted Per. (ft)	2.07	113.09	1.27

Plan: 20180712 Snoqualmie River Duvall WWTP RS: 2 Profile: PF 1 (Continued)

Min Ch El (ft)	3.00	Shear (lb/sq ft)	0.00	0.01	0.00
Alpha	1.00	Stream Power (lb/ft s)	0.00	0.01	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.00	1.65	0.01
C & E Loss (ft)	0.00	Cum SA (acres)	0.00	0.24	0.02

Plan: 20180712 Snoqualmie River Duvall WWTP RS: 2 Profile: PF 2

E.G. Elev (ft)	20.22	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.03	Wt. n-Val.	0.060	0.050	0.060
W.S. Elev (ft)	20.19	Reach Len. (ft)	90.00	105.00	105.00
Crit W.S. (ft)		Flow Area (sq ft)	43.10	1437.68	24.23
E.G. Slope (ft/ft)	0.000069	Area (sq ft)	43.10	1437.68	24.23
Q Total (cfs)	1952.00	Flow (cfs)	16.15	1927.24	8.61
Top Width (ft)	134.93	Top Width (ft)	16.66	109.00	9.27
Vel Total (ft/s)	1.30	Avg. Vel. (ft/s)	0.37	1.34	0.36
Max Chl Dpth (ft)	17.19	Hydr. Depth (ft)	2.59	13.19	2.62
Conv. Total (cfs)	235721.0	Conv. (cfs)	1950.0	232731.0	1040.0
Length Wtd. (ft)	104.79	Wetted Per. (ft)	17.45	113.09	10.62
Min Ch El (ft)	3.00	Shear (lb/sq ft)	0.01	0.05	0.01
Alpha	1.06	Stream Power (lb/ft s)	0.00	0.07	0.00
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	0.10	2.74	0.23
C & E Loss (ft)	0.00	Cum SA (acres)	0.04	0.24	0.06

Appendix B

RiverPlume6 Modeling Spreadsheet

Spread of a Plume from a Point Source in a River with Boundary Effects from the Shoreline

Based on the method of Fischer et al. (1979) with correction for the effective origin of effluent.

	Chronic	Acute	HH Non-Carcinogen	HH Carcinogen
INPUT				
1. Effluent Discharge Rate (MGD)			0.72	1.20
or, Effluent Discharge Rate (cfs)			1.12	1.86
2. Receiving Water Characteristics Downstream from Discharge:				
Stream Depth (ft)			10.62	15.21
Stream Flow (cfs) (7Q10 chronic & acute, 30Q5 for non-carc, harm. mean for carc)			574	1952
% of stream flow allowed for Dilution Factor (e.g., 25% for chronic & 2.5% for acute)			25%	25%
Stream Velocity (fps)			0.52	1.23
Channel Width (ft)			117.0	138.0
Stream Slope (ft/ft) or Manning roughness "n"			0.05	0.05
0 if slope or 1 if Manning "n" in previous cell			1	1
3. Discharge Distance from Nearest Shoreline (ft)			16.2	27.2
4. Location of Point of Interest to Estimate Dilution:				
Distance Downstream to Point of Interest (ft)			310	310
Distance From Nearest Shoreline (ft)			16.2	27.2
5. Transverse Mixing Coefficient Constant (usually 0.6):			0.6	0.6
6. Original Fischer Method (enter 0) or Effective Origin Modification (enter 1)			0	0
7. Is the Plume bounded by the shoreline?			Yes	Yes
OUTPUT				
1. Source Conservative Mass Input Rate:				
Concentration of Conservative Substance (%)	100.00	100.00	100.00	100.00
Source Conservative Mass Input Rate (cfs*%)	0.00	0.00	111.56	185.68
2. Shear Velocity based on slope (ft/sec)	#VALUE!	#VALUE!	#N/A	#N/A
Shear Velocity based on Manning "n" (using Prasuhn equations 8-26 and 8-54 assuming hydraulic radius equals depth for wide channel):				
Darcy-Weisbach friction factor "f"	#VALUE!	#VALUE!	0.132	0.117
Shear Velocity from Darcy-Weisbach "f" (ft/sec)	#VALUE!	#VALUE!	0.067	0.149
Selected Shear Velocity for next step (ft/sec)	#VALUE!	#VALUE!	0.067	0.149
3. Transverse Mixing Coefficient (ft2/sec)	#VALUE!	#VALUE!	0.426	1.358
4. Plume Characteristics Accounting for Shoreline Effect (Fischer et al., 1979):				
Co	#DIV/0!	#DIV/0!	1.73E-01	7.19E-02
x'	#VALUE!	#VALUE!	1.85E-02	1.80E-02
y'o	#DIV/0!	#DIV/0!	1.38E-01	1.97E-01
y' at point of interest	#DIV/0!	#DIV/0!	1.38E-01	1.97E-01
Solution using superposition equation (Fischer eqn 5.9):				
Term for n= -2	#DIV/0!	#DIV/0!	1.85E-94	2.16E-97
Term for n= -1	#DIV/0!	#DIV/0!	3.69E-24	6.82E-25
Term for n= 0	#DIV/0!	#DIV/0!	1.36E+00	1.12E+00
Term for n= 1	#DIV/0!	#DIV/0!	4.04E-18	2.64E-16
Term for n= 2	#DIV/0!	#DIV/0!	6.27E-82	2.81E-79
Upstream Distance from Outfall to Effective Origin of Effluent Source (ft)	#VALUE!	#VALUE!	#N/A	#N/A
Effective Distance Downstream from Effluent to Point of Interest (ft)	#VALUE!	#VALUE!	310.0	310.0
x' Adjusted for Effective Origin	#VALUE!	#VALUE!	1.85E-02	1.80E-02
C/Co (dimensionless)	#VALUE!	#VALUE!	2.81E+00	2.35E+00
Concentration at Point of Interest (Fischer Eqn 5.9)	#VALUE!	#VALUE!	4.85E-01	1.69E-01
Unbounded Plume half-width (ft)	#VALUE!	#VALUE!	45.1	52.3
Distance from near shore to discharge point (ft)	0.0	0.0	16.2	27.2
Distance from far shore to discharge point (ft)	0.0	0.0	100.8	110.8
RESULTS				
W, Plume width bounded by shoreline (ft)	**#VALUE!**	**#VALUE!**	**61.3**	**79.5**
W, Unbounded Plume Width at Point of Interest (ft)	**#VALUE!**	**#VALUE!**	**90.1**	**104.7**
Approximate Downstream Distance to Complete Mix (ft)	**#DIV/0!**	**#DIV/0!**	**4,966**	**4,448**
Theoretical Dilution Factor at Complete Mix	**#DIV/0!**	**#DIV/0!**	**579**	**1,390**
Calculated Flux-Average Dilution Factor Across Entire Plume Width	**#VALUE!**	**#VALUE!**	**303**	**801**
Calculated Dilution Factor at Point of Interest	**#VALUE!**	**#VALUE!**	**206**	**593**

Regulatory Max Plume Widths and Dilution Factors

Wmax, Regulatory Max Plume Width (ft)	0.0	0.0	29.3	34.5
Regulatory Max Dilution Factor (e.g, effluent well-mixed with 25% of 7Q10 flow)	#DIV/0!	#DIV/0!	130	264

Most Restrictive Dilution Factor	**#DIV/0!**	**#DIV/0!**	**130**	**264**

APPENDIX C

BASIN UNIT COUNTS, APPLIED MODELING FLOWS

Existing Wastewater Flow Calculation (Dry weather, no I/I)

Basin	City Count	PMX Spot Check Count	Difference	Count Used?	Comment
Cedars	48	-11	N/A	PMX	*11 units moved from Cedars to MidBigRock
UpBigRock	0	-	N/A	City	
BattenRoad	0	-	N/A	City	
MidBigRock	240	251	11	PMX	*11 units from Cedars
290th	0	-	N/A	City	
School	0	-	N/A	City	
NorthHill	186	-	N/A	City	
TayRidge	126	-	N/A	City	
J	390	-	N/A	City	
F	155	-	N/A	City	
AD	345	-	N/A	City	
B	201	-	N/A	City	
A	99	127	28	PMX	
RioVista	77	59	-18	PMX	
LowBigRock	22	-	N/A	City	
CherryVal	93	-	N/A	City	
E	161	158	-3	PMX	
ParksApts	12	-	N/A	City	
P	283	220	-63	City	*businesses, units with multiple residences
CH	305	-	N/A	City	
DuvVillage	0	-	N/A	City	
WWTP	30	-	N/A	City	
CopHillSq	85	-	N/A	City	
Total =	2865				
1 ERU =	140	gpd	*non I&I ERU		
Flow =	401100	gpd	*equals approx. that of avg. monthly dry weather flow at WWTP		

Existing Condition Sewer Loading to Model

Model Node	units	flow, gpd	flow, mgd
MidBigRock			
147	12	1680	0.00168
177	12	1680	0.00168
207	8	1120	0.00112
208	4	560	0.00056
210	3	420	0.00042
223	2	280	0.00028
264	108	15120	0.01512
277	6	840	0.00084
278	20	2800	0.00280
280	10	1400	0.00140
803	55	7700	0.00770
910	11	1540	0.00154
Basin E			
417	27	3780	0.00378
426	7	980	0.00098
438	33	4620	0.00462
439	33	4620	0.00462
446	34	4760	0.00476
450	9	1260	0.00126
512	2	280	0.00028
733	13	1820	0.00182
A			
104	27	3780	0.00378
108	29	4060	0.00406
112	21	2940	0.00294
409	38	5320	0.00532
641	12	1680	0.00168
Basin P			
423	131	18340	0.01834
425	1	140	0.00014
436	10	1400	0.00140
463	1	140	0.00014
488	82	11480	0.01148
498	11	1540	0.00154
499	12	1680	0.00168
3003 PS	35	4900	0.00490

Model Node	units	flow, gpd	flow, mgd
Rio Vista			
116	25	3500	0.00350
118	34	4760	0.00476
CH			
476	305	42700	0.04270
B			
505	201	28140	0.02814
CopHillSq			
660	85	11900	0.01190
LowBigRock			
794	22	3080	0.00308
ParksApts			
423	12	1680	0.00168
CherryVal			
3002 PS	93	13020	0.01302
WWTP			
491	25	3500	0.00350
509	5	700	0.00070
Total	30	4200	0.00420
Cedars, 290th, School, NorthHill, Tay Ridge, J, F			
104	907	126980	0.19651
AD			
116	332	46480	0.07193

Existing Conditions: Infiltration and Inflow

Basin	Area (acre)	I/I Flow (gpd)*	I/I Flow (mgd)	Node Applied
A	61.5	67650	0.0677	104
AD	92.5	101750	0.1018	116
B	84	92400	0.0924	505
Cedars	16	17600	0.0176	104
CH	115	126500	0.1265	476
CherryVal	32	35200	0.0352	3002
CopHillSq	8	8800	0.0088	660
E	68	74800	0.0748	727
F	50	55000	0.0550	104
J	119	130900	0.1309	104
LowBigRock	16	17600	0.0176	920
MidBigRock	107	117700	0.1177	147
NorthHill	37	40700	0.0407	104
P	75	82225	0.0822	423
ParksApts	1	1100	0.0011	423
RioVista	22	24200	0.0242	116
School	40	44000	0.0440	104
TayRidge	73	80300	0.0803	104
WWTP	45	49500	0.0495	half on 473, half on 922
Total	1062	1167925	1.1679	

*Uses 1100 gpad

Future Condition Sewer Loading to Model

Model Node	units	flow, gpd	flow, mgd
MidBigRock			
147	12	1680	0.00168
177	12	1680	0.00168
207	8	1120	0.00112
208	4	560	0.00056
210	3	420	0.00042
223	2	280	0.00028
264	108	15120	0.01512
277	6	840	0.00084
278	20	2800	0.00280
280	10	1400	0.00140
803	55	7700	0.00770
910	11	1540	0.00154
Basin E			
417	27	3780	0.00378
426	7	980	0.00098
438	33	4620	0.00462
439	33	4620	0.00462
446	34	4760	0.00476
450	9	1260	0.00126
512	2	280	0.00028
733	13	1820	0.00182
A			
104	27	3780	0.00378
108	29	4060	0.00406
112	21	2940	0.00294
409	38	5320	0.00532
641	12	1680	0.00168
Basin P			
423	131	18340	0.01834
425	1	140	0.00014
436	10	1400	0.00140
463	24	3360	0.00336
488	101	14140	0.01414
498	11	1540	0.00154
499	12	1680	0.00168
3003 PS	42	5880	0.00588

Model Node	units	flow, gpd	flow, mgd
Rio Vista			
116	25	3500	0.00350
118	113	15820	0.01582
CH			
476	319	44660	0.04466
B			
505	201	28140	0.02814
CopHillSq			
660	85	11900	0.01190
LowBigRock			
794	22	3080	0.00308
799	144	20160	0.02016
917	208	29120	0.02912
ParksApts			
423	12	1680	0.00168
CherryVal			
3002 PS	93	13020	0.01302
WWTP			
491	25	3500	0.00350
509	5	700	0.00070
Total	30	4200	0.00420
Cedars, 290th, School, NorthHill, Tay Ridge, J, F			
104	1019	142660	0.14266
AD			
116	332	46480	0.07193
Duv Village			
132	99	13860	0.01386
North UGA			
104	66	9240	0.00924
3002	198	27720	0.02772
Northwest UGA			
489	20	2800	0.00280
Southwest UGA			
794	3	420	0.00042

Future Conditions: Infiltration and Inflow

Basin	Area (acre)	I/I Flow (gpd)*	I/I Flow (mgd)	Node Applied
A	62	67650	0.0677	104
AD	97.5	107250	0.1073	116
B	84	92400	0.0924	505
Cedars	16	17600	0.0176	104
CH	119	130900	0.1309	476
CherryVal	32	35200	0.0352	3002
CopHillSq	8	8800	0.0088	660
DuvVillage	24	26400	0.0264	922
E	68	74800	0.0748	727
F	50	55000	0.0550	104
J	119	130900	0.1309	104
LowBigRock	80	88000	0.0880	920
MidBigRock	107	117700	0.1177	147
NorthHill	75	82500	0.0825	104
P	78	85800	0.0858	423
ParksApts	1	1100	0.0011	423
RioVista	31	34100	0.0341	116
School	40	44000	0.0440	104
TayRidge	73	80300	0.0803	104
WWTP	45	49500	0.0495	half on 473, half on 922
Total	1209	1329900	1.3299	

*Uses 1100 gpad

APPENDIX D

HYDRAULIC MODEL OVERVIEW AND DETAILED SCENARIO RESULTS

Legend

- WWTP Outlet
- Forcemain
- Pump
- Pump Station WW
- Manhole
- Gravity Main
- Parcel Boundary

N

0 0.125 0.25 0.5 Miles

Model Overview

Existing Conditions - Gravity Main Output - Sorted by q/Q

		ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpd)	Unpeakable Flow (gpd)	Peakable Flow (gpd)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpd)	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
1	☐	196	109	110	8	462	0.0079	840,776	436,198	134,859	Free Surface	4.55	0.76	0.93	0.51	0.54	1.13	904,658	No	0.51	4.55
2	☐	195	110	111	8	402	0.0110	840,776	436,198	134,859	Free Surface	5.25	0.67	0.79	0.45	0.54	1.47	1,068,249	No	0.45	5.25
3	☐	616	108	109	8	49	0.0185	840,776	436,198	134,859	Free Surface	6.43	0.56	0.61	0.37	0.54	2.05	1,384,904	Yes	0.44	5.30
4	☐	723	660	134	12	114	0.0044	935,935	445,798	163,379	Free Surface	3.85	0.48	0.47	0.48	0.51	1.11	1,985,115	No	0.48	3.85
5	☐	9	491	492	11	271	0.0041	712,516	344,598	122,639	Free Surface	3.50	0.48	0.47	0.44	0.45	1.05	1,515,780	No	0.44	3.50
6	☐	13	509	660	12	273	0.0044	891,435	436,998	151,479	Free Surface	3.82	0.47	0.45	0.47	0.50	1.12	1,991,716	Yes	0.48	3.74
7	☐	6	505	509	12	384	0.0044	889,335	436,998	150,779	Free Surface	3.81	0.47	0.45	0.47	0.50	1.12	1,991,598	Yes	0.47	3.81
8	☐	738	128	129	8	172	0.0049	290,278	125,999	54,760	Free Surface	3.01	0.44	0.41	0.30	0.31	1.12	715,277	No	0.30	3.01
9	☐	421	502	501	8	119	0.0042	257,099	118,499	46,200	Free Surface	2.74	0.43	0.39	0.29	0.29	1.03	660,058	No	0.29	2.74
10	☐	14	134	135	12	183	0.0071	935,935	445,798	163,379	Free Surface	4.60	0.42	0.37	0.42	0.51	1.44	2,522,392	No	0.42	4.60
11	☐	364	499	498	8	397	0.0050	262,139	118,499	47,880	Pressurized	2.95	0.42	0.36	0.28	0.30	1.14	722,680	Yes	0.67	1.16
12	☐	11	506	505	12	309	0.0044	712,516	344,598	122,639	Free Surface	3.60	0.41	0.36	0.41	0.44	1.14	1,991,802	Yes	0.44	3.30
13	☐	379	500	499	8	399	0.0050	257,099	118,499	46,200	Pressurized	2.93	0.41	0.36	0.28	0.29	1.13	720,412	Yes	0.67	1.14
14	☐	1	472	476	10	293	0.0048	447,418	218,099	76,440	Free Surface	3.30	0.41	0.35	0.34	0.37	1.15	1,276,931	No	0.34	3.30
15	☐	423	489	488	8	450	0.0040	222,659	118,499	34,720	Free Surface	2.59	0.41	0.35	0.27	0.27	1.01	643,911	No	0.27	2.59
16	☐	3	478	491	9	270	0.0237	702,016	344,598	119,139	Free Surface	6.73	0.39	0.33	0.30	0.48	2.52	2,145,407	Yes	0.37	5.03
17	☐	403	501	500	8	405	0.0062	257,099	118,499	46,200	Free Surface	3.16	0.39	0.32	0.26	0.29	1.26	800,159	Yes	0.67	1.14
18	☐	10	492	506	12	338	0.0061	712,516	344,598	122,639	Free Surface	4.04	0.38	0.30	0.38	0.44	1.34	2,338,773	Yes	0.40	3.81
19	☐	352	473	472	8	63	0.0032	165,959	99,599	22,120	Free Surface	2.20	0.37	0.29	0.25	0.23	0.91	573,066	Yes	0.67	0.74
20	☐	450	425	436	8	429	0.0056	218,039	118,499	33,180	Free Surface	2.91	0.37	0.29	0.24	0.27	1.21	760,999	No	0.24	2.91
21	☐	2	476	478	10	299	0.0180	702,016	344,598	119,139	Free Surface	6.05	0.36	0.28	0.30	0.46	2.25	2,479,743	No	0.30	6.05
22	☐	365	474	469	7	277	0.0050	141,159	74,800	22,120	Free Surface	2.51	0.36	0.28	0.21	0.22	1.12	506,479	No	0.21	2.51
23	☐	448	423	425	8	413	0.0063	217,619	118,499	33,040	Free Surface	3.04	0.35	0.27	0.24	0.27	1.28	807,690	Yes	0.59	1.03
24	☐	199	444	133	8	408	0.1065	870,595	436,198	144,799	Free Surface	12.40	0.35	0.26	0.23	0.55	5.29	3,322,423	No	0.23	12.40
25	☐	615	112	406	8	192	0.1020	849,596	436,198	137,799	Free Surface	12.13	0.35	0.26	0.23	0.54	5.17	3,251,201	No	0.23	12.13
26	☐	313	409	440	8	244	0.1088	865,556	436,198	143,119	Free Surface	12.48	0.35	0.26	0.23	0.55	5.34	3,357,141	No	0.23	12.48
27	☐	197	111	112	8	204	0.1039	840,776	436,198	134,859	Free Surface	12.17	0.35	0.26	0.23	0.54	5.23	3,281,966	Yes	0.23	12.09
28	☐	314	406	409	8	156	0.1078	849,596	436,198	137,799	Free Surface	12.37	0.34	0.25	0.23	0.54	5.32	3,342,853	Yes	0.23	12.31
29	☐	824	280	911	8	120	0.0054	190,359	117,699	24,220	Free Surface	2.77	0.34	0.25	0.23	0.25	1.19	749,929	No	0.23	2.77
30	☐	355	498	0001	8	249	0.0108	266,759	118,499	49,420	Pressurized	3.91	0.34	0.25	0.23	0.30	1.69	1,059,773	Yes	0.67	1.18
31	☐	64	277	278	8	157	0.0050	177,759	117,699	20,020	Free Surface	2.64	0.34	0.25	0.23	0.24	1.14	717,767	No	0.23	2.64
32	☐	198	641	444	8	259	0.1277	870,595	436,198	144,799	Free Surface	13.24	0.33	0.24	0.22	0.55	5.80	3,638,102	Yes	0.23	12.81
33	☐	614	440	641	8	130	0.1270	865,556	436,198	143,119	Free Surface	13.19	0.33	0.24	0.22	0.55	5.78	3,627,533	No	0.22	13.19
34	☐	1113	150	207	8	144	0.0028	122,739	117,699	1,680	Free Surface	1.93	0.33	0.23	0.22	0.20	0.85	535,929	No	0.22	1.93
35	☐	353	469	473	7	265	0.0079	141,159	74,800	22,120	Free Surface	2.96	0.32	0.22	0.19	0.22	1.41	634,749	Yes	0.22	2.42
36	☐	822	278	280	8	378	0.0080	186,159	117,699	22,820	Free Surface	3.17	0.31	0.20	0.20	0.25	1.45	909,942	Yes	-0.17	-1.00
37	☐	876	151	148	8	127	0.0039	122,739	117,699	1,680	Free Surface	2.19	0.30	0.19	0.20	0.20	1.02	639,079	No	0.20	2.19
38	☐	875	147	151	8	163	0.0042	122,739	117,699	1,680	Free Surface	2.23	0.29	0.19	0.20	0.20	1.05	657,894	Yes	0.20	2.21
39	☐	878	149	150	8	139	0.0045	122,739	117,699	1,680	Free Surface	2.28	0.29	0.18	0.19	0.20	1.08	679,180	Yes	0.20	2.09
40	☐	877	148	149	8	83	0.0046	122,739	117,699	1,680	Free Surface	2.31	0.29	0.18	0.19	0.20	1.10	688,546	Yes	0.19	2.29
41	☐	376	446	438	8	142	0.0049	123,519	74,800	16,240	Free Surface	2.37	0.28	0.17	0.19	0.20	1.14	715,471	No	0.19	2.37
42	☐	442	452	464	8	166	0.0175	222,239	118,499	34,580	Free Surface	4.41	0.27	0.17	0.18	0.27	2.15	1,344,811	No	0.18	4.41
43	☐	76	207	208	8	144	0.0073	126,099	117,699	2,800	Free Surface	2.75	0.26	0.14	0.17	0.20	1.39	872,430	No	0.17	2.75
44	☐	65	264	277	8	286	0.0143	175,239	117,699	19,180	Free Surface	3.84	0.26	0.14	0.17	0.24	1.94	1,217,835	Yes	0.20	3.11
45	☐	194	106	108	12	65	0.0407	828,596	436,198	130,799	Free Surface	8.36	0.25	0.14	0.25	0.48	3.50	6,055,045	Yes	0.26	7.80
46	☐	74	208	210	8	206	0.0091	127,779	117,699	3,360	Free Surface	2.99	0.24	0.13	0.16	0.20	1.55	973,653	No	0.16	2.99
47	☐	58	104	106	12	289	0.0447	828,596	436,198	130,799	Free Surface	8.64	0.24	0.13	0.24	0.48	3.66	6,348,503	No	0.24	8.64
48	☐	315	437	446	8	138	0.0072	109,239	74,800	11,480	Free Surface	2.63	0.24	0.13	0.16	0.19	1.38	866,489	Yes	0.17	2.34
49	☐	15	133	135	15	169	0.0446	1,435,633	722,296	237,779	Free Surface	9.88	0.24	0.12	0.30	0.60	3.79	11,487,868	No	0.30	9.88

Existing Conditions - Gravity Main Output - Sorted by q/Q

		ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpd)	Unpeakable Flow (gpd)	Peakable Flow (gpd)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpd)	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
50	☐	416	512	369	8	236	0.0047	81,100	74,800	2,100	Free Surface	2.06	0.23	0.12	0.15	0.16	1.10	695,727	No	0.15	2.06
51	☐	438	464	463	8	169	0.0361	222,239	118,499	34,580	Free Surface	5.71	0.23	0.11	0.15	0.27	3.07	1,933,729	No	0.15	5.71
52	☐	599	132	133	12	213	0.0275	565,037	286,099	92,980	Free Surface	6.50	0.23	0.11	0.23	0.39	2.86	4,975,467	Yes	0.26	5.30
53	☐	737	127	128	8	255	0.0638	290,278	125,999	54,760	Free Surface	7.55	0.23	0.11	0.15	0.31	4.08	2,570,546	Yes	0.17	6.22
54	☐	740	131	132	12	258	0.0302	565,037	286,099	92,980	Free Surface	6.73	0.22	0.11	0.22	0.39	3.00	5,217,655	Yes	0.22	6.61
55	☐	432	463	490	8	173	0.0422	222,659	118,499	34,720	Free Surface	6.04	0.22	0.11	0.15	0.27	3.31	2,092,308	No	0.15	6.04
56	☐	417	369	366	8	425	0.0056	81,100	74,800	2,100	Free Surface	2.21	0.22	0.11	0.15	0.16	1.21	765,104	No	0.15	2.21
57	☐	735	125	126	8	169	0.0777	290,278	125,999	54,760	Free Surface	8.09	0.22	0.10	0.14	0.31	4.49	2,836,829	No	0.14	8.09
58	☐	736	126	127	8	285	0.0819	290,278	125,999	54,760	Free Surface	8.25	0.21	0.10	0.14	0.31	4.60	2,913,403	No	0.14	8.25
59	☐	533	118	125	8	170	0.0822	290,278	125,999	54,760	Free Surface	8.26	0.21	0.10	0.14	0.31	4.61	2,918,312	No	0.14	8.26
60	☐	742	129	130	12	212	0.0401	565,037	286,099	92,980	Free Surface	7.44	0.21	0.09	0.21	0.39	3.44	6,013,029	No	0.21	7.44
61	☐	734	117	118	8	152	0.0838	275,999	125,999	50,000	Free Surface	8.19	0.21	0.09	0.14	0.30	4.65	2,946,081	No	0.14	8.19
62	☐	739	130	131	12	292	0.0415	565,037	286,099	92,980	Free Surface	7.53	0.21	0.09	0.21	0.39	3.50	6,116,395	Yes	0.21	7.11
63	☐	446	454	452	8	131	0.0565	222,239	118,499	34,580	Free Surface	6.69	0.20	0.09	0.14	0.27	3.81	2,419,042	Yes	0.16	5.34
64	☐	428	490	489	8	287	0.0586	222,659	118,499	34,720	Free Surface	6.78	0.20	0.09	0.14	0.27	3.88	2,463,674	Yes	0.20	3.83
65	☐	3001	135	3000	24	50	0.0200	2,371,568	1,168,094	401,158	Free Surface	8.18	0.20	0.09	0.40	0.67	2.72	26,952,503	No	0.40	8.18
66	☐	705	732	733	8	226	0.0072	74,800	74,800	0	Free Surface	2.35	0.20	0.09	0.13	0.16	1.36	862,644	No	0.13	2.35
67	☐	68	251	264	8	93	0.0225	129,879	117,699	4,060	Free Surface	4.13	0.20	0.08	0.13	0.21	2.40	1,528,355	Yes	0.15	3.38
68	☐	831	919	918	12	274	0.0090	240,719	135,299	35,140	Free Surface	3.41	0.20	0.08	0.20	0.25	1.62	2,847,143	No	0.20	3.41
69	☐	449	436	454	8	166	0.0723	222,239	118,499	34,580	Free Surface	7.30	0.19	0.08	0.13	0.27	4.30	2,736,482	Yes	0.13	6.98
70	☐	535	116	117	8	160	0.1147	275,999	125,999	50,000	Free Surface	9.15	0.19	0.08	0.13	0.30	5.41	3,447,241	No	0.13	9.15
71	☐	422	488	502	8	113	0.1022	257,099	118,499	46,200	Free Surface	8.61	0.19	0.08	0.13	0.29	5.10	3,254,579	Yes	0.21	4.28
72	☐	375	438	450	8	137	0.0292	137,379	74,800	20,860	Free Surface	4.60	0.19	0.08	0.13	0.21	2.73	1,740,573	No	0.13	4.60
73	☐	838	913	912	12	198	0.0107	240,719	135,299	35,140	Free Surface	3.63	0.19	0.08	0.19	0.25	1.77	3,108,157	No	0.19	3.63
74	☐	855	794	921	12	91	0.0116	249,959	135,299	38,220	Free Surface	3.77	0.19	0.08	0.19	0.26	1.84	3,229,041	No	0.19	3.77
75	☐	3003	3002	0002	8	10	0.0100	74,260	35,200	13,020	Pressurized	2.63	0.18	0.07	0.12	0.15	1.59	1,017,993	Yes	0.67	0.33
76	☐	856	921	922	12	395	0.0138	249,959	135,299	38,220	Free Surface	4.01	0.18	0.07	0.18	0.26	2.00	3,524,062	No	0.18	4.01
77	☐	841	800	799	12	304	0.0130	240,719	135,299	35,140	Free Surface	3.89	0.18	0.07	0.18	0.25	1.94	3,427,553	No	0.18	3.89
78	☐	825	829	823	12	99	0.0088	190,359	117,699	24,220	Free Surface	3.16	0.18	0.07	0.18	0.22	1.60	2,819,299	No	0.18	3.16
79	☐	832	918	917	12	413	0.0150	240,719	135,299	35,140	Free Surface	4.09	0.17	0.07	0.17	0.25	2.08	3,677,368	No	0.17	4.09
80	☐	827	911	829	12	48	0.0100	190,359	117,699	24,220	Free Surface	3.31	0.17	0.06	0.17	0.22	1.69	3,000,325	No	0.17	3.31
81	☐	843	798	797	12	300	0.0165	240,719	135,299	35,140	Free Surface	4.23	0.17	0.06	0.17	0.25	2.17	3,851,978	No	0.17	4.23
82	☐	418	366	379	8	332	0.0175	81,100	74,800	2,100	Free Surface	3.29	0.17	0.06	0.11	0.16	2.09	1,346,031	No	0.11	3.29
83	☐	410	416	417	8	256	0.0187	81,100	74,800	2,100	Free Surface	3.37	0.16	0.06	0.11	0.16	2.16	1,392,593	No	0.11	3.37
84	☐	846	795	794	12	192	0.0261	240,719	135,299	35,140	Free Surface	4.96	0.15	0.05	0.15	0.25	2.71	4,844,763	Yes	0.17	4.21
85	☐	839	912	801	12	299	0.0265	240,719	135,299	35,140	Free Surface	4.99	0.15	0.05	0.15	0.25	2.73	4,884,369	No	0.15	4.99
86	☐	842	799	798	12	298	0.0278	240,719	135,299	35,140	Free Surface	5.08	0.15	0.05	0.15	0.25	2.79	5,001,602	Yes	0.16	4.62
87	☐	401	426	439	8	139	0.0389	95,380	74,800	6,860	Free Surface	4.57	0.15	0.05	0.10	0.18	3.08	2,007,247	No	0.10	4.57
88	☐	706	439	437	8	145	0.0523	109,239	74,800	11,480	Free Surface	5.28	0.15	0.05	0.10	0.19	3.57	2,328,529	Yes	0.13	3.56
89	☐	840	801	800	12	308	0.0306	240,719	135,299	35,140	Free Surface	5.25	0.15	0.05	0.15	0.25	2.92	5,247,746	Yes	0.16	4.48
90	☐	600	922	129	12	301	0.0422	274,759	160,099	38,220	Free Surface	6.12	0.14	0.04	0.14	0.27	3.42	6,163,407	Yes	0.18	4.59
91	☐	844	797	796	12	128	0.0324	240,719	135,299	35,140	Free Surface	5.36	0.14	0.04	0.14	0.25	3.00	5,404,065	No	0.14	5.36
92	☐	837	802	913	12	167	0.0354	240,719	135,299	35,140	Free Surface	5.53	0.14	0.04	0.14	0.25	3.13	5,646,925	No	0.14	5.53
93	☐	71	210	223	8	186	0.0912	129,039	117,699	3,780	Free Surface	6.74	0.14	0.04	0.09	0.21	4.69	3,073,682	No	0.09	6.74
94	☐	845	796	795	12	114	0.0408	240,719	135,299	35,140	Free Surface	5.81	0.14	0.04	0.14	0.25	3.35	6,059,270	Yes	0.14	5.36
95	☐	453	450	474	8	141	0.1301	141,159	74,800	22,120	Free Surface	7.84	0.13	0.04	0.09	0.22	5.58	3,672,131	Yes	0.15	3.72
96	☐	833	917	916	12	322	0.0474	240,719	135,299	35,140	Free Surface	6.12	0.13	0.04	0.13	0.25	3.60	6,535,206	No	0.13	6.12
97	☐	405	358	512	8	258	0.0488	80,260	74,800	1,820	Free Surface	4.70	0.13	0.04	0.09	0.16	3.40	2,247,950	Yes	0.12	2.91
98	☐	69	223	251	8	195	0.1279	129,879	117,699	4,060	Free Surface	7.60	0.13	0.04	0.09	0.21	5.51	3,640,375	Yes	0.11	5.42

		ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpd)	Unpeakable Flow (gpd)	Peakable Flow (gpd)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpd)	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
99	☐	519	803	920	12	95	0.0440	223,119	117,699	35,140	Free Surface	5.83	0.13	0.04	0.13	0.24	3.46	6,293,069	No	0.13	5.83
100	☐	826	823	176	12	149	0.0333	190,359	117,699	24,220	Free Surface	5.04	0.13	0.03	0.13	0.22	3.00	5,474,717	No	0.13	5.04
101	☐	830	920	919	12	159	0.0585	240,719	135,299	35,140	Free Surface	6.59	0.12	0.03	0.12	0.25	3.97	7,259,470	No	0.12	6.59
102	☐	836	914	802	12	153	0.0668	240,719	135,299	35,140	Free Surface	6.90	0.12	0.03	0.12	0.25	4.23	7,755,809	No	0.12	6.90
103	☐	469	733	513	8	135	0.0714	80,260	74,800	1,820	Free Surface	5.37	0.12	0.03	0.08	0.16	4.08	2,720,335	No	0.08	5.37
104	☐	393	513	358	8	150	0.0782	80,260	74,800	1,820	Free Surface	5.54	0.12	0.03	0.08	0.16	4.26	2,846,307	Yes	0.08	5.09
105	☐	828	176	177	12	131	0.0510	190,359	117,699	24,220	Free Surface	5.86	0.12	0.03	0.12	0.22	3.68	6,780,729	No	0.12	5.86
106	☐	5	177	175	12	114	0.0554	195,399	117,699	25,900	Free Surface	6.07	0.11	0.03	0.11	0.23	3.83	7,062,939	No	0.11	6.07
107	☐	834	916	915	12	266	0.0852	240,719	135,299	35,140	Free Surface	7.52	0.11	0.03	0.11	0.25	4.75	8,758,847	No	0.11	7.52
108	☐	857	905	803	12	395	0.0708	200,019	117,699	27,440	Free Surface	6.66	0.11	0.03	0.11	0.23	4.30	7,983,547	No	0.11	6.66
109	☐	419	379	416	8	354	0.1061	81,100	74,800	2,100	Free Surface	6.18	0.11	0.02	0.07	0.16	4.92	3,315,626	Yes	0.09	4.42
110	☐	409	417	426	8	188	0.1537	92,440	74,800	5,880	Free Surface	7.32	0.11	0.02	0.07	0.17	5.90	3,991,361	Yes	0.08	5.57
111	☐	810	825	905	12	313	0.0856	200,019	117,699	27,440	Free Surface	7.12	0.10	0.02	0.10	0.23	4.71	8,779,472	Yes	0.11	6.89
112	☐	835	915	914	12	256	0.1309	240,719	135,299	35,140	Free Surface	8.74	0.10	0.02	0.10	0.25	5.81	10,858,763	No	0.10	8.74
113	☐	820	910	825	12	114	0.0971	200,019	117,699	27,440	Free Surface	7.44	0.10	0.02	0.10	0.23	5.00	9,350,910	Yes	0.10	7.28
114	☐	702	729	730	8	64	0.1223	74,800	74,800	0	Free Surface	6.34	0.10	0.02	0.07	0.16	5.24	3,560,470	No	0.07	6.34
115	☐	821	175	824	12	192	0.1004	195,399	117,699	25,900	Free Surface	7.48	0.10	0.02	0.10	0.23	5.07	9,512,452	No	0.10	7.48
116	☐	700	727	728	8	205	0.1384	74,800	74,800	0	Free Surface	6.62	0.10	0.02	0.06	0.16	5.55	3,787,812	No	0.06	6.62
117	☐	818	824	910	12	28	0.1194	195,399	117,699	25,900	Free Surface	7.95	0.10	0.02	0.10	0.23	5.50	10,371,905	Yes	0.10	7.60
118	☐	704	731	732	8	82	0.1597	74,800	74,800	0	Free Surface	6.96	0.09	0.02	0.06	0.16	5.94	4,067,912	No	0.06	6.96
119	☐	701	728	729	8	84	0.1918	74,800	74,800	0	Free Surface	7.42	0.09	0.02	0.06	0.16	6.47	4,458,665	No	0.06	7.42
120	☐	703	730	731	8	127	0.1951	74,800	74,800	0	Free Surface	7.46	0.09	0.02	0.06	0.16	6.52	4,496,009	No	0.06	7.46
121	☐	3005	3003	0001	8	10	0.0100	14,700	0	4,900	Pressurized	1.62	0.08	0.01	0.06	0.07	1.46	1,017,993	Yes	0.67	0.07

Future Conditions - Gravity Main Output - Sorted by q/Q

		ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpd)	Unpeakable Flow (gpd)	Peakable Flow (gpd)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpd)	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
1	☐	196	109	110	8	462	0.0079	969,495	490,097	159,799	Pressurized	4.30	1.00	1.07	0.67	0.56	0.93	904,658	No	0.67	4.30
2	☐	195	110	111	8	402	0.0110	969,495	490,097	159,799	Free Surface	5.36	0.75	0.91	0.50	0.57	1.36	1,068,249	No	0.50	5.36
3	☐	616	108	109	8	49	0.0185	969,495	490,097	159,799	Free Surface	6.64	0.62	0.70	0.41	0.57	1.98	1,384,904	Yes	0.67	4.30
4	☐	421	502	501	8	119	0.0042	421,298	173,799	82,500	Free Surface	3.10	0.58	0.64	0.39	0.38	0.97	660,058	No	0.39	3.10
5	☐	364	499	498	8	397	0.0050	426,398	173,799	84,200	Pressurized	3.34	0.55	0.59	0.37	0.38	1.08	722,680	Yes	0.67	1.89
6	☐	423	489	488	8	450	0.0040	378,998	173,799	68,400	Free Surface	2.97	0.55	0.59	0.37	0.36	0.96	643,911	No	0.37	2.97
7	☐	9	491	492	11	271	0.0041	890,295	404,298	161,999	Free Surface	3.70	0.55	0.59	0.51	0.51	1.02	1,515,780	No	0.51	3.70
8	☐	379	500	499	8	399	0.0050	421,298	173,799	82,500	Pressurized	3.32	0.55	0.58	0.37	0.38	1.07	720,412	Yes	0.67	1.87
9	☐	723	660	134	12	114	0.0044	1,114,194	505,497	202,899	Free Surface	4.02	0.54	0.56	0.54	0.56	1.08	1,985,115	No	0.54	4.02
10	☐	13	509	660	12	273	0.0044	1,069,694	496,697	190,999	Free Surface	3.99	0.52	0.54	0.52	0.55	1.09	1,991,716	Yes	0.53	3.93
11	☐	6	505	509	12	384	0.0044	1,067,594	496,697	190,299	Free Surface	3.99	0.52	0.54	0.52	0.55	1.09	1,991,598	Yes	0.52	3.99
12	☐	403	501	500	8	405	0.0062	421,298	173,799	82,500	Free Surface	3.59	0.52	0.53	0.34	0.38	1.21	800,159	Yes	0.67	1.87
13	☐	1	472	476	10	293	0.0048	614,797	273,399	113,799	Free Surface	3.59	0.49	0.48	0.41	0.43	1.12	1,276,931	No	0.41	3.59
14	☐	738	128	129	8	172	0.0049	342,698	141,399	67,100	Free Surface	3.14	0.49	0.48	0.33	0.34	1.10	715,277	No	0.33	3.14
15	☐	450	425	436	8	429	0.0056	340,798	158,399	60,800	Free Surface	3.28	0.47	0.45	0.31	0.34	1.18	760,999	No	0.31	3.28
16	☐	11	506	505	12	309	0.0044	890,295	404,298	161,999	Free Surface	3.81	0.47	0.45	0.47	0.50	1.12	1,991,802	Yes	0.49	3.55
17	☐	14	134	135	12	183	0.0071	1,114,194	505,497	202,899	Free Surface	4.82	0.47	0.44	0.47	0.56	1.42	2,522,392	No	0.47	4.82
18	☐	448	423	425	8	413	0.0063	340,498	158,399	60,700	Free Surface	3.43	0.45	0.42	0.30	0.34	1.26	807,690	Yes	0.62	1.56
19	☐	3	478	491	9	270	0.0237	879,795	404,298	158,499	Free Surface	7.14	0.45	0.41	0.33	0.54	2.49	2,145,407	Yes	0.42	5.35
20	☐	355	498	0001	8	249	0.0108	430,898	173,799	85,700	Pressurized	4.45	0.44	0.41	0.30	0.38	1.65	1,059,773	Yes	0.67	1.91
21	☐	10	492	506	12	338	0.0061	890,295	404,298	161,999	Free Surface	4.29	0.43	0.38	0.43	0.50	1.33	2,338,773	Yes	0.45	4.04
22	☐	2	476	478	10	299	0.0180	879,795	404,298	158,499	Free Surface	6.44	0.41	0.35	0.34	0.52	2.23	2,479,743	No	0.34	6.44
23	☐	615	112	406	8	192	0.1020	978,195	490,097	162,699	Free Surface	12.61	0.38	0.30	0.25	0.57	5.15	3,251,201	No	0.25	12.61
24	☐	199	444	133	8	408	0.1065	999,195	490,097	169,699	Free Surface	12.88	0.38	0.30	0.25	0.58	5.27	3,322,423	Yes	0.26	11.99
25	☐	313	409	440	8	244	0.1088	994,095	490,097	167,999	Free Surface	12.96	0.37	0.30	0.25	0.58	5.32	3,357,141	No	0.25	12.96
26	☐	197	111	112	8	204	0.1039	969,495	490,097	159,799	Free Surface	12.66	0.37	0.30	0.25	0.57	5.21	3,281,966	Yes	0.25	12.58
27	☐	314	406	409	8	156	0.1078	978,195	490,097	162,699	Free Surface	12.86	0.37	0.29	0.25	0.57	5.30	3,342,853	Yes	0.25	12.81
28	☐	352	473	472	8	63	0.0032	166,199	99,599	22,200	Free Surface	2.20	0.37	0.29	0.25	0.23	0.91	573,066	Yes	0.67	0.74
29	☐	365	474	469	7	277	0.0050	141,399	74,800	22,200	Free Surface	2.51	0.36	0.28	0.21	0.22	1.12	506,479	No	0.21	2.51
30	☐	198	641	444	8	259	0.1277	999,195	490,097	169,699	Free Surface	13.76	0.36	0.27	0.24	0.58	5.78	3,638,102	Yes	0.24	13.31
31	☐	614	440	641	8	130	0.1270	994,095	490,097	167,999	Free Surface	13.71	0.36	0.27	0.24	0.58	5.77	3,627,533	No	0.24	13.71
32	☐	442	452	464	8	166	0.0175	344,998	158,399	62,200	Free Surface	4.99	0.35	0.26	0.23	0.34	2.14	1,344,811	No	0.23	4.99
33	☐	824	280	911	8	120	0.0054	190,299	117,699	24,200	Free Surface	2.77	0.34	0.25	0.23	0.25	1.19	749,929	No	0.23	2.77
34	☐	64	277	278	8	157	0.0050	177,699	117,699	20,000	Free Surface	2.64	0.34	0.25	0.23	0.24	1.14	717,767	No	0.23	2.64
35	☐	1113	150	207	8	144	0.0028	122,799	117,699	1,700	Free Surface	1.93	0.33	0.23	0.22	0.20	0.85	535,929	No	0.22	1.93
36	☐	353	469	473	7	265	0.0079	141,399	74,800	22,200	Free Surface	2.96	0.32	0.22	0.19	0.22	1.41	634,749	Yes	0.22	2.42
37	☐	822	278	280	8	378	0.0080	186,099	117,699	22,800	Free Surface	3.17	0.31	0.20	0.20	0.25	1.45	909,942	Yes	-0.17	-1.00
38	☐	876	151	148	8	127	0.0039	122,799	117,699	1,700	Free Surface	2.19	0.30	0.19	0.20	0.20	1.02	639,079	No	0.20	2.19
39	☐	599	132	133	12	213	0.0275	948,995	442,298	168,899	Free Surface	7.55	0.30	0.19	0.30	0.51	2.88	4,975,467	Yes	0.32	6.72
40	☐	3003	3002	0002	8	10	0.0100	193,599	71,500	40,700	Pressurized	3.47	0.30	0.19	0.20	0.25	1.63	1,017,993	Yes	0.67	0.86
41	☐	875	147	151	8	163	0.0042	122,799	117,699	1,700	Free Surface	2.23	0.29	0.19	0.20	0.20	1.05	657,894	Yes	0.20	2.21
42	☐	878	149	150	8	139	0.0045	122,799	117,699	1,700	Free Surface	2.28	0.29	0.18	0.19	0.20	1.08	679,180	Yes	0.20	2.09
43	☐	438	464	463	8	169	0.0361	344,998	158,399	62,200	Free Surface	6.48	0.29	0.18	0.19	0.34	3.09	1,933,729	No	0.19	6.48
44	☐	877	148	149	8	83	0.0046	122,799	117,699	1,700	Free Surface	2.31	0.29	0.18	0.19	0.20	1.10	688,546	Yes	0.19	2.30
45	☐	740	131	132	12	258	0.0302	907,295	442,298	154,999	Free Surface	7.71	0.28	0.17	0.28	0.50	3.02	5,217,655	Yes	0.29	7.46
46	☐	376	446	438	8	142	0.0049	123,699	74,800	16,300	Free Surface	2.38	0.28	0.17	0.19	0.20	1.14	715,471	No	0.19	2.38
47	☐	432	463	490	8	173	0.0422	355,198	158,399	65,600	Free Surface	6.91	0.28	0.17	0.19	0.35	3.34	2,092,308	No	0.19	6.91
48	☐	15	133	135	15	169	0.0446	1,948,190	932,395	338,598	Free Surface	10.79	0.28	0.17	0.35	0.70	3.81	11,487,868	No	0.35	10.79
49	☐	855	794	921	12	91	0.0116	513,397	249,699	87,900	Free Surface	4.65	0.27	0.16	0.27	0.37	1.87	3,229,041	No	0.27	4.65

		ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpd)	Unpeakable Flow (gpd)	Peakable Flow (gpd)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpd)	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
50	☐	194	106	108	12	65	0.0407	957,195	490,097	155,699	Free Surface	8.71	0.27	0.16	0.27	0.52	3.50	6,055,045	Yes	0.29	7.84
51	☐	742	129	130	12	212	0.0401	907,295	442,298	154,999	Free Surface	8.53	0.26	0.15	0.26	0.50	3.48	6,013,029	No	0.26	8.53
52	☐	58	104	106	12	289	0.0447	957,195	490,097	155,699	Free Surface	9.01	0.26	0.15	0.26	0.52	3.67	6,348,503	No	0.26	9.01
53	☐	739	130	131	12	292	0.0415	907,295	442,298	154,999	Free Surface	8.64	0.26	0.15	0.26	0.50	3.54	6,116,395	Yes	0.27	8.15
54	☐	856	921	922	12	395	0.0138	513,397	249,699	87,900	Free Surface	4.95	0.26	0.15	0.26	0.37	2.04	3,524,062	No	0.26	4.95
55	☐	76	207	208	8	144	0.0073	126,099	117,699	2,800	Free Surface	2.75	0.26	0.14	0.17	0.20	1.39	872,430	No	0.17	2.75
56	☐	428	490	489	8	287	0.0586	355,198	158,399	65,600	Free Surface	7.77	0.26	0.14	0.17	0.35	3.93	2,463,674	Yes	0.27	4.16
57	☐	65	264	277	8	286	0.0143	175,299	117,699	19,200	Free Surface	3.84	0.26	0.14	0.17	0.24	1.94	1,217,835	Yes	0.20	3.11
58	☐	446	454	452	8	131	0.0565	344,998	158,399	62,200	Free Surface	7.60	0.26	0.14	0.17	0.34	3.85	2,419,042	Yes	0.20	6.05
59	☐	737	127	128	8	255	0.0638	342,698	141,399	67,100	Free Surface	7.92	0.25	0.13	0.16	0.34	4.09	2,570,546	Yes	0.19	6.25
60	☐	74	208	210	8	206	0.0091	127,899	117,699	3,400	Free Surface	2.99	0.24	0.13	0.16	0.20	1.55	973,653	No	0.16	2.99
61	☐	422	488	502	8	113	0.1022	421,298	173,799	82,500	Free Surface	9.94	0.24	0.13	0.16	0.38	5.18	3,254,579	Yes	0.27	4.81
62	☐	838	913	912	12	198	0.0107	398,298	205,699	64,200	Free Surface	4.21	0.24	0.13	0.24	0.33	1.79	3,108,157	No	0.24	4.21
63	☐	315	437	446	8	138	0.0072	109,299	74,800	11,500	Free Surface	2.63	0.24	0.13	0.16	0.19	1.38	866,489	Yes	0.17	2.34
64	☐	449	436	454	8	166	0.0723	344,998	158,399	62,200	Free Surface	8.30	0.24	0.13	0.16	0.34	4.35	2,736,482	Yes	0.16	7.94
65	☐	735	125	126	8	169	0.0777	342,698	141,399	67,100	Free Surface	8.50	0.23	0.12	0.16	0.34	4.50	2,836,829	No	0.16	8.50
66	☐	843	798	797	12	300	0.0165	458,898	205,699	84,400	Free Surface	5.11	0.23	0.12	0.23	0.35	2.22	3,851,978	No	0.23	5.11
67	☐	736	126	127	8	285	0.0819	342,698	141,399	67,100	Free Surface	8.66	0.23	0.12	0.15	0.34	4.62	2,913,403	No	0.15	8.66
68	☐	533	118	125	8	170	0.0822	342,698	141,399	67,100	Free Surface	8.67	0.23	0.12	0.15	0.34	4.63	2,918,312	No	0.15	8.67
69	☐	416	512	369	8	236	0.0047	81,100	74,800	2,100	Free Surface	2.06	0.23	0.12	0.15	0.16	1.10	695,727	No	0.15	2.06
70	☐	841	800	799	12	304	0.0130	398,298	205,699	64,200	Free Surface	4.51	0.23	0.12	0.23	0.33	1.97	3,427,553	No	0.23	4.51
71	☐	3001	135	3000	24	50	0.0200	3,062,384	1,437,893	541,497	Free Surface	8.81	0.23	0.11	0.46	0.77	2.74	26,952,503	No	0.46	8.81
72	☐	734	117	118	8	152	0.0838	328,298	141,399	62,300	Free Surface	8.62	0.23	0.11	0.15	0.33	4.67	2,946,081	No	0.15	8.62
73	☐	831	919	918	12	274	0.0090	310,998	205,699	35,100	Free Surface	3.68	0.22	0.11	0.22	0.29	1.64	2,847,143	No	0.22	3.68
74	☐	417	369	366	8	425	0.0056	81,100	74,800	2,100	Free Surface	2.21	0.22	0.11	0.15	0.16	1.21	765,104	No	0.15	2.21
75	☐	535	116	117	8	160	0.1147	328,298	141,399	62,300	Free Surface	9.63	0.21	0.10	0.14	0.33	5.44	3,447,241	No	0.14	9.63
76	☐	846	795	794	12	192	0.0261	458,898	205,699	84,400	Free Surface	6.01	0.21	0.09	0.21	0.35	2.77	4,844,763	Yes	0.24	4.93
77	☐	842	799	798	12	298	0.0278	458,898	205,699	84,400	Free Surface	6.14	0.20	0.09	0.20	0.35	2.86	5,001,602	Yes	0.22	5.58
78	☐	600	922	129	12	301	0.0422	564,597	300,898	87,900	Free Surface	7.57	0.20	0.09	0.20	0.39	3.53	6,163,407	Yes	0.23	6.26
79	☐	705	732	733	8	226	0.0072	74,800	74,800	0	Free Surface	2.35	0.20	0.09	0.13	0.16	1.36	862,644	No	0.13	2.35
80	☐	68	251	264	8	93	0.0225	129,999	117,699	4,100	Free Surface	4.13	0.20	0.09	0.13	0.21	2.40	1,528,355	Yes	0.15	3.38
81	☐	844	797	796	12	128	0.0324	458,898	205,699	84,400	Free Surface	6.49	0.20	0.08	0.20	0.35	3.08	5,404,065	No	0.20	6.49
82	☐	832	918	917	12	413	0.0150	310,998	205,699	35,100	Free Surface	4.41	0.20	0.08	0.20	0.29	2.10	3,677,368	No	0.20	4.41
83	☐	839	912	801	12	299	0.0265	398,298	205,699	64,200	Free Surface	5.80	0.19	0.08	0.19	0.33	2.78	4,884,369	No	0.19	5.80
84	☐	375	438	450	8	137	0.0292	137,499	74,800	20,900	Free Surface	4.60	0.19	0.08	0.13	0.21	2.73	1,740,573	No	0.13	4.60
85	☐	840	801	800	12	308	0.0306	398,298	205,699	64,200	Free Surface	6.10	0.19	0.08	0.19	0.33	2.98	5,247,746	Yes	0.21	5.20
86	☐	845	796	795	12	114	0.0408	458,898	205,699	84,400	Free Surface	7.03	0.19	0.08	0.19	0.35	3.44	6,059,270	Yes	0.20	6.49
87	☐	837	802	913	12	167	0.0354	398,298	205,699	64,200	Free Surface	6.42	0.18	0.07	0.18	0.33	3.20	5,646,925	No	0.18	6.42
88	☐	825	829	823	12	99	0.0088	190,299	117,699	24,200	Free Surface	3.16	0.18	0.07	0.18	0.22	1.60	2,819,299	No	0.18	3.16
89	☐	827	911	829	12	48	0.0100	190,299	117,699	24,200	Free Surface	3.31	0.17	0.06	0.17	0.22	1.69	3,000,325	No	0.17	3.31
90	☐	833	917	916	12	322	0.0474	398,298	205,699	64,200	Free Surface	7.12	0.17	0.06	0.17	0.33	3.68	6,535,206	No	0.17	7.12
91	☐	418	366	379	8	332	0.0175	81,100	74,800	2,100	Free Surface	3.29	0.17	0.06	0.11	0.16	2.09	1,346,031	No	0.11	3.29
92	☐	410	416	417	8	256	0.0187	81,100	74,800	2,100	Free Surface	3.37	0.16	0.06	0.11	0.16	2.16	1,392,593	No	0.11	3.37
93	☐	836	914	802	12	153	0.0668	398,298	205,699	64,200	Free Surface	8.03	0.15	0.05	0.15	0.33	4.34	7,755,809	No	0.15	8.03
94	☐	401	426	439	8	139	0.0389	95,500	74,800	6,900	Free Surface	4.57	0.15	0.05	0.10	0.18	3.08	2,007,247	No	0.10	4.57
95	☐	706	439	437	8	145	0.0523	109,299	74,800	11,500	Free Surface	5.28	0.15	0.05	0.10	0.19	3.57	2,328,529	Yes	0.13	3.56
96	☐	834	916	915	12	266	0.0852	398,298	205,699	64,200	Free Surface	8.74	0.15	0.05	0.15	0.33	4.87	8,758,847	No	0.15	8.74
97	☐	830	920	919	12	159	0.0585	310,998	205,699	35,100	Free Surface	7.12	0.14	0.04	0.14	0.29	4.03	7,259,470	No	0.14	7.12
98	☐	71	210	223	8	186	0.0912	129,099	117,699	3,800	Free Surface	6.74	0.14	0.04	0.09	0.21	4.69	3,073,682	No	0.09	6.74

		ID	From ID	To ID	Diameter (in)	Length (ft)	Slope	Total Flow (gpd)	Unpeakable Flow (gpd)	Peakable Flow (gpd)	Flow Type	Velocity (ft/s)	d/D	q/Q	Water Depth (ft)	Critical Depth (ft)	Froude Number	Full Flow (gpd)	Backwater Adjustment	Adjusted Depth (ft)	Adjusted Velocity (ft/s)
99	☐	453	450	474	8	141	0.1301	141,399	74,800	22,200	Free Surface	7.85	0.13	0.04	0.09	0.22	5.58	3,672,131	Yes	0.15	3.72
100	☐	835	915	914	12	256	0.1309	398,298	205,699	64,200	Free Surface	10.16	0.13	0.04	0.13	0.33	5.97	10,858,763	No	0.13	10.16
101	☐	69	223	251	8	195	0.1279	129,999	117,699	4,100	Free Surface	7.61	0.13	0.04	0.09	0.21	5.51	3,640,375	Yes	0.11	5.42
102	☐	405	358	512	8	258	0.0488	80,200	74,800	1,800	Free Surface	4.70	0.13	0.04	0.09	0.16	3.40	2,247,950	Yes	0.12	2.91
103	☐	519	803	920	12	95	0.0440	222,999	117,699	35,100	Free Surface	5.83	0.13	0.04	0.13	0.24	3.46	6,293,069	No	0.13	5.83
104	☐	826	823	176	12	149	0.0333	190,299	117,699	24,200	Free Surface	5.04	0.13	0.03	0.13	0.22	3.00	5,474,717	No	0.13	5.04
105	☐	469	733	513	8	135	0.0714	80,200	74,800	1,800	Free Surface	5.37	0.12	0.03	0.08	0.16	4.08	2,720,335	No	0.08	5.37
106	☐	393	513	358	8	150	0.0782	80,200	74,800	1,800	Free Surface	5.54	0.12	0.03	0.08	0.16	4.26	2,846,307	Yes	0.08	5.09
107	☐	828	176	177	12	131	0.0510	190,299	117,699	24,200	Free Surface	5.86	0.12	0.03	0.12	0.22	3.68	6,780,729	No	0.12	5.86
108	☐	5	177	175	12	114	0.0554	195,399	117,699	25,900	Free Surface	6.07	0.11	0.03	0.11	0.23	3.83	7,062,939	No	0.11	6.07
109	☐	857	905	803	12	395	0.0708	199,899	117,699	27,400	Free Surface	6.66	0.11	0.03	0.11	0.23	4.30	7,983,547	No	0.11	6.66
110	☐	419	379	416	8	354	0.1061	81,100	74,800	2,100	Free Surface	6.18	0.11	0.02	0.07	0.16	4.92	3,315,626	Yes	0.09	4.42
111	☐	409	417	426	8	188	0.1537	92,500	74,800	5,900	Free Surface	7.32	0.11	0.02	0.07	0.17	5.90	3,991,361	Yes	0.08	5.57
112	☐	810	825	905	12	313	0.0856	199,899	117,699	27,400	Free Surface	7.12	0.10	0.02	0.10	0.23	4.71	8,779,472	Yes	0.11	6.89
113	☐	820	910	825	12	114	0.0971	199,899	117,699	27,400	Free Surface	7.44	0.10	0.02	0.10	0.23	5.00	9,350,910	Yes	0.10	7.28
114	☐	702	729	730	8	64	0.1223	74,800	74,800	0	Free Surface	6.34	0.10	0.02	0.07	0.16	5.24	3,560,470	No	0.07	6.34
115	☐	821	175	824	12	192	0.1004	195,399	117,699	25,900	Free Surface	7.48	0.10	0.02	0.10	0.23	5.07	9,512,452	No	0.10	7.48
116	☐	700	727	728	8	205	0.1384	74,800	74,800	0	Free Surface	6.62	0.10	0.02	0.06	0.16	5.55	3,787,812	No	0.06	6.62
117	☐	818	824	910	12	28	0.1194	195,399	117,699	25,900	Free Surface	7.95	0.10	0.02	0.10	0.23	5.50	10,371,905	Yes	0.10	7.60
118	☐	704	731	732	8	82	0.1597	74,800	74,800	0	Free Surface	6.96	0.09	0.02	0.06	0.16	5.94	4,067,912	No	0.06	6.96
119	☐	3005	3003	0001	8	10	0.0100	17,700	0	5,900	Pressurized	1.71	0.09	0.02	0.06	0.07	1.48	1,017,993	Yes	0.67	0.08
120	☐	701	728	729	8	84	0.1918	74,800	74,800	0	Free Surface	7.42	0.09	0.02	0.06	0.16	6.47	4,458,665	No	0.06	7.42
121	☐	703	730	731	8	127	0.1951	74,800	74,800	0	Free Surface	7.46	0.09	0.02	0.06	0.16	6.52	4,496,009	No	0.06	7.46

APPENDIX E

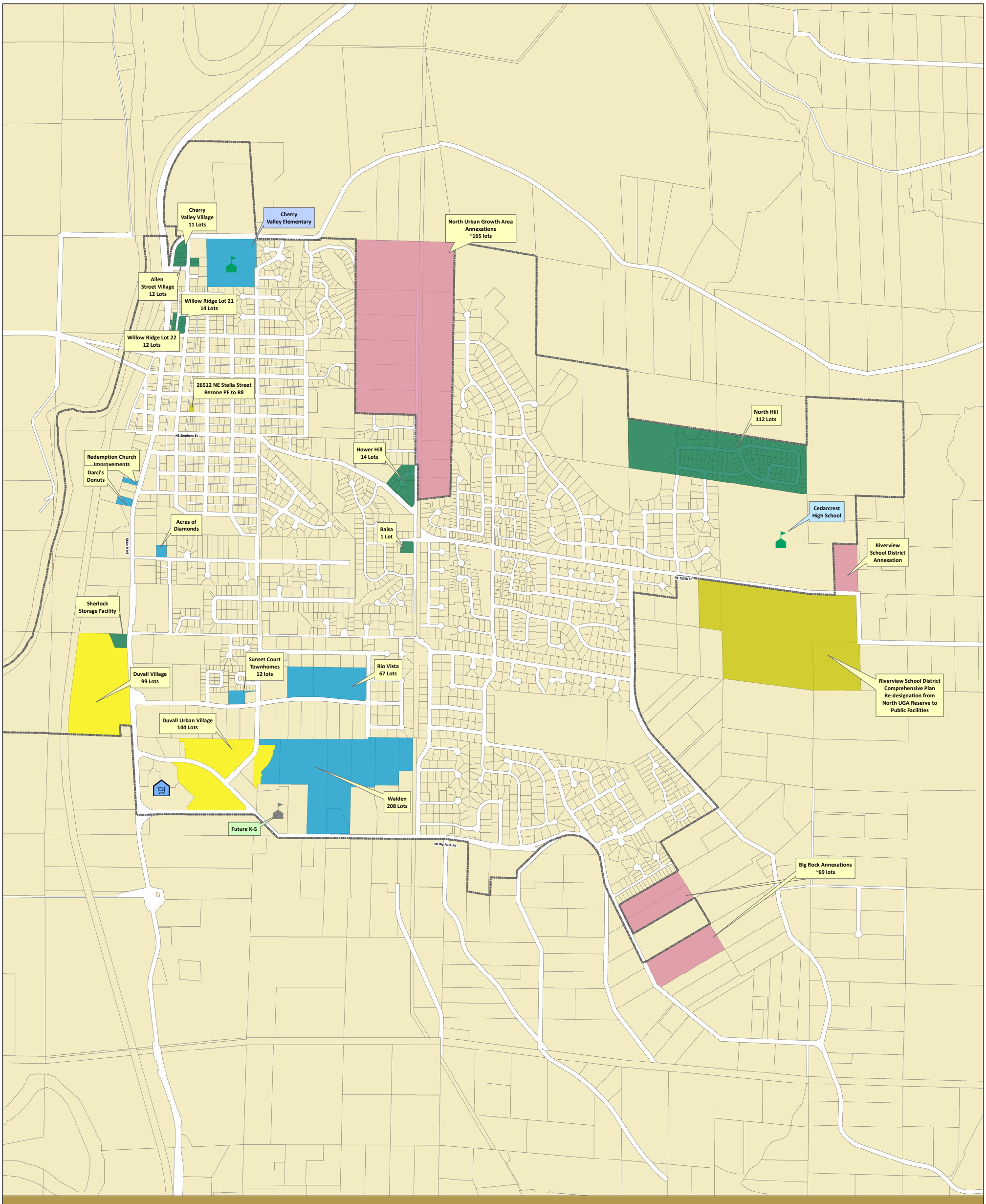
CURRENT AND FUTURE DEVELOPMENT LOT COUNTS AND LOCATIONS

Development	Current Status	Current Zoning	Application/ DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat (Years, Ave= 10.3)	Size (Acres)	Total Lots	Building Permits Issued	Building Permits Remaining (7/13/18)	2018 Anticipated (remaining)	2019 Anticipated	2020 Anticipated	2021 Anticipated	2022 Anticipated
Allen Street Village	Legal Lots	R-12 (12 Units/Acre)	11/16/2006	6/15/2007	3/21/2017	10.3	1.04	12	10	2	2				
Cherry Valley Village	Legal Lots	R-12 (12 Units/Acre)	3/20/2006	12/11/2006	3/21/2017	11	1.04	11	9	2	2				
Bowe Court	Legal Lots	R-6 (6 Units/Acre)	BLA June 2015	NA	NA	NA	0.9	6	6	0	0				
Hower Hill	Legal Lots	R-4 (4 Units/Acre)	7/27/2015	1/4/2016	9/6/2016	1.2	3.6	14	14	0	0				
North Hill	Legal Lots	R-4 (4 Units/Acre)	7/19/2007	7/16/2009, 2/3/2014 Amended	1/7/2017	9.5	40	112	70	42	22	20			
Willow Ridge - Lot 21	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	10/24/2013	16	0.55	14	14	0	0				
Willow Ridge - Lot 22	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	11/14/2013	16	0.62	12	0	12	12				
Ring Street Cottages	Legal Lots	R-4 (4 Units/Acre)	BLA 2016	NA	NA	NA	0.23	2	2	0	0				
Baisa	Legal Lots	R-4 (4 Units/Acre)	39287	39514	42521	8.8	0.62	1	0	1	0	1			
Duvall Village	Construction Drawings Approved	MU12	7/6/2015	7/6/2015	Fall 2018*	3.2*	30.8	99		99	0	24	25	25	25
DUV1 Toll	Construction Drawing Review	MU12	1/20/2009	40345	June 2018*	8.5	23.3	144		144	0	34	34	38	38
Rio Vista	Construction Drawings Submittal	R-12 (12 Units/Acre)	42171	8/12/2016	September 2018??	2.1*	12.72	67		67	0	16	17	17	17
Permits To Date (7/13/2018)										Total	38	95	76	80	80

Residential Developments Under Review (more process before ready to build homes)

Development Name	Current Status	Current Zoning	Application/DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat	Size (Acres)	Total Lots	Building Permits Issued
Sunset Court	Pending Preliminary Plat	R12 (12 Units/Acre)	3/22/2016	Under Review	Future Submittal	>0.25 Years	1.02	12	NA
Walden	Pending Preliminary Plat	R-8 (8 Units/Acre) & MUI (Mixed Use Institutional)	Agreement - 12/14/2007	Under Review	Future Submittal	>10.5 Years	38.54	208	NA
65 Degrees	Pending Preliminary Plat	R-20 (20 Units/Acre)	TBD	Under Review	Future Submittal	TBD	4.53	51	NA
						Total	**44.09**	**271**	**NA**

one of the 65 Degrees lot is a 12 unit condo



2018 Current Development Map

Residential Developments Under Review (more process before ready to build homes)

Development Name	Current Status	Current Zoning	Application/DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat	Size (Acres)	Total Lots	Building Permits Issued
Duvall Urban Village	Clearing & Grading	MU-12 (12 Units/Acre)	12/22/2008	6/16/2010	Future Submittal	>9.5 Years	23.3	144	NA
Duvall Village	Clearing & Grading	MU-12 (12 Units/Acre)	2001 Agreement - 4/18/2014	7/6/2015	Future Submittal	>17.5 Years	34.3	99	NA
Rio Vista	Pending Construction Submitta	R-8 (8 Units/Acre)	6/16/2015	8/12/2016	Future Submittal	>2 Years	12.7	67	NA
Sunset Court	Pending Preliminary Plat	R12 (12 Units/Acre)	3/22/2016	Under Review	Future Submittal	>0.25 Years	1.02	12	NA
Walden	Pending Preliminary Plat	R-8 (8 Units/Acre) & MUI (Mixed Use Institution	Agreement - 12/14/2007	Under Review	Future Submittal	>10.5 Years	38.54	208	NA
						Total	109.86	530	NA

Legal Lots (Ready to Build Homes)

Development	Current Status	Current Zoning	Application/DA Date (Vesting)	Preliminary Plat Approval	Final Plat Approval	Vesting to Final Plat (Years, Ave= 10.3)	Size (Acres)	Total Lots	Building Permits Issued
Allen Street Village	Legal Lots	R-12 (12 Units/Acre)	11/16/2006	6/15/2007	2/9/2018	10.3	1.04	12	9
Cherry Valley Village	Legal Lots	R-12 (12 Units/Acre)	3/20/2006	12/11/2006	2/9/2018	11	1.04	11	9
Bowe Court	Legal Lots	R-6 (6 Units/Acre)	BLA June 2015	NA	NA	NA	0.9	6	6
Hower Hill	Legal Lots	R-4 (4 Units/Acre)	7/27/2015	1/4/2016	9/6/2016	1.2	3.6	14	14
North Hill	Legal Lots	R-4 (4 Units/Acre)	7/19/2007	7/16/2009, 2/3/14 Amended	1/7/2017	9.5	40	112	71
Willow Ridge - Lot 21	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	10/24/2013	16	0.55	14	14
Willow Ridge - Lot 22	Legal Lots	R-12 (12 Units/Acre)*	1997	7/23/1998	11/14/2013	16	0.62	12	0
Baisa	Legal Lots	R-4 (4 Units/Acre)	7/24/2007	3/7/2008	5/31/2016	8.8	0.62	1	0
						Total	48.37	182	123

Legend

- City Limits

Residential Pipeline

- Legal Lot (Home construction in 0 to 2 years)
- Plat Construction (Home construction in 1 to 3 years)
- Construction Drawing Review (Home construction in 2 to 4 years)
- DA/P-Plat (Home construction in 3 to 10 years)
- Annexation (Home construction unknown)
- CPA
- Parcels

N W E S

City of Duvall
Small Town. Real Life.

APPENDIX F

CIP PROJECT COSTS

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: CS-1
Prepared by: B. Moss
Date: 11/12/2020
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	UV System Replacement				
1	Mobilization (8%)	1	LS	$ 17,100	$ 17,100
2	Temporary Project Traffic Control	1	LS	$ 10,000	$ 10,000
3	Sanitary Sewer Bypass	1	LS	$ 20,000	$ 20,000
4	Demo Ex. 8" Sewer	462	LF	$ 12	$ 5,600
5	12" Sewer (PVC C900)	462	LF	$ 160	$ 73,920
6	Shoring or Extra Excavation Class B	1,848	SF	$ 2	$ 3,700
7	Gravel Borrow for Trench Backfill	520	CY	$ 50	$ 26,000
8	Roaway Removal and Reconstruction	620	SY	$ 120	$ 74,400
9	Sewer MH	1	EA	$ 6,000	$ 6,000
				Sub-Total	$ 236,800
				Tax (8.9%)	$ 21,100
				Admin & Engineering (20%)	$ 47,400
				Contingency (30%)	$ 71,100
				11/2020 - 8/2021 CCI Increase (5.2%)	$ 12,500
				Total	$ 388,900

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-1
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	UV System Replacement				
1	Mobilization (8%)	1	LS	$ 34,100	$ 34,100
2	Equipment	1	LS	$ 265,000	$ 265,000
3	Other pipe or equipment costs	1	LS	$ 6,500	$ 6,500
4	Mechanical installation	1	LS	$ 119,300	$ 119,300
5	Electrical installation	1	LS	$ 35,000	$ 35,000
				Sub-Total	$ 459,900
				Tax (8.9%)	$ 41,000
				Admin & Engineering (20%)	$ 92,000
				Contingency (30%)	$ 138,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 55,100
				Total	$ 786,000

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-3
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	WWTP Generator ATS Inspection				
1	Inspection	1	LS	$ 7,000	$ 7,000
	WWTP Generator Load Test				
1	100-percent load bank testing (annually or bi-annually)	1	LS	$ 4,000	$ 4,000
2	Evaluate for equipment degradation	1	LS	$ 1,000	$ 1,000
				Sub-Total	$ 12,000
				Tax (8.9%)	$ 1,100
				Admin (5%)	$ 600
				Contingency (30%)	$ 3,600
				CCI Increase (2/2019 - 8/2021, 12%)	$ 1,500
				Total	$ 18,800

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-4
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Grit Removal				
1	Mobilization (8%)	1	LS	$ 1,300	$ 1,300
1	Demolition	1	LS	$ 3,500	$ 3,500
2	Type II Manhole	2	EA	$ 2,500	$ 5,000
3	Install	1	LS	$ 7,500	$ 7,500
	Fats, Oils, & Grease (FOG)				
1	Mobilization (8%)	1	LS	$ 14,400	$ 14,400
1	Little John Digester	1	LS	$ 100,000	$ 100,000
2	Install (Mechanical + Electrical)	1	LS	$ 80,000	$ 80,000
	Drum Screen				
1	Mobilization (8%)	1	LS	$ 21,400	$ 21,400
1	Replace Hycor screen with drum screen	1	LS	$ 150,000	$ 150,000
2	Replace/widen concrete channel wall with SS	1	LS	$ 50,000	$ 50,000
3	Mechanical Install	1	LS	$ 67,500	$ 67,500
	Anoxic Basin Pump Replacement				
1	Mobilization (8%)	1	LS	$ 6,300	$ 6,300
1	Replace old anoxic basin pumps	2	EA	$ 35,000	$ 70,000
2	Install	1	LS	$ 8,000	$ 8,000
				Sub-Total	$ 584,900
				Tax (8.9%)	$ 52,100
				Admin & Engineering (20%)	$ 117,000
				Contingency (30%)	$ 175,500
				CCI Increase (2/2019 - 8/2021, 12%)	$ 70,100
				Total	$ 999,600

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-5
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Electrical Panel				
1	Conduct an arc-flash study	1	LS	$ 10,000	$ 10,000
	Heat Trace Headworks				
1	Upgrade heat trace system	1	LS	$ 15,000	$ 15,000
	Headworks Power Panel (MCC 20)				
1	Replace MCC 20 with NEMA 12 rated MCC panel	1	LS	$ 50,000	$ 50,000
2	Install	1	LS	$ 100,000	$ 100,000
	Headworks Panel H				
1	Replace panel H with NEMA 3R of 4X enclosure	1	LS	$ 4,000	$ 4,000
				Sub-Total	$ 179,000
				Tax (8.9%)	$ 16,000
				Admin & Engineering (20%)	$ 35,800
				Contingency (30%)	$ 53,700
				CCI Increase (2/2019 - 8/2021, 12%)	$ 21,500
				Total	$ 306,000

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-6
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Planning and Design				
1	Planning & Design	1	LS	$ 490,000	$ 490,000
				Sub-Total	$ 490,000
				Admin (5%)	$ 24,500
				Contingency (30%)	$ 147,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 58,700
				Total	$ 720,200

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-7
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Three Treatment Trains				
1	Mobilization (8%)	1	LS	$ 63,000	$ 63,000
2	Upgrade teatment trains w/ pump motors	1	LS	$ 437,000	$ 437,000
3	Mechanical Install	1	LS	$ 196,700	$ 196,700
4	Electrical Install	1	LS	$ 153,000	$ 153,000
	Blower Replacement				
1	Mobilization (8%)	1	LS	$ 129,600	$ 129,600
2	Aeration & MBR Blowers	1	LS	$ 900,000	$ 900,000
3	Mechanical Install	1	LS	$ 405,000	$ 405,000
4	Electrical Install	1	LS	$ 315,000	$ 315,000
	Blower Piping Modifications				
1	Mobilization (8%)	1	LS	$ 3,200	$ 3,200
2	Connect discharge lines between blowers	1	LS	$ 40,000	$ 40,000
	Pump Control				
1	Mobilization (8%)	1	LS	$ 4,400	$ 4,400
2	Install VFD	1	LS	$ 30,000	$ 30,000
3	Mechanical Install	1	LS	$ 13,500	$ 13,500
4	Electrical Install	1	LS	$ 10,500	$ 10,500
	Solids Handling (Drying)				
1	Mobilization (8%)	1	LS	$ 69,300	$ 69,300
2	Replace the existing screening/grit conveyor	1	LS	$ 42,000	$ 42,000
3	Screw press	1	LS	$ 330,000	$ 330,000
4	Sludge Feed Pump	1	LS	$ 12,000	$ 12,000
5	Polymer system	1	LS	$ 15,000	$ 15,000
6	Control Panel: NEMA 4X	1	LS	$ 65,000	$ 65,000
7	Roll-up door	1	LS	$ 15,000	$ 15,000
8	Remove belt press	1	LS	$ 2,500	$ 2,500
9	Mechanical Install	1	LS	$ 216,700	$ 216,700
10	Electrical Install	1	LS	$ 167,700	$ 167,700
	Security				
1	Mobilization (8%)	1	LS	$ 1,100	$ 1,100
2	Fencing	150	L.F.	$ 50	$ 10,000
3	Replace signage	1	LS	$ 3,000	$ 3,000
	Lighting Improvements				
1	Mobilization (8%)	1	LS	$ 2,800	$ 2,800
2	Anoxic Area	1	LS	$ 20,000	$ 20,000
3	MBR Area	1	LS	$ 15,000	$ 15,000

Structural Repairs							
1	Mobilization (8%)	1	LS	$	8,000	$	8,000
2	Concrete Repair	1	LS	$	80,000	$	80,000
3	Seismic bracing for pipes in solids handling building	1	LS	$	20,000	$	20,000
Slide Gate Replacement							
1	Mobilization (8%)	1	LS	$	16,400	$	16,400
2	Motorized stainless-steel gates	1	LS	$	130,000	$	130,000
3	Removal & Install	1	LS	$	75,000	$	75,000
Electrical Engineering Study							
1	Mobilization (8%)	1	LS	$	4,000	$	4,000
2	Engineering study	1	LS	$	50,000	$	50,000
Valve Actuator							
1	Mobilization (8%)	1	LS	$	1,400	$	1,400
2	Valve actuator (reuse)	1	LS	$	12,000	$	12,000
3	Mechanical Install	1	LS	$	5,400	$	5,400
Influent & Effluent Samplers							
1	Mobilization (8%)	1	LS	$	1,600	$	1,600
2	Influent samplers and cabinets	2	EA	$	8,000	$	16,000
3	Install	1	LS	$	3,600	$	3,600
					Sub-Total	$	4,111,400
					Tax (8.9%)	$	366,000
					Admin & Const. Engr (15%)	$	616,800
					Contingency (30%)	$	1,233,500
					CCI Increase (2/2019 - 8/2021, 12%)	$	492,500
					Total	$	6,820,200

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-8
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Anoxic Tank Foam				
1	Mobilization (8%)	1	LS	$ 2,400	$ 2,400
2	Telescoping Skimmer Valves with install	2	EA	$ 10,000	$ 20,000
3	Reuse water piping w/ spray heads	1	LS	$ 9,000	$ 9,000
				Sub-Total	$ 31,400
				Tax (8.9%)	$ 2,800
				Admin & Engineering (20%)	$ 6,300
				Contingency (30%)	$ 9,500
				CCI Increase (2/2019 - 8/2021, 12%)	$ 3,800
				Total	$ 53,800

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-1
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Pump Evaluations				
1	Pump Evaluation and Repair (Assumes 1 pump replacement and 1 repair/rebuild per station)	4	LS	$ 25,000	$ 100,000
				Sub-Total	$ 100,000
				Tax (8.9%)	$ 8,900
				Admin (5%)	$ 5,000
				Contingency (30%)	$ 30,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 12,000
				Total	$ 155,900

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-2
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	All Pump Stations				
1	Mobilization (8%)	1	LS	$ 1,000	$ 1,000
2	Fall Protection	4	EA	$ 3,000	$ 12,000
				Sub-Total	$ 13,000
				Tax (8.9%)	$ 1,200
				Admin & Engineering (20%)	$ 2,600
				Contingency (30%)	$ 3,900
				CCI Increase (2/2019 - 8/2021, 12%)	$ 1,600
				Total	$ 22,300

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-3
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	All Pump Stations				
1	Telemetry Upgrades	4	EA	$ 5,000	$ 20,000
				Sub-Total	$ 20,000
				Tax (8.9%)	$ 1,800
				Admin & Engineering (20%)	$ 4,000
				Contingency (30%)	$ 6,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 2,400
				Total	$ 34,200

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-4
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	All Pump Stations				
1	Mobilization (8%)	1	LS	$ 3,200	$ 3,200
2	Clean/remove corrosion in Wet Well	4	EA	$ 2,000	$ 8,000
3	Valve Vault Corrosion Repair (Cherry Brooke, Cedars)	2	EA	$ 6,000	$ 12,000
4	Recoat piping and fittings	4	EA	$ 5,000	$ 20,000
				Sub-Total	$ 43,200
				Tax (8.9%)	$ 3,900
				Admin & Engineering (20%)	$ 8,700
				Contingency (30%)	$ 13,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 5,200
				Total	$ 74,000

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-5
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	All Pump Stations				
1	Mobilization (8%)	1	LS	$ 3,100	$ 3,100
2	Replace fencing (3 PSs)	450	LF	$ 65	$ 29,300
3	Corner Posts	15	EA	$ 160	$ 2,400
4	Gates	3	EA	$ 2,300	$ 6,900
				Sub-Total	$ 41,700
				Tax (8.9%)	$ 3,800
				Admin (5%)	$ 2,100
				Contingency (30%)	$ 12,600
				CCI Increase (2/2019 - 8/2021, 12%)	$ 5,000
				Total	$ 65,200

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-6
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	All Pump Stations				
1	Generator Load Bank Testing (6 stations)	1	LS	$ 20,000	$ 20,000
				Sub-Total	$ 20,000
				Tax (8.9%)	$ 1,800
				Admin (5%)	$ 1,000
				Contingency (30%)	$ 6,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 2,400
				Total	$ 31,200

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-7a & 7b
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Cherry Brooke & Railroad PS				
1	Replace Generator and ATS	2	EA	$ 50,000	$ 100,000
				Sub-Total	$ 100,000
				Tax (8.9%)	$ 8,900
				Admin & Engineering (20%)	$ 20,000
				Contingency (30%)	$ 30,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 12,000
				Total	$ 170,900

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-8
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Cherry Brooke				
	Mechanical Upgrades				
1	Mobilization (8%)	1	LS	$ 1,400	$ 1,400
2	Air Release Valve Replacement	1	LS	$ 15,000	$ 15,000
3	Backflow Prevention Relocation	1	LS	$ 2,000	$ 2,000
4	"Lead Pump On" Float Replacement	1	LS	$ 500	$ 500
				Sub-Total	$ 18,900
				Tax (8.9%)	$ 1,700
				Admin & Engineering (20%)	$ 3,800
				Contingency (30%)	$ 5,700
				CCI Increase (2/2019 - 8/2021, 12%)	$ 2,300
				Total	$ 32,400

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-9
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Cherry Brooke				
	Electrical				
1	Mobilization (8%)	1	LS	$ 400	$ 400
1	Main Disconnection Reconfiguration	1	LS	$ 1,500	$ 1,500
2	Panel-Mounted GFCI Receptacle Replacement	1	LS	$ 200	$ 200
3	Increase air gap between wet well conduits and control panel entry, provide expanded steel mesh around wet well	1	LS	$ 1,500	$ 1,500
4	Provide conduit and conductors, remove control panel receptacle and cord connection to generator	1	LS	$ 1,500	$ 1,500
				Sub-Total	$ 5,100
				Tax (8.9%)	$ 500
				Admin & Engineering (20%)	$ 1,100
				Contingency (30%)	$ 1,600
				CCI Increase (2/2019 - 8/2021, 12%)	$ 700
				Total	$ 9,000

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-10
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Railroad				
	Electrical				
1	Mobilization (8%)	1	LS	$ 700	$ 700
1	Panel-mounted alarm light for fail/backup float operation	1	LS	$ 300	$ 300
2	Provide adequate air gap preventing gasses from entering control panel	1	LS	$ 2,000	$ 2,000
3	Grounding electrode conductor replacement and new crimp splice connections for ground conductors	1	LS	$ 300	$ 300
4	Generator exhaust extension (if generator not replaced)	1	LS	$ 5,000	$ 5,000
				Sub-Total	$ 8,300
				Tax (8.9%)	$ 800
				Admin & Engineering (20%)	$ 1,700
				Contingency (30%)	$ 2,500
				CCI Increase (2/2019 - 8/2021, 12%)	$ 1,000
				Total	$ 14,300

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-11
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Taylor Ridge				
	Electrical: Pump Motor Conduit				
1	Provide three separate conduits for pump and float cables, Increase air gap between wet well conduits and control panel entry to meet minimum 18 inch distance and provide expanded steel mesh around wet well	1	LS	$ 5,000	$ 5,000
	Electrical: Control Panel				
1 2 3 4 5 6 7 8 9	Replace complete control panel door components and RTU input conductors Back panel New relay RTU input conductors New terminal strip Motor starter equipment MCC doors with selector switches Low/low-level float for pump interlock	1	LS	$ 10,000	$ 10,000
		1	LS	$ 12,500	$ 12,500
				Sub-Total	$ 27,500
				Tax (8.9%)	$ 2,500
				Admin & Engineering (20%)	$ 5,500
				Contingency (30%)	$ 8,300
				CCI Increase (2/2019 - 8/2021, 12%)	$ 3,300
				Total	$ 47,100

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: PS-13
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Taylor Ridge				
	Electrical				
1	Replace/upsize the generator and ATS	1	LS	$ 50,000	$ 50,000
				Sub-Total	$ 50,000
				Tax (8.9%)	$ 4,500
				Admin & Engineering (20%)	$ 10,000
				Contingency (30%)	$ 15,000
				CCI Increase (2/2019 - 8/2021, 12%)	$ 6,000
				Total	$ 85,500

City of Duvall
Engineers Opinion of Probable Construction Cost
Water Projects - 2019 CIP

Project: WWTP-2
Prepared by: E. Goltiao; B. Moss
Date: 2/21/2019
Checked by: R. Raymond

Item Number	Description	Quantity	Unit	Unit Price	Total
	Reuse Pump Skid Replacement				
1	Mobilization (8%)	1	LS	$ 16,700	$ 16,700
2	Paco Pump Skid (includes VFD)	1	LS	$ 133,000	$ 133,000
3	Electrical install	1	LS	$ 15,000	$ 15,000
4	Mechanical install	1	LS	$ 59,900	$ 59,900
	New Hoist System				
1	Mobilization (8%)	1	LS	$ 800	$ 800
2	Crane/Hoist System for Mechanical Equipment	1	LS	$ 5,000	$ 5,000
3	Mechanical install	1	LS	$ 4,000	$ 4,000
				Sub-Total	$ 234,400
				Tax (8.9%)	$ 20,900
				Admin & Engineering (20%)	$ 46,900
				Contingency (30%)	$ 70,400
				CCI Increase (2/2019 - 8/2021, 12%)	$ 28,100
				Total	$ 400,700

APPENDIX G

2021 SEWER RATE STUDY

City of Duvall

Sewer Utility

Sewer Utility Rate Study: Revenue Requirement & GFC Update

FINAL REPORT

October 2021

Washington
7525 166th Avenue NE, Ste. D215
Redmond, WA 98052
425.867.1802

Oregon
5335 Meadows Road, Ste. 330
Lake Oswego, OR 97035
503.841.6543

Colorado
1320 Pearl St, Ste 120
Boulder, CO 80302
719.284.9168

www.fcsgroup.com

FCS GROUP
Solutions-Oriented Consulting

FCS GROUP
Solutions-Oriented Consulting

Firm Headquarters
Redmond Town Center
7525 166th Ave NE, Ste. D-215
Redmond, Washington 98052

Established 1988
Washington | 425.867.1802
Oregon | 503.841.6543
Colorado | 719.284.9168

October 14, 2021

Steven Leniszewski, Public Works Director
City of Duvall
15535 Main St. NE
Duvall, WA, 98019

Subject: City of Duvall Sewer Utility Rate Study - Revenue Requirement & GFC Update

Dear Mr. Leniszewski:

FCS GROUP is pleased to submit this report documenting the sewer utility revenue requirement and general facilities charge (GFC) update. These analyses were performed in support of the Duvall Wastewater System Evaluation & Planning study conducted by Parametrix, Inc. The recommended sewer utility rate adjustments are shown below. These increases are forecast to generate the revenue needed to fully fund the utility on a standalone basis, considering operating and maintenance expenditures, fiscal policy achievement, existing debt service payments, and capital project needs.

Recommended Rate Schedule	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual Rate Adjustments		1.60%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Single Family Fixed Charge	$77.86	$79.11	$81.08	$83.11	$85.19	$87.32	$89.50	$91.74	$94.03	$96.38	$98.79
Commercial / Other Fixed Charge	$77.86	$79.11	$81.08	$83.11	$85.19	$87.32	$89.50	$91.74	$94.03	$96.38	$98.79
Commercial Volume Rate (per ccf over 9)	$2.83	$2.88	$2.95	$3.02	$3.10	$3.17	$3.25	$3.33	$3.42	$3.50	$3.59

Additionally, the existing and updated GFCs (per ERU) are shown below.

General Facilities Charge	Existing (as of 2021)	Calculated
Per Equivalent Residential Unit (ERU)	$11,953	$14,087

The detailed methodologies used to derive the revenue requirement and GFC are included in this report. It has been a pleasure to work with you and other City staff on this effort. Please let us know if you have any questions or need additional information. Tage can be reached at (425) 615-6487 or TageA@fcsgroup.com.

Sincerely,

John Ghilarducci
Project Principal

Tage Aaker
Project Manager

Matthew Morrison
Analyst

TABLE OF CONTENTS

Section I. INTRODUCTION

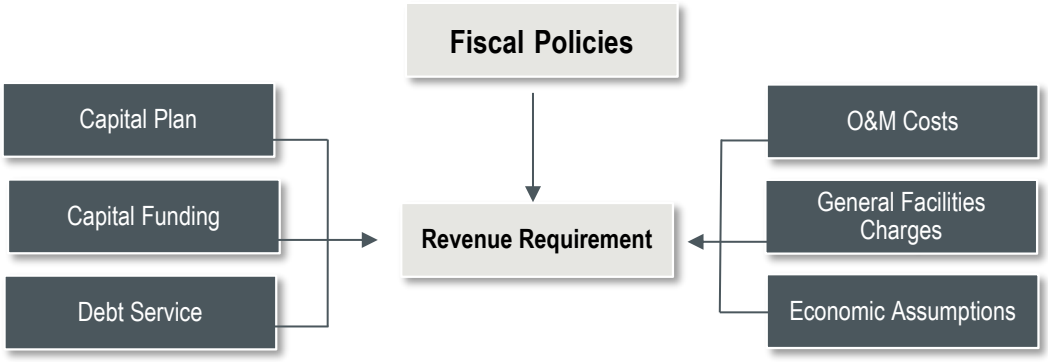
Utility Background

The City of Duvall (City) sewer utility provides collection and treatment services for its customers, covering a service area of over two square miles. The utility is responsible for maintaining approximately 30 miles of sewer collection pipe, 6 lift stations, and the City's wastewater treatment plant. Revenue to fund the sewer system includes monthly sewer fees and general facilities charges (connection charges). Roughly 96% of monthly sewer fees come from residential customers, and 4% of fees come from commercial customers. Completion of this rate study was done in coordination with the Duvall Wastewater System Evaluation & Planning study and the capital improvement needs identified in that study.

Revenue Requirement

One purpose of this rate study is to develop a funding plan ("revenue requirement") for the City's sewer utility for the 2021-2030 rate setting study period. The revenue requirement identifies the total revenue needed to fully fund the utility on a standalone basis considering current financial obligations and future capital expenditures identified in the capital improvement program (CIP). Revenue increases are applied "across-the-board" for the utility; there were no rate design changes incorporated in this rate study.

Exhibit 1: Revenue Requirement Overview



General Facilities Charges

The second purpose of this rate study is to update the City's existing GFCs. General facilities charges are designed to recover from new development a proportionate share of the cost of capital facilities. GFCs are one time charges, not ongoing rates. They are payable at the time a structure is newly connected to the sewer system or a structure is redeveloped to a higher level of demand. GFCs serve two primary purposes: to provide equity between existing and new customers; and to provide a source of capital funding for system capital costs, as growth occurs. While the revenue requirement focuses on the 2021-2030 period, the GFC considers all projects in the City's CIP, which extends through 2037.

Section II. FINANCIAL HISTORY

This section includes a historical summary of financial performance as reported on the City's C-4 Statement (*Fund Resources and Uses Arising from Cash Transactions)* for the combined sewer funds. Comparative statements for the previous six years (2014 through 2019) are summarized in **Exhibit 2,** which covers beginning reserves, revenues, expenses, and ending reserves for each year.

Exhibit 2: Fund Resources and Uses Arising from Cash Transactions (C-4 Statement)

C-4 Statement: 402 Sewer Fund	2014	2015	2016	2017	2018	2019
Beginning Cash & Investments						
30810 Reserved	$ 1,456,611	$ 1,211,956	$ 3,017,391	$ 1,418,943	$ 494,000	$ 335,000
30880 Unreserved	759,662	1,041,743	680,414	977,615	2,086,056	2,917,542
388 / 588 Net Adjustments	-	-	-	-	-	-
Total Beginning Cash & Investments	**$ 2,216,273**	**$ 2,253,699**	**$ 3,697,805**	**$ 2,396,558**	**$ 2,580,056**	**$ 3,252,542**
Revenues						
330 Intergovernmental Revenues	$ 236,885	$ -	$ -	$ -	$ -	$ -
340 Charges for Goods and Services	2,094,191	2,181,995	2,352,037	2,323,751	2,405,993	2,516,137
360 Miscellaneous Revenues	145,098	128,402	18,466	905,465	548,117	644,138
Total Revenues	**$ 2,476,174**	**$ 2,310,397**	**$ 2,370,503**	**$ 3,229,216**	**$ 2,954,110**	**$ 3,160,275**
Expenditures						
510 General Government	$ -	$ 1,280	$ -	$ 135	$ -	$ -
530 Utilities	1,359,586	1,445,191	1,482,356	1,569,906	1,774,239	1,978,169
Total Operating Expenses	**$ 1,359,586**	**$ 1,446,471**	**$ 1,482,356**	**$ 1,570,041**	**$ 1,774,239**	**$ 1,978,169**
Nonoperating Revenues						
370-380, 395 & 398 Other Financing Sources	$ 253,623	$ 1,293,686	$ 398,707	$ -	$ 27,312	$ -
Total Nonoperating Revenues	**$ 253,623**	**$ 1,293,686**	**$ 398,707**	**$ -**	**$ 27,312**	**$ -**
Nonoperating Expenditures						
591-593 Debt Service	$ 568,424	$ 565,885	$ 566,260	$ 777,802	$ 472,930	$ 334,555
594-595 Capital Expenditures	691,013	96,916	1,446,339	70,430	9,537	498,770
597 Transfers-Out	73,346	50,709	575,747	627,446	52,230	-
Total Nonoperating Expenditures:	**$ 1,332,783**	**$ 713,510**	**$ 2,588,346**	**$ 1,475,678**	**$ 534,697**	**$ 833,325**
Net Increase (Decrease) in Cash and Investments	**$ 37,428**	**$ 1,444,102**	**$ (1,301,492)**	**$ 183,497**	**$ 672,486**	**$ 348,781**
Ending Cash and Investments						
5081000 Reserved	$ 1,211,956	$ 1,487,837	$ 1,242,025	$ 494,000	$ 335,000	$ 335,000
5088000 Unreserved	1,041,743	2,209,968	1,154,285	2,086,059	2,917,541	3,266,324
Total Ending Cash and Investments	**$ 2,253,699**	**$ 3,697,805**	**$ 2,396,310**	**$ 2,580,059**	**$ 3,252,541**	**$ 3,601,324**

Some observations are provided below:

- Charges for goods and services have steadily increased from $2.1 million to $2.5 million from 2014 to 2019, for a compound annual growth rate of approximately 3.7 percent.
- Operating expenditures have also steadily increased from $1.4 million to $2.0 million in 2019, for a compound annual growth rate of approximately 7.8 percent.
- The debt service coverage ratio (calculated as revenue less expenses, divided by total annual debt expenses) was approximately 2.0 in 2014, rose to 3.5 by 2019, and did not dip below 1.5 in the six-year period.
- The City increased its ending cash and investments in each year apart from 2016, in which there was a significant amount of capital expenditures.

Section III. Fiscal Policies

Background

The basic framework for evaluating utility revenue needs includes sound fiscal policies. Several policy topics are important to consider as part of managing the finances of the utility including cash reserves, debt management, and rate funded system reinvestment (planned rate funded capital).

According to the City's adopted Financial Policies document, per Resolution 04-04, a sewer reserve fund of $800,000 was set up in 2009 to provide sufficient cash flow to meet any unforeseen emergency. Based on annual inflationary adjustments, the City currently maintains a sewer reserve of nearly $1,000,000. During this rate study, City staff requested that FCS GROUP evaluate the City's current policies as compared to industry standards. The following *Operating Reserves* and *Capital Reserves* sections apply such industry standards to the City's sewer utility to arrive at a combined minimum reserve funding target of between $550,000 and $950,000. Reserves higher than this may be prudent, especially in the capital reserve, if the City is saving up in advance to help cash fund a portion of upcoming capital projects.

Cash Reserves

When evaluating reserve levels and objectives, it is important to recognize that the value of reserves lies in their potential use. A reserve strategy that deliberately avoids any use of reserves negates their purpose. The fluctuation of reserve levels may indicate that the system is working, while lack of variation over many years strongly suggests that the reserves are, in fact, unnecessary.

Operating Reserves

An operating reserve is designed to provide a liquidity cushion; it protects the utility from the risk of short-term variation in the timing of revenue collection or payment of expenses. The most common operating reserve target for sewer utilities is between 45 days to 60 days of operating expenses.

Recommended Policy: Achieve a year-end minimum balance target of between **45-60 days (12%-16%)** of total annual operating expenditures. This equates to a range of between roughly **$250,000-$350,000** based on the 2021 operating budget of roughly $2.1 million.

Capital Reserve

The capital reserve provides a source of emergency funding for unexpected asset failures or other unanticipated capital needs. This capital reserve policy is not intended to guard against catastrophic system failure or extreme acts of nature. The most common capital reserve target for sewer utilities is between 1-2% of the original cost of the utility's plant-in-service.

Recommended Policy: Achieve a year-end minimum balance target of between **1-2%** of the original cost of the utility's plant-in-service. This equates to a range of roughly **$300,000-$600,000** based on the plant-in-service cost estimate of $30 million by the end of 2021.

Debt Management

The City currently has one outstanding sewer utility loan from the Department of Ecology (DOE) State Revolving Fund (SRF) which was taken out to help fund the wastewater treatment plant upgrade project completed in 2005. Annual debt service payments on this loan total approximately $335,000 and are forecast to end in 2025 as the loan matures. In the financial plan presented in this report, $2,100,000 of new debt is assumed in 2024 to help fund a portion of the capacity upgrade project at the wastewater treatment plant. This helps mitigate near-term rate adjustments that would otherwise be needed to fully cash-fund the project. Because the existing loan matures in 2025, there would only be a brief overlap for debt service payments on the two loans.

Debt Reserve

A debt reserve is most often required as a condition of bond issuance, though some state loan programs also require a reserve. The reserve intends to protect bondholders (or the agency issuing loans) from the risk of the borrower defaulting on their payments and is most often linked to either average annual debt service or maximum annual debt service.

Recommended Policy: The City's current SRF loan requires that the City keep in a restricted reserve an amount equal to the average annual debt service on the loan. This policy should be updated in the future by terms outlined in covenants for future debt obligations.

Debt Service Coverage

Debt service coverage is typically a requirement associated with revenue bonds and some state loans, and it is an important benchmark to measure the riskiness of the sewer utility's capital funding plans. Coverage is most easily understood as a factor applied to annual debt service. In such a case, if it issues revenue bonds, the sewer utility agrees to collect enough revenue to meet operating expenses and not only pay debt service but to collect an additional 25% above bonded debt service. The extra revenue is a "cushion" that makes bondholders more confident that debt service will be paid on time.

The City's SRF loan does not appear to require the City to achieve a specified debt service coverage target. If the City were to ever go to market for revenue bonds, they would likely be required to achieve a minimum debt service coverage target of 1.25, which is the common legal minimum coverage for municipal revenue bonds.

Recommended Policy: We recommend a more conservative internal policy coverage target of at least 1.50 to 2.00 on revenue bond debt. The City's debt service coverage achievement on *total* debt never dips below 4.4 throughout the ten-year forecast.

Rate Funded System Reinvestment

Rate funded system reinvestment is the funding of long-term infrastructure replacement needs through a regular (annual) and predictable rate provision, which helps minimize reliance on debt. Specific benchmarks for annual funding might include any of the following: original cost depreciation expense; replacement cost depreciation expense; an amount determined by an asset management plan; and directly budgeted replacement as needs arise.

Most commonly, utilities that have addressed replacement funding needs have used historical (original cost) depreciation expense as the basis for a reasonable level of reinvestment in the system. This strategy and level of funding satisfies several standards for reasonable rates:

- It avoids decline in system asset value (financial integrity);
- It charges customers commensurate with their consumption of facility useful lives and avoids the possibility of charging customers more than the current cost to provide service (rate equity); and
- It provides a substantial source of funding for replacement (capital funding adequacy).

Recommended Policy: We recommend that the City strive to fully fund original cost depreciation expense by the end of the study period. This is currently estimated to be $800,000 and is forecast to be roughly $1,000,000 by 2030. In order to track this policy over time, it is important that the City maintain current fixed asset inventory records.

Recommendations

Exhibit 3 provides a summary of the recommended fiscal policies for the sewer utility.

Exhibit 3: Summary of Fiscal Policies

Policy	Recommended Target
Operating Reserve	60 days of O&M ($350,000 based on 2021 budget)
Capital Reserve	2% of original cost of plant-in-service ($600,000 based on 2021 assets)
Debt Service Coverage	An internal policy target of at least 1.50 to 2.00 would be prudent
Rate Funded System Reinvestment	Fully fund original cost depreciation by the end of the study period ($1,000,000 / yr.)

Section IV. Revenue Requirement

This section presents the revenue requirement analysis results for the sewer utility, which are summarized in **Exhibit 4**. As mentioned previously, these increases are forecast to generate the revenue needed to fully fund the sewer utility on a standalone basis, considering operating and maintenance expenditures, debt service, fiscal policy achievement, and capital project needs. Preliminary results were presented to the City Council on January 5th, 2021. The proposed rate increases documented in this report include a 1.6% automatic CPI-based increase that has already been adopted, followed by 2.5% increases annually thereafter.

Exhibit 4: Summary Results of the Revenue Requirement Forecast

Recommended Rate Schedule	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual Rate Adjustments	1.60%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%

Economic & Inflation Factors

The operating and maintenance expenditure forecast largely relies on the City's 2021-22 adopted budget for the Sewer Fund (Fund 402). The line items in the budget are then adjusted each year by utilizing one of the following factors:

- General Cost Inflation – assumed to be 2.5 percent per year based on both the Washington State Economic & Revenue Forecast Council projection for the Consumer Price Index (CPI) as well as the recent historical performance of the Seattle-Tacoma-Bellevue CPI.
- Construction Cost Inflation – assumed to be 3.0 percent per year based on the historical Engineering News-Record Construction Cost Index (20-City Average).
- Personnel Cost Inflation – assumed to be 3.6 percent per year based on industry experience in the region as well as by referencing the Employment Cost Indices for wages and benefits (3.00 percent per year for wages and 5.00 percent per year for benefits).
- Taxes – State Excise tax rate of 3.852 percent, State Business and Occupation tax rate of 1.75 percent, and City Utility tax rate of 10 percent.
- Fund Earnings – assumed to be 0.50 percent per year based on the Local Government Investment Pool (LGIP) for Washington.
- Customer Growth – Based on discussions with City staff, the City is assumed to add 605 ERUs 2020 through 2025 (roughly 100 units per year), and approximately 30 ERUs annually thereafter.

Fund Balances

The Sewer Fund (Fund 402) and Sewer CIP Fund (Fund 408) track operating and capital activity related to the sewer utility. Fund 402 had an estimated beginning fund balance on January 1, 2021 of approximately $3.5 million and Fund 408 had an estimated beginning fund balance on January 1, 2021 of approximately $2.5 million.

Exhibit 5: Cash Balances for Fund 402 & 408

Description	Beginning 2021 Cash Balances
Fund 402 - Operating	$3,502,627
Fund 408 - Capital	$2,452,050
Total Beginning Cash January 1, 2021	**$5,954,677**

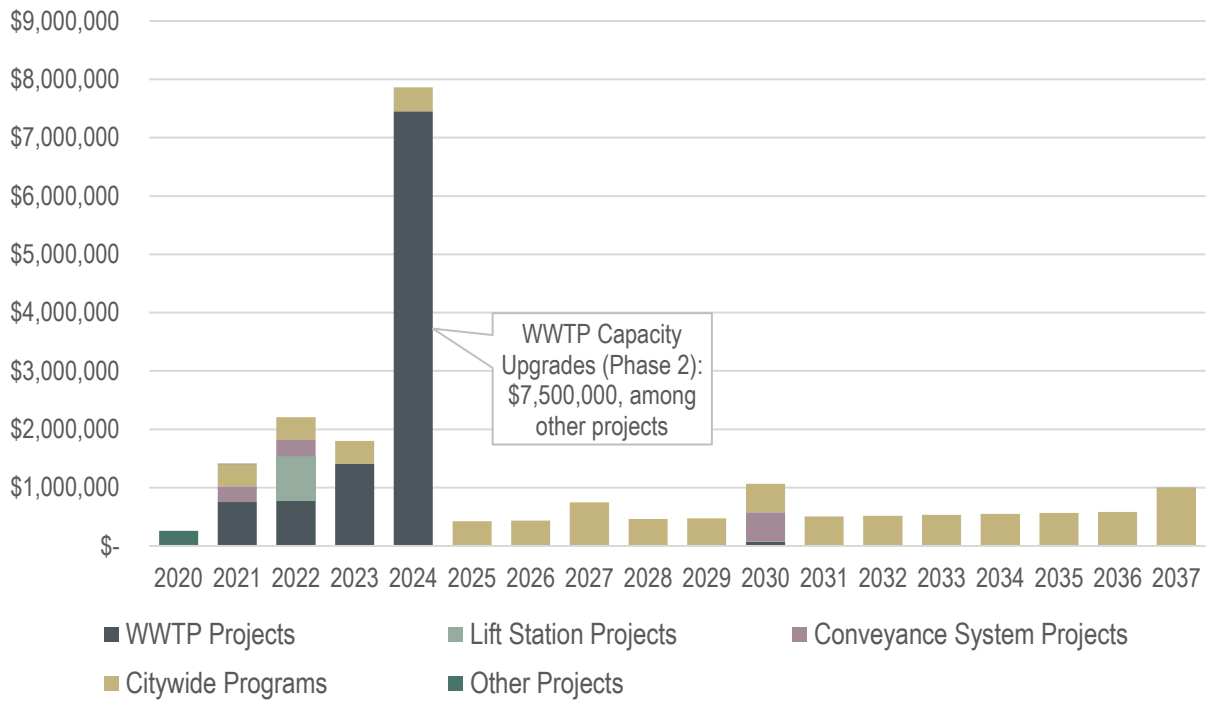
Existing Debt Obligations

The City currently has one outstanding debt obligation for the sewer utility. The annual debt service payment is approximately $335,000 and will be paid off in 2025.

Capital Expenditure Forecast

Capital projects through 2037 were provided by the City and its consulting engineer, Parametrix, Inc. Costs were provided by project, by year, and are in 2021 dollars. To estimate the actual spending by year, costs are escalated to the estimated year of construction for the revenue requirement forecast. **Exhibit 6** shows the planned annual capital spending, with cost escalation.

Exhibit 6: Capital Expenditure Forecast (2020-2037)



Revenue Requirement Methodology

While capital expenditures were provided through 2037, the revenue requirement forecast focuses on the ten-year period for rate setting purposes. The revenue requirement analysis evaluates the sufficiency of the utility's revenues against its financial obligations in the context of two tests described below:

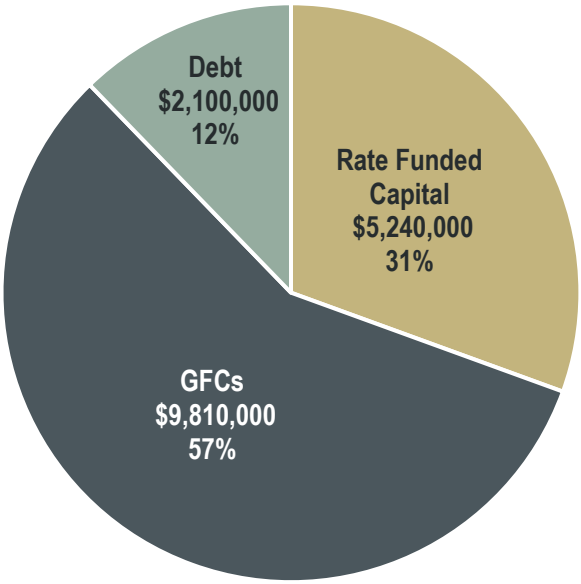
- **Cash Flow Test.** The cash flow test determines whether or not the utility's annual revenues are sufficient to cover the known cash requirements for each year of the forecast. The City can temporarily waive the requirements of the cash flow test as part of a conscious decision to phase in rate increases, as long as its operating reserve balance is sufficient to absorb the resulting cash-flow deficit.
- **Coverage Test.** The coverage test evaluates the utility's ability to meet applicable bond coverage requirements. As this test focuses on annual financial performance, it precludes the use of reserves to cover shortfalls.

In determining the annual revenue requirement, the test with the greatest deficiency generally drives the rate increase in any given year. For this forecast, the cash flow sufficiency test always produces a greater deficiency than the debt service coverage test. As previously noted, with the recommended rate increases, a comfortable debt service coverage ratio of 4.4 or greater is achieved throughout the forecast.

Capital Funding Strategy

The 2020-30 capital plan totals $17.1 million with cost escalation, of which $9.8 million is expected to be funded through GFC revenues, $5.2 million is expected to be funded through annual rate revenues, and $2.1 million is expected to be debt-funded. The capital funding strategy is summarized in **Exhibit 7**.

Exhibit 7: Capital Funding Strategy 2020-30



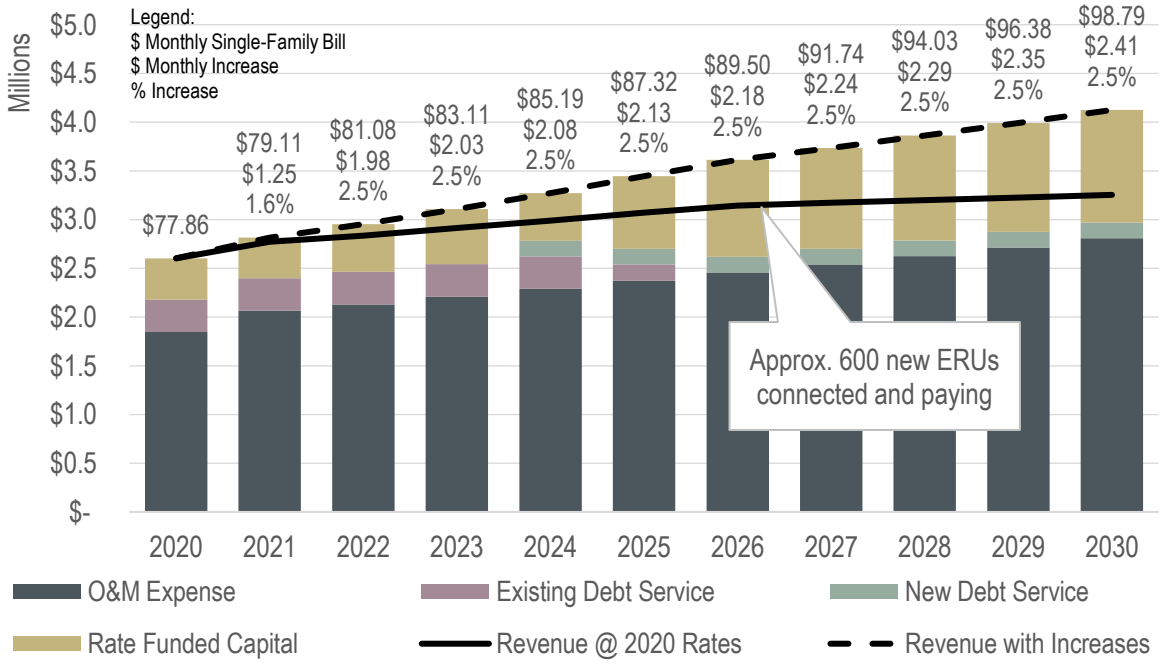
Revenue Requirement Results

Exhibit 8 graphically represents the revenue requirement forecast through 2030. The bars represent costs of the utility such as operating expenses, existing debt service, new debt service, and annual rate revenue earmarked for capital projects.

Additional observations are provided below:

- Solid line: Revenue at existing rates.
  - » Rate revenue is expected to be roughly $2.6 million in 2020 and is expected to increase with customer growth before future rate adjustments. This also includes miscellaneous revenues.
- Dashed line: Revenues with rate increases.
  - » Rate revenues with increases are expected to grow to approximately $4.1 million by 2030.
- Dark blue bar: Operating and maintenance expense (O&M).
  - » Operating expenses are based on the adopted 2021-22 budget and increase with the annual cost escalation assumptions previously discussed.
- Pink bar: Existing debt service.
  - » Annual payments of approximately $335,000 will continue until 2024. The final payment in 2025 is only $167,000.
- Light green bar: New debt service.
  - » The forecast assumes the City will issue new debt of $2.1 million in 2024, resulting in an annual payment of approximately $160,000.
- Tan bar: Rate revenue that is available for capital projects.
  - » This amount increases gradually after 2021 as revenues increase with rate increases. By 2030, $1.1 million per year would be available for capital projects.

Exhibit 8: Revenue Requirement Forecast

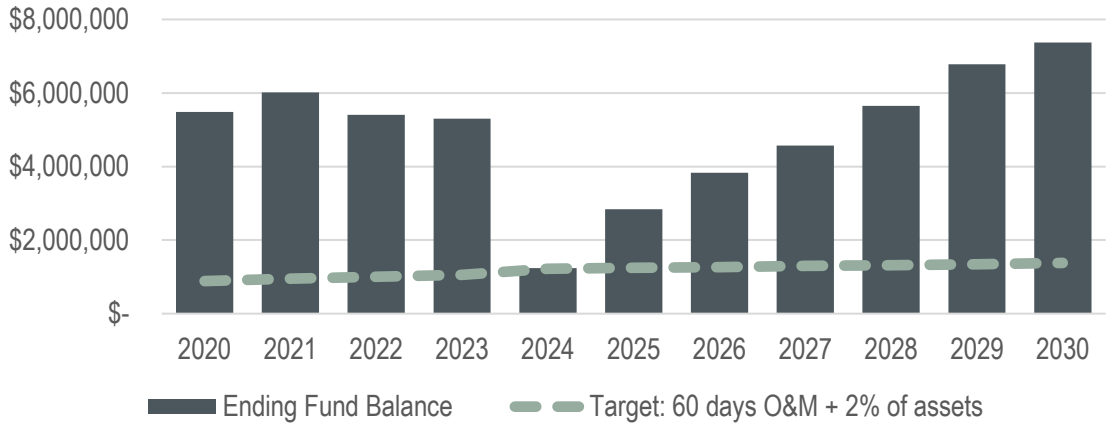


Forecasted Reserve Balances

The recommended operating fund balance is 60 days of total annual operating expenditures, and the recommended capital fund balance is 2% of the original cost of the utility's plant-in-service. These two reserve targets combine to approximately $900,000 – this amount grows as operating

expenditures increase and as the City adds assets to the sewer utility. **Exhibit 9** shows that in each year of the forecast, the utility is expected to meet the combined target. The significant dip in fund balance in 2024 is attributable to the Phase II Wastewater Treatment Plant Capacity Upgrade project. As cash balances begin to build towards the end of the study period, the City should reevaluate its upcoming operating and capital needs to determine if annual adjustments of 2.5% are still prudent.

Exhibit 9: Combined Reserve Forecast



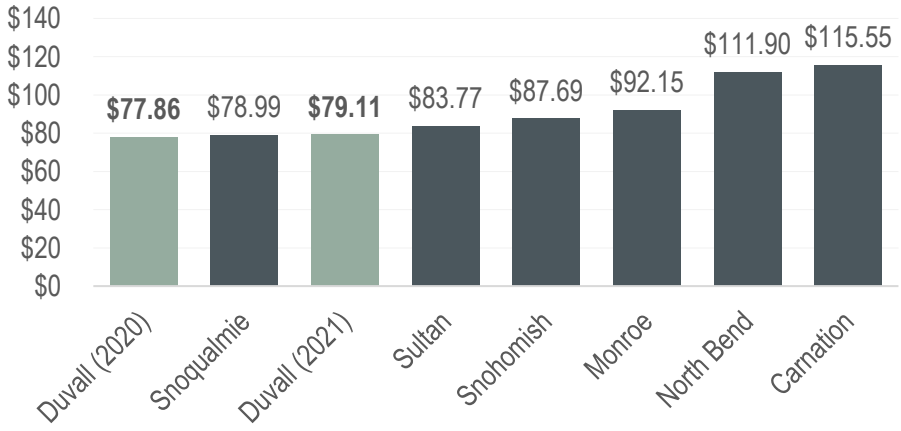
Single-Family Residential Rate Comparison

As a resource to the City and its customers, a rate survey of regional sewer utilities is provided below. **Exhibit 10** shows each jurisdiction's 2020 annual single-family residential (SFR) rate. Note that each jurisdiction has a unique set of geographic traits, customers, and system characteristics that can have a significant impact on rates.

Some cities embed their city utility tax in their rates, while others separately itemize the tax on customer bills above the stated rates. We do not have complete data on the billing practices of other cities, so there may or may not be a tax embedded in the utility rates for other jurisdictions. Lastly, some of these jurisdictions may have adjusted rates effective 2021, so the City's current position may change relative to changes in other jurisdictions.

The City's 2020 sewer fee is at the bottom of the survey group and stays near the bottom even after the 1.6 percent increase in 2021.

Exhibit 10: Monthly 2020 Single-Family Residential Sewer Rates



Affordability

The US Environmental Protection Agency (USEPA), since the inception of the Clean Water Act, has provided some guidance on how to measure financial burdens. Called the residential indicator (RI), the EPA's measure divides the annual residential cost of utility service by the median household income (MHI) of the relevant service area. The resulting value is the RI. A value of 2.0% or higher indicates a "high burden" based on USEPA standards for sewer utilities.

The median household income for Duvall, Washington is estimated to be $166,000 as of 2020. This is based on a survey from the Census Bureau in 2018. The median income is forecasted to include a 2.5% annual escalation; two years of inflation have been added to the Census Bureau survey figure.

Exhibit 11 presents an average single-family bill with the projected annual rate increases for the forecast period, tested against the threshold. Applying the 2.0% test, Duvall's rates are forecasted to remain well within the indicated affordable range through 2039.

Exhibit 11: Affordability Table

Year	Inflation	Median HH Income	Projected Monthly Bill	Projected Annual Bill	% of Median HH Income
2020	2.50%	$165,718	$77.86	$934.32	0.56%
2021	2.50%	$169,861	$79.11	$949.27	0.56%
2022	2.50%	$174,107	$81.08	$973.00	0.56%
2023	2.50%	$178,460	$83.11	$997.33	0.56%
2024	2.50%	$182,922	$85.19	$1,022.26	0.56%
2025	2.50%	$187,495	$87.32	$1,047.82	0.56%
2026	2.50%	$192,182	$89.50	$1,074.01	0.56%
2027	2.50%	$196,986	$91.74	$1,100.86	0.56%
2028	2.50%	$201,911	$94.03	$1,128.38	0.56%
2029	2.50%	$206,959	$96.38	$1,156.59	0.56%
2030	2.50%	$212,133	$98.79	$1,185.51	0.56%
2031	2.50%	$217,436	$101.26	$1,215.14	0.56%
2032	2.50%	$222,872	$103.79	$1,245.52	0.56%
2033	2.50%	$228,444	$106.39	$1,276.66	0.56%
2034	2.50%	$234,155	$109.05	$1,308.58	0.56%
2035	2.50%	$240,009	$111.77	$1,341.29	0.56%
2036	2.50%	$246,009	$114.57	$1,374.82	0.56%
2037	2.50%	$252,159	$117.43	$1,409.20	0.56%
2038	2.50%	$258,463	$120.37	$1,444.43	0.56%
2039	2.50%	$264,925	$123.38	$1,480.54	0.56%

Section V. GFC UPDATE

Introduction

General facilities charges (GFCs) are one-time fees, paid at the time of development, intended to recover a share of the cost of system capacity needed to serve growth.

They serve two primary purposes:

- to provide equity between existing and new customers; and
- to provide a source of funding for system capital costs, as growth occurs.

The charge is an upfront charge imposed on growth and is primarily a charge on new development, although also applicable to expansion or densification of development when such actions increase requirements for utility system capacity.

Legal Basis

There are a variety of approaches that are used in the industry to establish a defensible general facilities charge. The City is authorized to assess such charges under Section 35.92.025 of the Revised Code of Washington (RCW). The City's methodology to determine cost-based general facilities charges must be consistent with RCW 35.92.025 and applicable case law.

> RCW 35.92.025: "Cities and towns are authorized to charge property owners seeking to connect to the water or sewerage system of the city or town as a condition to granting the right to so connect, in addition to the cost of such connection, such reasonable connection charge as the legislative body of the city or town shall determine proper in order that such property owners shall bear their equitable share of the cost of such system."

Since the calculated charges represent the maximum allowable charge, the City may choose to implement a charge at any level up to the calculated charge.

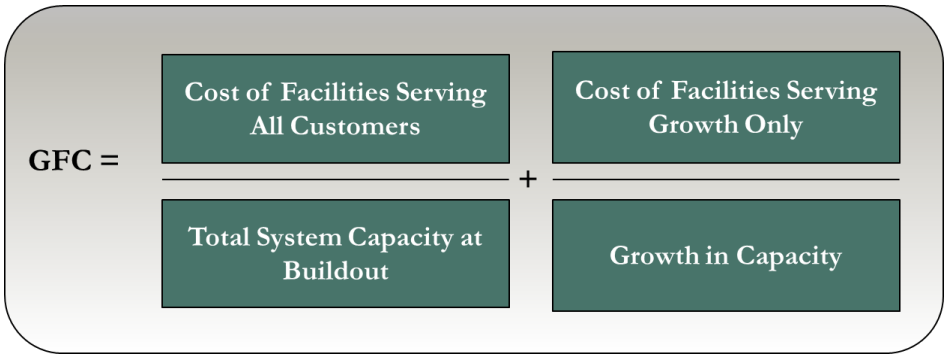
Methodology

Exhibit 12 shows the recommended approach for the City's GFC calculation, consistent with the methodology initially developed for the City in 2003-04. This methodology is comprised of two components:

- Component 1: Cost of (existing and future) Facilities Serving All Customers ÷ Total System Capacity at Buildout
  - » Many of the City's existing sewer facilities were constructed with available capacity to provide sewer service to growth as it occurs. The general facilities charge is designed to recognize this investment, made by the existing ratepayers on behalf of future development, and recover an equitable and proportionate share of this cost.
  - » Additionally, upgrade projects identified within the capital improvement plan are assumed to benefit all customers and are therefore shared proportionately by existing and future customers (total system capacity).

- Component 2: Cost of (future) Facilities Serving Growth Only ÷ Growth in Capacity
  - » To ensure that new development pays its equitable share of planned facilities, City staff identified the capacity-increasing portion of each project on the project list (if applicable). The total of these project costs is recovered only from the number of ERUs to be added by buildout.

Exhibit 12: Recommended Methodology



Component 1 of 2: Cost of Facilities Serving All Customers

The summary cost of facilities serving all customers is shown in **Exhibit 13**, totaling $20.2 million.

Exhibit 13: Cost of Facilities Serving All Customers

Cost Basis	Amount
Utility Plant-in-Service (through 2019)	$28,839,922
Less: Contributed Capital (through 2019)	(18,226,658)
Plus: Interest on Non-Contributed Plant (through 2019)	4,814,521
Plus: Cost of Planned Future Upgrade Facilities (through 2037)	4,077,175
Plus: Construction-Work-in-Progress (end of 2019)	672,000
Total Cost of facilities serving all customers	**$20,176,959**

A summary of each component is provided below:

- Utility Plant-in-Service (through 2019). The existing cost basis is typically comprised of the original cost of plant-in-service, as documented in the fixed asset schedule of the utility.
  - » The City's consulting engineer, Parametrix, Inc., provided an asset inventory including the estimated original cost of the existing plant-in-service, which totals $28.8 million. A couple of adjustments were made to the original inventory based on updated wastewater treatment plant cost information.
- Less: Contributed Capital: Assets funded by developers, grants, or from any agency other than the City of Duvall are excluded from the cost basis on the premise that the GFC should only recover costs actually incurred by City ratepayers. Data for these adjustments were provided by Parametrix, Inc. as well as City staff.
  - » Approximately $12.9 million of sewer mains were donated by developers.
  - » An additional $4.4 million of the wastewater treatment plant is assumed to be grant funded.

  - » Lastly, $0.9 million of land originally purchased to site the wastewater treatment plant was later sold. The amount received for these parcels is not included in the calculation.
  - » These sources total $18.2 million in contributed capital.
- Plus: Interest on Non-Contributed Plant: RCW 35.92.025 and subsequent legal interpretations provide such charges can include interest on an asset at the rate applicable at the time of construction. Interest can accumulate for a maximum of ten years from the date of construction for any particular asset. Conceptually, this interest provision attempts to account for the opportunity costs that the City's customers incurred by supporting investments in infrastructure rather than having it available for other needs.
  - » Accumulated interest adds approximately $4.8 million to the cost basis. Interest on contributed capital was not included.
- Plus: Cost of Planned Future Upgrade Facilities (through 2037). Planned system upgrade facilities are assumed to benefit both existing and future customers and are included in the calculation. No repair and replacement projects have been included in the calculation.
  - » City staff and Parametrix, Inc. identified $4.1 million of upgrade projects or portions thereof.
- Plus: Construction-Work-in-Progress (end of 2019). The cost of construction work in progress is added to the cost basis to recognize investments that the utility has made in capital projects that are currently underway, even though these projects have not yet been placed into service.
  - » Per City staff, there was $672,000 in construction in progress as of the end of 2019.

These components and adjustments total $20.2 million. This cost is allocated to total capacity at buildout, which is assumed to be 3,928 ERUs as is shown in **Exhibit 14**.

Exhibit 14: Total System Capacity at Buildout

Description	Amount
Buildout Capacity Supported by WWTP	11,785 people
People per ERU	3.00
System Capacity (ERUs)	**3,928 ERUs**

Per Parametrix, Inc., once the Phase II Wastewater Treatment Plant Capacity Upgrade project is complete, the City's treatment plant will be able to meet the needs of the City's projected buildout population of 11,785 people. Assuming one ERU is equal to three people, the treatment plant will have the capacity to serve a total of 3,928 equivalent residential units (ERUs). As shown in **Exhibit 15**, a numerator of $20.2 million and a denominator of 3,928 ERUs results in a charge of $5,136. This will be combined with component two for a total GFC for the City's sewer utility.

Exhibit 15: GFC Component 1 of 2

Description	Amount
Total Cost of Facilities Serving All Customers	$20,176,959
System Capacity (ERUs)	3,928 ERUs
GFC Component 1 of 2	**$5,136.26 / ERU**

Component 2 of 2: Cost of Facilities Serving Growth Only

The cost of facilities serving future customers is shown in **Exhibit 16**, totaling $10.6 million.

Exhibit 16: Cost of Facilities Serving Growth Only (2020-2037)

Cost Basis	Amount
Total Projects in Capital Plan (not inflated)	$18,526,292
Less: Non-Capacity Upgrade CIP from Component 1	(4,077,175)
Less: Repair & Replacement Projects (mostly mains)	(3,884,592)
Less: Developer Contribution & Grants	0
Total Cost of Facilities Serving Growth Only	**$10,564,525**

A summary of each component is provided below:

- Total Projects in Capital Plan (not inflated). The calculation starts with the total capital cost included in the capital plan (2020-2037). This figure assumes that annual projects including CP-1 Infiltration & Inflow Program, CP-2 Collection System Repair and Replacement, and CP-4 Sewer Facility Building Maintenance continue through 2037, which is the last year in the provided CIP.
  - The sewer utility's CIP totals $18.5 million.
- Less: Non-Capacity Upgrade CIP from Component 1. Capital projects or portions thereof that were included in the first component are not included in the second component.
  - Component 1 included $4.1 million of upgrade projects, which are therefore excluded.
- Less: Repair & Replacement Projects (mostly mains). Repair and replacement projects are not included in the GFC cost basis, and therefore, must be funded by existing ratepayers as those assets are replaced and retired.
  - The CIP contained $3.9 million of repair and replacement projects, which were mostly main replacement projects.

These components and adjustments total $10.6 million. This cost is allocated to the number of ERUs to be added by buildout, which is estimated to be 1,180 ERUs, as shown in **Exhibit 17**.

Exhibit 17: ERUs added by Buildout

Cost Basis	Amount
Buildout Capacity (11,785 people ÷ 3 / ERU)	3,928
Existing ERUs in 2019 (8,244 people ÷ 3 / ERU)	2,748
ERUs added by Buildout (3,928 - 2,748)	**1,180**

The City's sewer system served an estimated 2,748 ERUs in 2019. While 2020 population data was available, Parametrix provided a 2019 population estimate for this analysis so that the population data could be aligned with the fixed asset data which reflects assets through the end of 2019.

As previously discussed, the treatment plant will have the capacity to serve 3,928 ERUs in total. Therefore, there are 1,180 ERUs of capacity available to serve future development which will be supported by the 2020-2037 CIP.

As shown in **Exhibit 18**, a numerator of $10.6 million and a denominator of 1,180 ERUs results in a partial GFC of $8,950. This will be combined with component one to form a total GFC for the City's sewer utility.

Exhibit 18: GFC Component 2 of 2

Description	Amount
Total Cost of Facilities Serving Growth	$10,564,525
ERUs Added by Buildout	1,180 ERUs
GFC Component 2 of 2	**$8,950.46 / ERU**

Combined General Facilities Charge Calculation

Exhibit 19 below shows the combined GFC calculation, which includes a component one charge of $5,136 per ERU and component two charge of $8,950 per ERU for a total charge of $14,087 per ERU (with rounding). This is a $2,134 increase above the existing GFC of $11,953.

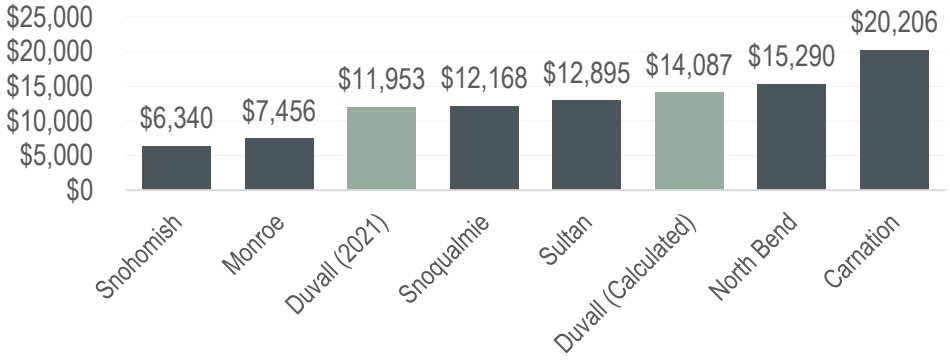
Exhibit 19: General Facilities Charge Calculation

Cost Basis	Amount
Component 1 general facilities charge	$5,136 / ERU
Component 2 general facilities charge	$8,950 / ERU
Total Calculated GFC (rounded)	**$14,087 / ERU**
Existing GFC (as of 2021)	$11,953 / ERU
Increase	$2,134 / ERU

Single-Family GFC Comparison

A survey of GFCs from regional sewer utilities is provided in **Exhibit 20**. Other jurisdictions' GFCs in the survey are as adopted in 2020; while the Duvall GFC is as adopted in 2021 by Resolution 15-03, meaning other jurisdictions may have increased their GFCs since the survey was conducted. If the City increases the GFC to the calculated maximum, it will exceed Snoqualmie and Sultan, while remaining less expensive than North Bend and Carnation. It also should be noted that Carnation's GFC includes an amortized $66 per month charge for use of the King County treatment facility.

Exhibit 20: 2020 Single-Family GFC Comparison



Section VI. Conclusion

Revenue Requirement & Rate Schedule

The recommended rate increases in **Exhibit 21** allow the sewer utility to accomplish the following during the 2020-30 rate setting period:

- Continue to fund existing operations, plus inflation;
- Allow the utility to complete its $17.1 million CIP while borrowing $2.1 million;
- Generate approximately $1.1 million per year for capital projects by 2030, and;
- Maintain utility reserves at a healthy level throughout the forecast.

Exhibit 21: Recommended Rate Schedule

Recommended Rate Schedule	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual Rate Adjustments		**1.60%**	**2.50%**	**2.50%**	**2.50%**	**2.50%**	**2.50%**	**2.50%**	**2.50%**	**2.50%**	**2.50%**
Single Family Fixed Charge	$77.86	$79.11	$81.08	$83.11	$85.19	$87.32	$89.50	$91.74	$94.03	$96.38	$98.79
Commercial / Other Fixed Charge	$77.86	$79.11	$81.08	$83.11	$85.19	$87.32	$89.50	$91.74	$94.03	$96.38	$98.79
Commercial Volume Rate (per ccf over 9)	$2.83	$2.88	$2.95	$3.02	$3.10	$3.17	$3.25	$3.33	$3.42	$3.50	$3.59

GFC Calculation and Schedule

The updated GFC is shown in **Exhibit 22**. Note that the increased GFC represents the calculated maximum allowable GFC; the City is not obligated to increase the GFC or may choose to phase-in increases over time to mitigate immediate impacts to development.

Exhibit 22: Calculated Maximum GFC

Description	Results
Existing GFC per ERU	$11,953
Calculated Maximum GFC per ERU	$14,087
Increase	**$2,134**

Updating This Study's Findings

It is recommended that the City revisit the study findings during the forecast period to check that the assumptions used (such as customer growth) are still appropriate and that no significant changes have occurred that would alter the results of the study. The City should use the study findings as a living document, routinely comparing the study outcomes to actual revenues and expenses. Any significant or unexpected changes may require adjustments to the rate strategy recommended in this report.

Section VII. Appendix: Model Summary

Operating Revenues & Expenditures		2020 Actual	2021 Forecast	2022 Forecast	2023 Forecast	2024 Forecast	2025 Forecast	2026 Forecast	2027 Forecast	2028 Forecast	2029 Forecast	2030 Forecast
Annual Rate Increases			1.60%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Single-Family Annual Rate		$77.86	$79.11	$81.08	$83.11	$85.19	$87.32	$89.50	$91.74	$94.03	$96.38	$98.79
Beginning Operating Balance		$ 2,519,702	$ 3,502,627	$ 338,546	$ 348,506	$ 361,182	$ 374,277	$ 387,922	$ 401,909	$ 415,461	$ 429,352	$ 443,728
Operating Revenues												
Sewer Charges (including rate adjustments)	402-00-343-50-00-00	$ 2,586,543	$ 2,788,447	$ 2,939,484	$ 3,096,330	$ 3,258,688	$ 3,431,278	$ 3,601,120	$ 3,723,060	$ 3,848,846	$ 3,978,595	$ 4,112,426
Side Sewer Connection Fees	402-00-343-59-00-00	9,350	9,350	9,350	9,350	9,350	9,350	9,350	9,350	9,350	9,350	9,350
Miscellaneous	402-00-369-91-00-00	22	22	22	22	22	22	22	22	22	22	22
Sales of Scrap & Junk	402-00-369-10-00-00	-	-	-	-	-	-	-	-	-	-	-
Interest Earnings		7,033	18,981	3,160	3,210	3,274	4,142	3,374	3,444	3,512	3,581	3,653
Total Operating Revenues		$ 2,602,948	$ 2,816,800	$ 2,952,016	$ 3,108,912	$ 3,271,333	$ 3,444,792	$ 3,613,866	$ 3,735,876	$ 3,861,730	$ 3,991,548	$ 4,125,451
	Percent change	2.5%	8.2%	4.8%	5.3%	5.2%	5.3%	4.9%	3.4%	3.4%	3.4%	3.4%
Budgeted Operating Expenses												
Salaries & Wages	402-27-535-80-11-00	$ 548,640	$ 624,000	$ 667,000	$ 687,010	$ 707,620	$ 728,849	$ 750,714	$ 773,236	$ 796,433	$ 820,326	$ 844,936
Overtime and Buyouts	402-27-535-80-11-01	36,592	37,000	38,000	39,140	40,314	41,524	42,769	44,052	45,374	46,735	48,137
Personnel Benefits	402-27-535-80-21-00	224,558	284,000	314,000	329,700	346,185	363,494	381,669	400,752	420,790	441,830	468,339
Overtime and Buyout Benefits	402-27-535-80-21-01	12,467	8,000	8,000	8,400	8,820	9,261	9,724	10,210	10,721	11,257	11,932
Office & Operating Supplies	402-27-535-80-31-00	55,151	60,263	60,340	61,848	63,395	64,980	66,604	68,269	69,976	71,725	73,518
Fuel	402-27-535-80-32-00	5,633	-	-	-	-	-	-	-	-	-	-
Small Tools & Minor Equipment	402-27-535-80-35-00	3,994	11,250	12,050	12,351	12,660	12,977	13,301	13,633	13,974	14,324	14,682
Computer Hardware & Software	402-27-535-80-35-01	-	500	500	513	525	538	552	566	580	594	609
Travel & Meals	402-27-535-40-43-00	17	2,500	2,500	2,563	2,627	2,692	2,760	2,829	2,899	2,972	3,046
Training	402-27-535-40-49-00	-	3,500	3,500	3,588	3,677	3,769	3,863	3,960	4,059	4,160	4,264
Janitorial/HVAC/Fac Maint	402-27-535-50-48-00	3,023	1,305	1,305	1,338	1,371	1,405	1,440	1,476	1,513	1,551	1,590
Repair Distribution System	402-27-535-50-48-01	23,586	35,000	35,000	35,875	36,772	37,691	38,633	39,599	40,589	41,604	42,644
Bio Solids Handling	402-27-535-60-41-00	48,976	65,000	65,000	66,625	68,291	69,998	71,748	73,542	75,380	77,265	79,196
Professional Services	402-27-535-80-41-00	95,518	82,500	82,500	84,563	86,677	88,843	91,065	93,341	95,675	98,067	100,518
Advertising	402-27-535-80-41-01	14	200	200	205	210	215	221	226	232	238	244
City Attorney Services	402-25-515-30-41-00	-	1,500	1,500	1,538	1,576	1,615	1,656	1,697	1,740	1,783	1,828
Communication & Postage	402-27-535-80-42-00	10,942	11,862	12,249	12,556	12,870	13,191	13,521	13,859	14,206	14,561	14,925
Insurance	402-27-535-80-46-00	80,045	49,336	53,224	54,554	55,918	57,316	58,749	60,218	61,723	63,266	64,848
Public Utilities	402-27-535-80-47-00	173,362	185,400	190,962	196,691	202,592	208,669	214,929	221,377	228,019	234,859	241,905
Repairs & Maintenance	402-27-535-80-48-01	34,678	43,250	43,250	44,331	45,440	46,576	47,740	48,933	50,157	51,411	52,696
Misc Professional Svcs	402-27-535-80-49-00	373	-	-	-	-	-	-	-	-	-	-
Bank Fees/Charges	402-27-535-80-49-12	9,591	11,791	12,558	13,374	14,243	15,169	16,155	17,205	18,324	19,515	20,783
Memberships & Subscriptions	402-27-535-80-49-00	-	4,376	4,494	4,607	4,722	4,840	4,961	5,085	5,212	5,342	5,476
Membership Fees & Permits-Govt	402-27-535-80-51-00	5,777	27,000	27,000	27,675	28,367	29,076	29,803	30,548	31,312	32,095	32,897
Permits - Governmental	402-27-535-80-45-00	10,217	30,300	30,300	31,058	31,834	32,630	33,446	34,282	35,139	36,017	36,918
I/F to 501	402-99-535-80-41-01	39,284	31,601	31,729	32,522	33,336	34,169	35,023	35,899	36,796	37,716	38,659
I/F to IT 502	402-99-535-80-41-02	49,041	52,503	49,231	50,461	51,723	53,016	54,341	55,700	57,092	58,520	59,983
I/F to 503 Building	402-99-535-80-41-03	7,939	10,546	6,044	6,195	6,349	6,508	6,671	6,838	7,009	7,184	7,363
Transfer Out-001 Gen Admin	402-99-597-00-01-00	69,507	80,169	43,454	44,540	45,654	46,795	47,965	49,164	50,393	51,653	52,944
Net State Excise & B&O Tax	402-99-535-10-44-00	56,036	62,301	67,533	72,321	77,319	82,652	88,010	92,269	96,676	101,236	105,952
City Utility	402-99-535-10-44-06	240,356	275,616	293,759	309,633	325,869	343,128	360,112	372,306	384,885	397,860	411,243
Total Budgeted Operating Expenses		$ 1,845,315	$ 2,065,568	$ 2,130,181	$ 2,208,098	$ 2,288,586	$ 2,372,511	$ 2,458,343	$ 2,540,524	$ 2,625,564	$ 2,713,568	$ 2,809,178
	Percent change	-6.3%	11.9%	3.1%	3.7%	3.6%	3.7%	3.6%	3.3%	3.3%	3.4%	3.5%
Other Activity												
Existing Debt Service		$ 334,555	$ 334,555	$ 334,555	$ 334,555	$ 334,555	$ 167,278	$ -	$ -	$ -	$ -	$ -
Use of Restricted Reserve for Debt Service		-	-	-	-	-	(167,278)	-	-	-	-	-
New Debt Service		-	-	-	-	160,670	160,670	160,670	160,670	160,670	160,670	160,670
Transfer to Capital		2,639,441	3,580,758	477,320	553,583	474,427	897,966	980,867	1,021,131	1,061,605	1,102,934	1,139,979
Total Other Activity		$ 2,973,996	$ 3,915,313	$ 811,875	$ 888,139	$ 969,652	$ 1,058,636	$ 1,141,537	$ 1,181,801	$ 1,222,275	$ 1,263,604	$ 1,300,649
Revenues Less Obligations		$ (2,216,363)	$ (3,164,081)	$ 9,960	$ 12,676	$ 13,095	$ 13,645	$ 13,987	$ 13,552	$ 13,892	$ 14,376	$ 15,624
Ending Operating Balance		$ 303,339	$ 338,546	$ 348,506	$ 361,182	$ 374,277	$ 387,922	$ 401,909	$ 415,460	$ 429,352	$ 443,728	$ 459,352
Target Minimum (60 Days of O&M)		*$ 303,339*	*$ 338,546*	*$ 348,506*	*$ 361,182*	*$ 374,277*	*$ 387,922*	*$ 401,909*	*$ 415,461*	*$ 429,352*	*$ 443,728*	*$ 459,352*

Capital Revenues & Expenditures		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Beginning Capital Balance		$ 747,966	$ 2,452,050	$ 5,679,191	$ 5,059,243	$ 4,939,806	$ 867,173	$ 2,451,124	$ 3,430,565	$ 4,156,244	$ 5,224,116	$ 6,338,221
Capital Revenues												
Rate Revenue for Capital Projects (Transfer from Operating)		$ 2,639,441	$ 3,580,758	$ 477,320	$ 553,583	$ 474,427	$ 897,966	$ 980,867	$ 1,021,131	$ 1,061,605	$ 1,102,934	$ 1,139,979
GFC Revenue		2,048,500	1,047,223	1,078,639	1,104,577	1,190,631	1,103,715	421,047	433,678	446,688	460,089	473,892
Loan Proceeds		-	-	-	-	2,100,000	-	-	-	-	-	-
Investment Interest		1,870	12,260	28,396	25,296	24,699	4,336	12,256	17,153	20,781	26,121	31,691
Total Revenues with Rate Increases		$ 4,689,811	$ 4,640,241	$ 1,584,355	$ 1,683,456	$ 3,789,757	$ 2,006,017	$ 1,414,169	$ 1,471,962	$ 1,529,075	$ 1,589,144	$ 1,645,562
Capital Expenditures												
Utility billing software - implementation costs	401-25-534-80-35-01	$ 10,792	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Projects - Blower Repair/Replace	402-27-594-35-XX-XX	15,000	15,000	-	-	-	-	-	-	-	-	-
Emergency Operations Equipment - Roll	402-27-594-35-64-00	135,000	-	-	-	-	-	-	-	-	-	-
Emergency Operations Equipment - Mobile Pump Unit	402-27-594-35-64-00	100,000	-	-	-	-	-	-	-	-	-	-
UV System Upgrades	WWTP-1	-	393,000	404,790	-	-	-	-	-	-	-	-
Generator Inspection & Testing	WWTP-2	-	-	-	19,945	-	-	-	-	-	-	-
Headworks Improvements & Capacity Upgrades	WWTP-3	-	-	-	1,060,476	-	-	-	-	-	-	-
Electrical Upgrades	WWTP-4	-	-	-	324,635	-	-	-	-	-	-	-
Capacity Upgrades - Phase 1	WWTP-5	-	360,100	370,903	-	-	-	-	-	-	-	-
Capacity Upgrades - Phase 2	WWTP-6	-	-	-	-	7,452,617	-	-	-	-	-	-
Anoxic Tank Foam	WWTP-7	-	-	-	-	-	-	-	-	-	-	70,197
Combined Pump Station Improvements	PS-1	-	-	764,260	-	-	-	-	-	-	-	-
Infiltration & Inflow Repair	CS-1	-	200,000	206,000	-	-	-	-	-	-	-	-
Old Town Alleys	CS-2	-	70,000	72,100	-	-	-	-	-	-	-	-
NE 145th Street	CS-3	-	-	-	-	-	-	-	-	-	-	507,426
Infiltration & Inflow Program	CP-1	-	150,000	154,500	159,135	163,909	168,826	173,891	179,108	184,481	190,016	195,716
Collection System Repair and Replacement	CP-2	-	200,000	206,000	212,180	218,545	225,102	231,855	238,810	245,975	253,354	260,955
Sewer Plan Update	CP-3	-	-	-	-	-	-	-	298,513	-	-	-
Sewer Facility Building Maintenance	CP-4	-	25,000	25,750	26,523	27,318	28,138	28,982	29,851	30,747	31,669	32,619
Sewer Plan Update	CP-5	-	-	-	-	-	-	-	-	-	-	-
Total Capital Expenditures		$ 260,792	$ 1,413,100	$ 2,204,303	$ 1,802,893	$ 7,862,389	$ 422,066	$ 434,728	$ 746,283	$ 461,203	$ 475,039	$ 1,066,913
Revenues less Expenditures		$ 4,429,019	$ 3,227,141	$ (619,948)	$ (119,437)	$ (4,072,633)	$ 1,583,951	$ 979,441	$ 725,679	$ 1,067,872	$ 1,114,105	$ 578,649
Ending Capital Balance		$ 5,176,985	$ 5,679,191	$ 5,059,243	$ 4,939,806	$ 867,173	$ 2,451,124	$ 3,430,565	$ 4,156,244	$ 5,224,116	$ 6,338,221	$ 6,916,870
Target Minimum (2% of fixed assets)		*$ 582,014*	*$ 610,276*	*$ 654,362*	*$ 690,420*	*$ 847,668*	*$ 856,109*	*$ 864,804*	*$ 879,730*	*$ 888,954*	*$ 898,454*	*$ 919,793*