OAK LODGE WATER SERVICES

Wastewater Master Plan

MARCH 2023

OAK LODGE WATER SERVICES

WSC

Brown AND Caldwell

OAK LODGE
WATER SERVICES

OAK LODGE WATER SERVICES

Wastewater Master Plan

MARCH 2023

SCOTT DUREN, PE

EXECUTIVE SUMMARY, CHAPTERS 1, 2, 3, 4, 5, 7

EXPIRES: DECEMBER 31, 2024

ARTHUR MOLSEED, PE

CHAPTER 6

Prepared by Water Systems Consulting, Inc and Brown and Caldwell

WSC

Brown AND Caldwell

ACKNOWLEDGEMENTS

The Wastewater Master Plan Consultant Team. would like to acknowledge the significant contributions of Oak Lodge Water Services, including the following staff.

OAK LODGE
WATER SERVICES

Sarah Jo Chaplen, General Manager

Brad Albert, PE, District Engineer

David Hawkins, Plant Superintendent

Jeff Page, Utility Operations Director

Chad Martinez, Collections Field Supervisor

Haakan Ogbeide, PE, Civil Engineer

Gail Stevens, Finance Director

The Wastewater Master Plan was prepared by Water Systems Consulting, Inc. and Brown and Caldwell. The primary authors are listed below.

WSC

Scott Duren, PE

Adam Donald, PE

Jeff Lawrence

Jason Rice, PE

Brown AND Caldwell

Art Molseed, PE

Mark Strahota, PE

Patricia Tam

Heather Lough, PE

Rick Kelly, PE

Water Systems Consulting, Inc. and Brown and Caldwell would like to acknowledge the contributions of Angelo Planning Group, Leeway Engineering, SFE Global, and West Yost. The primary contributors by firm are listed below.

Andrew Parish, AICP

Matt Hastie, AICP

Rob Lee, PE

Yarrow Murphy, PE

Mike Lemmen

Glenn Cumyn

Dylan Carver

Raj Kapur

Walt Meyer, PE

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACROYNMS & ABBREVIATIONS

A2O	Anaerobic-Anoxic-Oxic
AACE	Advancement of Cost Engineering International
ABAC	Ammonia-Based Aeration Control
ALUM	Aluminum Sulfate
BC	Brown and Caldwell
BFT	Belt Filter Press
BLI	Buildable Lands Inventory
BOD	Biochemical Oxygen Demand
BWF	Base Wastewater Flow
CCI	Construction Cost Index
CCTV	Closed Circuit Television
CFR	Code of Federal Regulations
CIP	Capital Improvement Plan
COF	Consequence of Failure
CWSRF	Clean Water State Revolving Fund
DEQ	Department of Environmental Quality
DO	Dissolved Oxygen
DS	Digested Sludge
EAM	Enterprise Asset Management
EDU	Equivalent Dwelling Unit
ENR	Engineering News-Record
EPA	Environmental Protection Agency
FTE	Full-Time Equivalent
GBT	Gravity Belt Thickener
GIS	Geographic Information System
GWI	Groundwater Infiltration
HP	Horsepower

HRT	Hydraulic Retention Time
IFAS	Integrated Fixed Film Activated Sludge
IGA	Intergovernmental Agreement
ILS	Influent Lift Station
IMLR	Internal Mixed Liquor Recycle
INF	Influent
KWH/D	Kilowatt-Hour per Day
LB	Pound
LOF	Likelihood of Failure
LS	Lift Station
MBR	Membrane Bioreactor
MGD	Million Gallons Per Day
MG/L	Milligrams per Liter
MH	Manhole
MLE	Modified Ludzack-Ettinger
NASSCO	National Association of Sewer Service Companies
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NRCS	Natural Resources Conservation Science
OAR	Oregon Administrative Rule
OLWS	Oak Lodge Water Services
O&M	Operations & Maintenance
OPCC	Opinion of Probable Construction Cost
ORS	Oregon Revised Statute
PACP	Pipeline Assessment Certification Program
POS	Parks and Open Space
POTW	Publicly Owned Treatment Works
PSU	Portland State University
PWWF	Peak Wet Weather Flow

RAS	Return Activated Sludge
RDII	Rainfall Derived Infiltration and Inflow
RDT	Rotary Drum Thickener
RLIS	Regional Land Information System
SCADA	Supervisory Control and Data Acquisition
SCS	Soil and Conservation Service
SDC	System Development Charge
SF	Square Feet
SHB	Solids Handling Building
SND	Simultaneous Nitrification and Denitrification
SOR	Surface Overflow Rate
SSMP	Sanitary Sewer Master Plan
SSO	Sanitary Sewer Overflow
SVI	Sludge Volume Index
TP	Total Phosphorus
TSS	Total Suspended Solids
TWAS	Thickened Waste Activated Sludge
USDA	United States Department of Agriculture
UV	Ultraviolet
VSR	Volatile Solids Reduction
WAS	Waste Activated Sludge
WES	Water Environment Services
WRF	Water Reclamation Facility
WSC	Water Systems Consulting
WWF	Wet Weather Flow
WWMP	Wastewater Master Plan
WWTP	Wastewater Treatment Plant

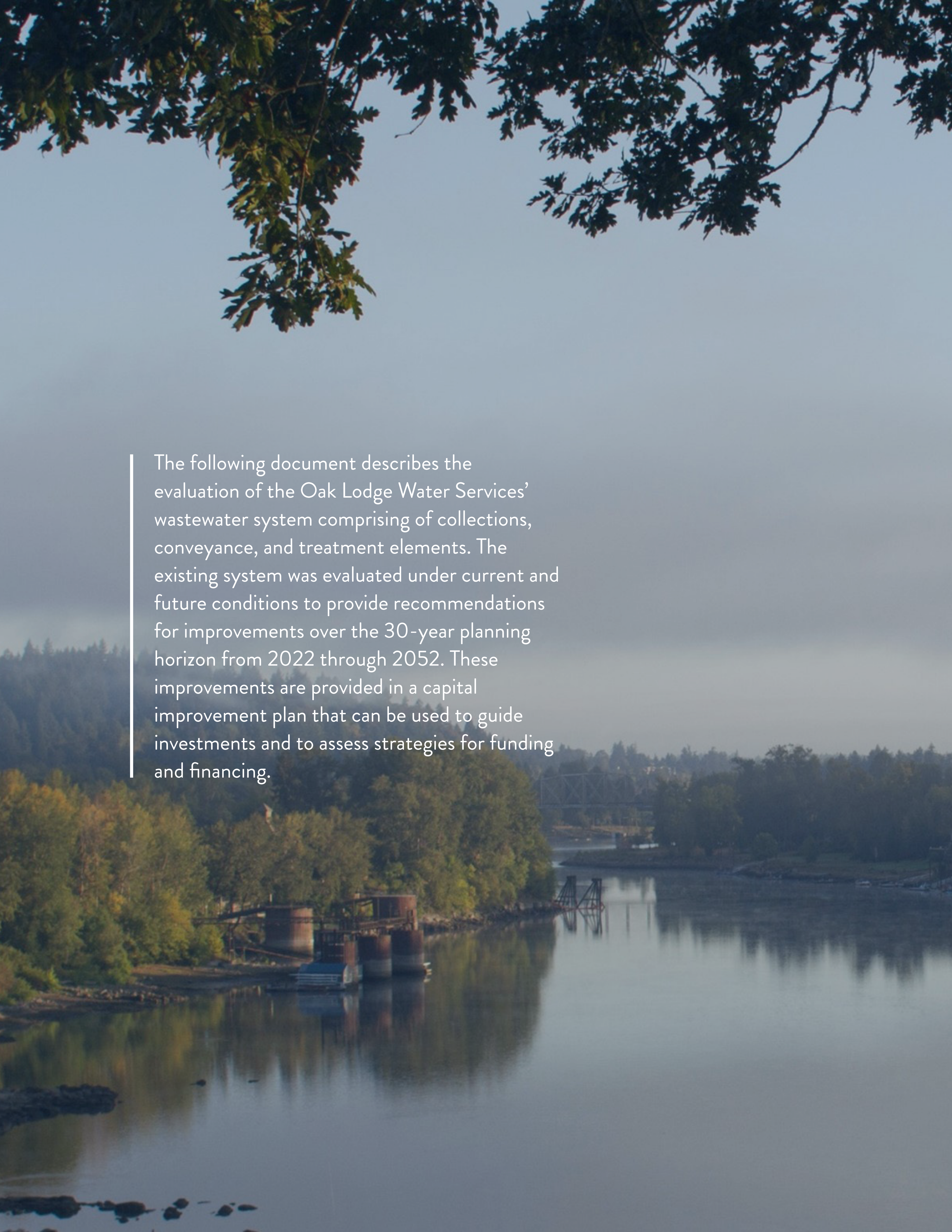
OAK LODGE
WATER SERVICES

Wastewater Master Plan

EXECUTIVE SUMMARY

2023

PREPARED BY: WSC



The following document describes the evaluation of the Oak Lodge Water Services' wastewater system comprising of collections, conveyance, and treatment elements. The existing system was evaluated under current and future conditions to provide recommendations for improvements over the 30-year planning horizon from 2022 through 2052. These improvements are provided in a capital improvement plan that can be used to guide investments and to assess strategies for funding and financing.

CONTENTS

Oak Lodge Water Services (OLWS) contracted with Water Systems Consulting, Inc. (WSC) to develop a Wastewater Master Plan (WWMP) to guide the planning of capital project expenditures through a 30-year planning horizon. OLWS has established four core commitments to customers and the WWMP takes these into account in the evaluation of the wastewater system and the recommendations provided. The 2022 WWMP updates two previous planning documents: a 2007 Sanitary Sewer Master Plan that focused on the treatment system and a 1992 WWMP. The WSC team includes multiple subconsultant specialists that have contributed to the document's preparation and are referenced where appropriate.

OLWS CORE COMMITMENTS

OLWS and WSC have evaluated the Wastewater System with the goal of meeting the core commitments.

- Protect Public Health
- Provide Excellent Customer Service
- Make Smart Investments and Work to Keep Rates Affordable
- Keep Local Streams and Rivers Clean

SECTION 02

Existing System

The OLWS wastewater service area is located in northwestern Clackamas County and serves the communities of Oak Grove, Jennings Lodge, and portions of the adjacent municipalities of Milwaukie and Gladstone. OLWS owns the portion of the lateral service pipes that collect raw wastewater from individual customers between the private property line and the wastewater collection main. Wastewater collection mains range in size from 4- to 30-inch diameter pipes, with several of the larger diameter pipes designated as trunks that convey the wastewater towards the wastewater treatment plant (WWTP) located on SE Renton Avenue. Due to the topography of the service area, several lift stations with pressurized force mains are required to convey the collected wastewater to the WWTP. Raw wastewater passes through screens, aeration basins, clarifiers, and ultraviolet disinfection prior to discharge to the Willamette River. Waste sludge from the treatment process is digested, dewatered, and hauled offsite for land application.

The collections system is divided into six basins, with the flow collected within each basin culminating at a lift station. A map of each of the basins, the major trunk mains, and the associated lift stations is provided in Figure ES-1.

Operations and maintenance responsibilities for the wastewater system are divided between treatment and collections, with shared support between the teams provided when necessary. Data on the condition of existing assets are collected and stored within several software programs that aid the operations teams with planning and prioritizing work orders and preventative maintenance tasks across the system. The evaluations and recommendations within this WWMP are partially based upon data provided by OLWS from these software systems, as well as additional data that was collected by the WSC-led consultant team. Additional details on the existing wastewater system can be found in Chapter 2.0 of this WWMP.

100
MILES OF WASTEWATER PIPE

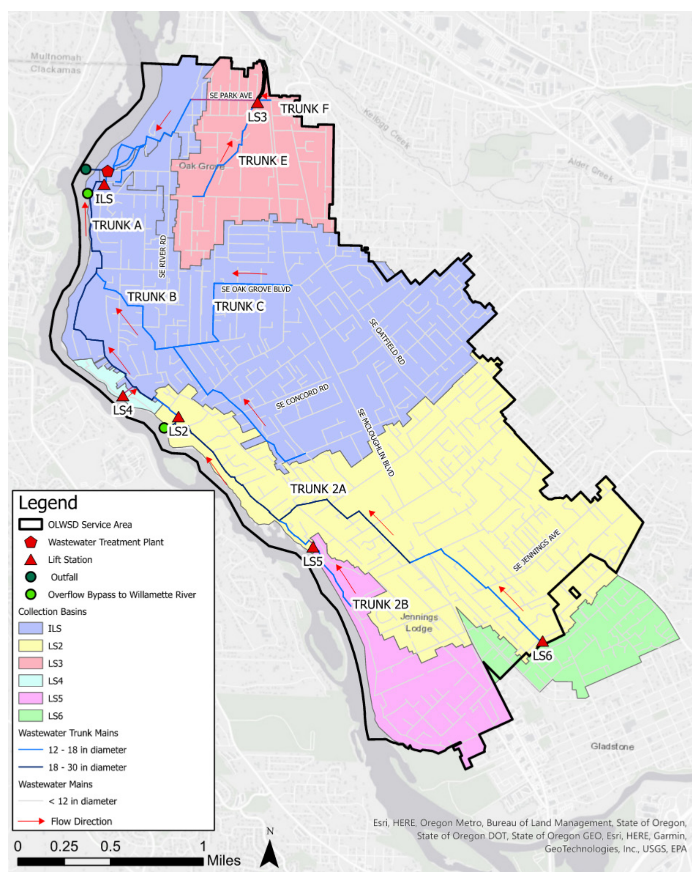
9,100
CUSTOMER CONNECTIONS

6
LIFT STATIONS

846
MANHOLES

1.5 billion
GALLONS OF WASTEWATER TREATED ANNUALY

Figure ES-1. OLWS Wastewater Service Area



Regulations and Policies

OLWS maintains interagency agreements (IGAs) with several adjacent wastewater providers. A summary of each IGA is provided below:

CLACKAMAS COUNTY

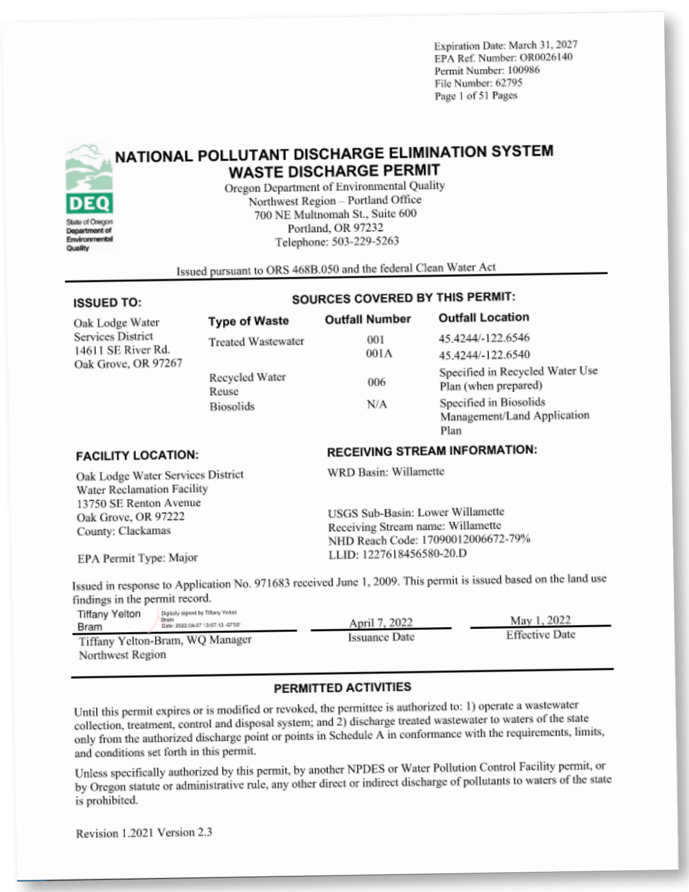
The majority of the OLWS collections system is located within Clackamas County roadways. An IGA streamlines the ability for OLWS to excavate and repair buried pipelines within County roadways. Additional IGAs with Clackamas Water Environment Services (WES) delineates service area boundaries and enables resource sharing during emergencies.

CITY OF GLADSTONE

Since 1971, a series of IGAs have covered the agreement for OLWS to receive, convey, and treat wastewater flows from the northern portion of Gladstone in an area that was formerly part of the Oak Lodge Sanitary District No. 2. At the time of writing, OLWS and Gladstone are working to finalize an updated IGA.

CITY OF MILWAUKIE

An IGA establishes rates and requirements for a limited number of properties within each agency's service boundary that are more efficiently provided by the other party's collection system.



Expiration Date: March 31, 2027
EPA Ref. Number: OR0026140
Permit Number: 100986
File Number: 62795
Page 1 of 51 Pages

DEQ State of Oregon Department of Environmental Quality

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
WASTE DISCHARGE PERMIT
Oregon Department of Environmental Quality
Northwest Region – Portland Office
700 NE Multnomah St., Suite 600
Portland, OR 97232
Telephone: 503-229-5263

Issued pursuant to ORS 468B.050 and the federal Clean Water Act

ISSUED TO:
Oak Lodge Water Services District
14611 SE River Rd.
Oak Grove, OR 97267

SOURCES COVERED BY THIS PERMIT:

Type of Waste	Outfall Number	Outfall Location
Treated Wastewater	001 001A	45.4244/-122.6546 45.4244/-122.6540
Recycled Water Reuse	006	Specified in Recycled Water Use Plan (when prepared)
Biosolids	N/A	Specified in Biosolids Management/Land Application Plan

FACILITY LOCATION:
Oak Lodge Water Services District
Water Reclamation Facility
13750 SE Renton Avenue
Oak Grove, OR 97222
County: Clackamas

EPA Permit Type: Major

RECEIVING STREAM INFORMATION:
WRD Basin: Willamette

USGS Sub-Basin: Lower Willamette
Receiving Stream name: Willamette
NHD Reach Code: 17090012006672-79%
LLID: 1227618456580-20.D

Issued in response to Application No. 971683 received June 1, 2009. This permit is issued based on the land use findings in the permit record.

Tiffany Yelton Bram (Digitally signed by Tiffany Yelton Bram Date: 2022.04.07 13:57:13 -07'00')
Tiffany Yelton-Bram, WQ Manager
Northwest Region

April 7, 2022
Issuance Date

May 1, 2022
Effective Date

PERMITTED ACTIVITIES

Until this permit expires or is modified or revoked, the permittee is authorized to: 1) operate a wastewater collection, treatment, control and disposal system; and 2) discharge treated wastewater to waters of the state only from the authorized discharge point or points in Schedule A in conformance with the requirements, limits, and conditions set forth in this permit.

Unless specifically authorized by this permit, by another NPDES or Water Pollution Control Facility permit, or by Oregon statute or administrative rule, any other direct or indirect discharge of pollutants to waters of the state is prohibited.

Revision 1.2021 Version 2.3

AT A GLANCE

In 2022, OLWS received a new NPDES permit that imposed stricter discharge limits into the Willamette River. The WWMP includes a forecast of potential future regulations that were evaluated as part of the WWTP planning process. Future permit updates may include additional pollutants.

The OLWS wastewater and treatment system must comply with federal, state, and local regulations associated with publicly owned wastewater systems. During the preparation of this WWMP, the Oregon Department of Environmental Protection issued a new Waste Discharge Permit (#100986) for OLWS that lowered some of the waste discharge parameters for the disposal of treated wastewater into the Willamette River. In particular, lower limits for both carbonaceous BOD_5 and total suspended solids present compliance challenges for the existing facilities during the shoulder seasons. The new waste discharge limits are provided in Table ES-1. Additional details on the regulations and policies can be found in Chapter 3.0 of this WWMP.

Table ES-1. NPDES Permit Waste Discharge Limits

Parameter	Average Effluent Concentrations		Monthly Average (lb/d)	Weekly Average (lb/d)	Daily Maximum (lb/d)
	Monthly (mg/L)	Weekly (mg/L)			
MAY 1 – OCTOBER 31					
Carbonaceous BOD_5 ($CBOD_5$)	10	15	490	740	980
Total Suspended Solids (TSS)	10	15	490	740	980
NOVEMBER 1 – APRIL 30					
CBOD5	30	45	2,600	3,900	5,200
TSS	30	45	2,600	3,900	5,200

SECTION 04

Wastewater Flows

To evaluate the hydraulic performance of the wastewater system, the volume of wastewater flow must be estimated. Wastewater flow consists of the following elements:

- **Base Wastewater Flow (BWF)** is the flow that enters the system under normal average conditions, regardless of weather.
- **Groundwater Infiltration (GWI)** occurs in wet weather months when groundwater elevations are elevated with respect to buried elements of the collection system.
- **Rainfall-Derived Infiltration and Inflow (RDII)** occurs during and after rainstorms resulting from inflow through manhole covers and cross-connections and infiltration through pipe and manhole joints, cracks, and fractures.

AT A GLANCE

The OLWS system sees relatively high volumes of RDII that increases pumping and treatment costs, and increases the risks of sanitary sewer overflows (SSOs). The Master Plan recommends basin focused rehabilitation projects to systematically address and reduce RDII. See Projects C-1 through C-6 in the CIP.

Existing and Future Base Wastewater Flows

BWF across the existing system was estimated using data from the WWTP Influent Lift Station flow meters during dry weather periods. The total BWF across the system is estimated to be 1.85 million gallons per day (mgd). Data from the WWTP was also used to develop an average diurnal curve to estimate the typical fluctuations in wastewater during the course of a 24-hour day. Winter water consumption records were used to proportionally allocate BWF geospatially across the OLWS service area and to identify representative wastewater generation factors for different residential and non-residential land use categories.

Angelo Planning Group completed a buildable lands inventory (BLI) to estimate the capacity for growth within the OLWS wastewater service area in three categories:

Buildout Development.
The capacity for currently vacant and partially vacant properties to develop.

Middle Housing Densification.
The capacity for increased density of development for vacant and partially vacant properties and for conversions of 5 percent of developed single-family properties into multi-family properties.

Commercial Redevelopment.
Conversion of underutilized parcels near the SE Park Avenue Transit Station into multifamily housing.

AT A GLANCE

The OLWS service area is nearly built-out.
The majority of growth will likely be infill development.
A buildable lands inventory was conducted to determine the capacity and results in a relatively small growth rate, meaning that the WWTP and most pipes and pump stations are sufficiently sized if RDII can be reduced.

Full development of the capacity identified in the BLI over the 30-year planning horizon would result in an

AVERAGE ANNUAL GROWTH RATE OF

0.77%

which is comparable to, and slightly higher than, growth rates forecasted by the Portland State University Population Research Center. The calculated future BWF for the OLWS wastewater system assumes the full development capacity in the buildable lands inventory is 2.19 mgd.

Existing and Future GWI and RDII

To determine the amount of GWI and RDII in the OLWS wastewater system, flow monitoring was conducted at eight locations during the winter of 2021-2022. The flow monitoring data during storms that produced more than 1 inch of rain over 24 hours was used to develop parameters for estimating RDII flows based on rainfall patterns. The volume of GWI was estimated by subtracting the BWF from flow monitoring data during a period without rainfall.

Since wet weather flows are dependent upon the volume and peak intensity of rainfall during a storm, a "design storm" must be selected to estimate flows. A 5-year return interval storm with a total rainfall of 3.0 inches over 24 hours, as defined by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) was used to establish existing and future wet weather flow. The flows associated with this storm are used to evaluate the capacity of the collection system to achieve the design criteria for freeboard and SSOs that are identified in Chapter 5.0.

In the evaluation of the WWTP, the highest Peak Wet Weather Flow (PWWF) observed over the six years of available data occurred when a smaller antecedent storm with approximately 1 inch of total rainfall occurred in the 24 hours prior to a larger 24 hour storm with two or more inches of total rainfall. In order to better align with historic PWWF at the plant, a revised hyetograph was generated to include an antecedent storm of 1.26 inches of rainfall in the 48-hours prior to the 5-year, 24 hour design storm. The antecedent storm hyetograph was generated based on storm data from the flow monitoring period and represents an actual 48-hour storm in the OLWS service area.

Table ES-2 provides a summary of wastewater flows used for the evaluation and Table ES-3 presents the wastewater loading at the WWTP. Additional details on the existing and buildout wastewater system flows can be found in Chapter 4.0 of this WWMP.

Figure ES-2. Components of Wastewater Flow

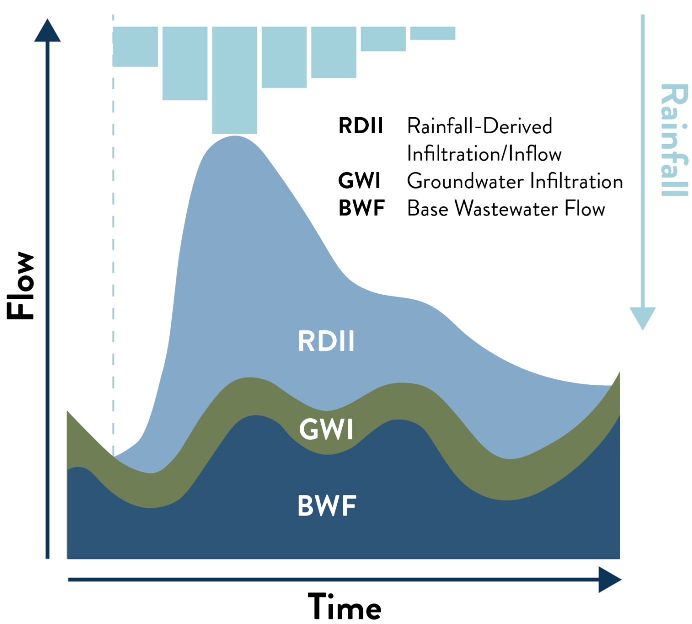


Table ES-2. Current and Future Flows for OLWS Wastewater System

Year	Equivalent Dwelling Units (EDU)	Base Wastewater Flow (gpd)	Peak Wet Weather Flow Collection System (gpd)	Peak Wet Weather Flow WWTP (gpd)
2022 – Existing	14,151	1,853,899	17,504,994	19,059,887
2052 - Buildout	16,726	2,191,112	17,956,410	19,522,181

Table ES-3. WWTP Loading

Parameter	2022	2052
Flow (mgd)		
• Average dry weather	2.2	2.5
• Average dry weather	3.2	3.5
• Average wet weather	4.4	4.8
• Max month dry weather	3.0	3.3
• Max month wet weather	6.3	6.7
• Peak day	15.1	15.5
• Peak hour	19.1	19.5
BOD (lb/d)		
• Annual average	4,950	5,850
• Max month dry weather	5,400	6,380
• Max month wet weather	6,290	7,440
TSS (lb/d)		
• Annual average	4,750	5,620
• Max month dry weather	5,230	6,180
• Max month wet weather	6,370	7,530

Note: ADWF is different than BWF. See Chapter 4 for more information.

AT A GLANCE

Although only 2,575 new dwelling units are projected over the next 30 years, OLWS sees a nearly tenfold increase in flows during wet weather. A diligent approach to rehabilitation of aging wastewater mains, manholes, and laterals will reduce RDII in wet weather, lessen the risk of sewer overflows, avoid costly pipe upsizing projects, and reduce the costs for pumping and treatment.

SECTION 05

Collections System Analysis

The collection system analysis looked at both capacity and condition data to determine deficiencies and to identify recommended improvements.

Hydraulic Capacity Evaluation

WSC developed a hydraulic model of the OLWS wastewater collection system to evaluate capacity based on a 5-year, 24-hour storm. Working with OLWS staff, evaluation criteria for wastewater mains focused on providing a minimum of two feet of freeboard between peak water surface elevations in manholes and the manhole rim to prevent overflows. In shallow manholes where the available freeboard is less than two feet, a maximum allowable surcharge relative to the overall manhole depth was used. Lift station capacity required the ability to pass wet weather flow with the largest pump out of service. Sanitary sewer overflows (SSOs) at any of the outfalls during the design storm are also not acceptable to OLWS, so surcharging must be kept below overflow weir elevations.

At buildout conditions, the wastewater system is anticipated to have 83 manholes (or approximately 3.6 percent of total system manholes) with insufficient freeboard and 36 locations where a SSO is anticipated. To address the capacity deficiencies at buildout, 19,259 linear feet of wastewater piping (primarily trunk mains and also representing approximately 3.6 percent of total pipe length in the system) must be upsized and the firm capacity of Lift Stations 2 and 5 must be increased.

AT A GLANCE

Unless action is taken, OLWS will experience multiple SSOs across the collection system. Upsizing of trunk mains is needed, but due to the locations, will require a large investment.

Condition Evaluation

OLWS has conducted closed-circuit television (CCTV) inspections on 98 percent of the collection system piping. Although the condition data from those CCTV inspections was collected using different defect coding systems over the years, the data was converted into NASSCO PACP equivalent defect scores for use evaluating the need for repairs and rehabilitation across the wastewater system. The pipe condition can be used to represent the likelihood of failure, with PACP Grade 4 and 5 defects requiring repair or replacement within the next 5 to 10 years to minimize the risk of failure. A proposed system for estimating consequence of failure was also proposed to support a risk-based prioritization method for determining where to invest in repairs when resources are limited.

AT A GLANCE

OLWS diligently inspects wastewater mains at regular intervals to assess condition before an unplanned failure occurs. These assessments have identified systemwide needs for repairs over the next 5 to 10 years. Continuous rehabilitation with prioritization of the highest risk mains will allow OLWS to invest wisely.

RDII Reduction Program

OLWS currently has capacity and condition deficiencies in the collection system that could be simultaneously addressed through an RDII reduction program. Focusing condition-based repairs within basins that are upstream of known capacity deficiencies may reduce the amount of trunk main upsizing while addressing the risk of structural failures.

A pilot-program for RDII reduction is recommended for the Lift Station 5 basin. Sub-basin flow monitoring will be conducted to identify areas of highest RDII to determine the extent and nature of wastewater rehabilitation. Smoke testing in each basin will identify potential sources of surface water entering the collection system so that repairs can be made. Focusing on those pipes with Grade 4 and 5 defects, rehabilitation of the wastewater main, the service laterals, and the manholes will be completed to both address structural defects and to reduce RDII. Following completion of repairs, another round of flow monitoring will be conducted to estimate the magnitude of RDII reduction and to guide future RDII reduction efforts in the Lift Station 2 and 6 basins. Additional details on the analysis of the OLWS wastewater collection system can be found in Chapter 5.0 of this WWMP.

AT A GLANCE

Without an ongoing RDII reduction program, expensive pipe upsizing will be necessary to avoid SSOs. Basin-wide investigations and targeted pipe repairs, most of which can be completed without excavation, will reduce capital and long-term operational costs.

SECTION 06

Wastewater Treatment Plant Analysis

The OLWS WWTP provides secondary treatment using activated sludge processes with ultraviolet disinfection to meet waste discharge requirements. The plant is rated for a total capacity of 20 mgd following a significant expansion in 2012 when a majority of the existing equipment was installed.

Existing WWTP Assessment

Brown and Caldwell (BC) utilized a combination of visual inspections, review of operational data, and discussions with OLWS operations staff to assess the condition, integrity, and operability of equipment at the WWTP. Findings from the assessment were used to make condition-based repair recommendations for the WWTP. Additional details can be found in Appendix A of the WWMP.

Plant data from 2016 to 2021 was evaluated to assess historical trends and operational performance. Effluent quality has almost consistently met permit requirements during the period with only recent exceedance of total suspended solids (TSS). With a new permit that limits the discharge concentration for carbonaceous biochemical oxygen demand (CBOD) and TSS to 10 mg/L, the WWTP may not reliably meet the new limits, especially for TSS. Future forecasts of long-term regulatory trends indicate that the WWTP could be subject to limits on total phosphorous and ammonia in upcoming permit cycles, which may require modifications to allow biological nutrient removal to take place.

AT A GLANCE

The WWTP cannot reliably meet new permit limits for total suspended solids. A high priority project to add tertiary treatment filters (T-12) will be completed.

A capacity assessment was conducted for the WWTP to identify existing capacity constraints and the timing of those constraints for each major treatment process. Extensive sampling throughout the plant was used to characterize the wastewater and to calibrate a biological process model and plant-wide solids mass balance to assess capacity.

Near term capacity constraints between now and 2030 include:

- Aeration system is near or at capacity under dry weather conditions
- Secondary clarifiers projected to reach solids loading limit under dry weather conditions when one clarifier is out of service
- Aerobic digesters require upstream thickening of solids to achieve hydraulic retention time requirements for Class B biosolids and aeration capacity may need to be increased to allow one of the four digesters to be taken out of service
- Any upsets to settling characteristics or clarifier operations could cause effluent to exceed the 10 mg/L limit for TSS

Longer term capacity constraints, beyond 2030, include the following:

- Aeration blowers projected to reach firm capacity limit in 2035 for wet weather conditions
- Similar to near term, the aeration capacity of the digester system is anticipated to be exceeded

The timing and extents of capacity constraints are based on the assumption that RDII will not increase due to aging wastewater mains. If RDII reduction projects are not completed, capacity constraints in the WWTP will occur sooner.

AT A GLANCE

Capacity constraints will be reached in the next 10 years due to limited aeration capacity. Improvements to the secondary treatment system will provide the necessary capacity while providing flexibility to meet potential future regulations.

Identification and Evaluation of WWTP Alternatives

Through a series of workshops with OLWS, conceptual alternatives for addressing condition and capacity deficiencies at the WWTP were identified and evaluated. Evaluation criteria included planning for future needs, operations and maintenance considerations, and environmental impacts. Conceptual cost estimates were developed for each alternative, both in terms of capital costs and long-term operational costs, to allow for comparison. The following improvements were recommended based on the results of the alternative analysis:

- Keep existing Huber Multi-Rake screens and adjust channel fit
- Keep existing grit removal equipment with improvements to HeadCell access
- Conversion of secondary treatment process to simultaneous nitrification denitrification (SND) to address aeration capacity issues
- Future addition of Anaerobic-Anoxic-Oxic (A2O) capabilities along with SND to address phosphorous removal if required in future discharge permits without the need for costly chemical addition
- Keep existing Trojan UV system and make gate and actuator improvements
- Add tertiary disc filters to reliably meet new TSS limit year-round
- Construction of a new solids handling building with redundant thickening and dewatering units, thickened waste activated sludge and digested sludge pumps, polymer and odor control equipment, electrical room, and drive-under solids storage hopper in area south of existing Digesters 1 and 2
- Replacement of Digesters 3 and 4 with two new aerobic digesters adjacent to the existing Digesters 1 and 2

Additional details on the alternatives analysis and recommendations for WWTP improvements can be found in Chapter 6.0 of this WWMP.

AT A GLANCE

Handling and managing solids at the plant is time-consuming and creates odors. A future recommendation for a new solids handling building will reduce operational costs and avoid the need to store solids onsite.

Capital Improvement Plan

A capital improvement plan (CIP) was prepared to include anticipated timing and costs for recommended projects within the collections and treatment systems. Cost estimates are based on conceptual understanding of projects, and include a contingency markup to account for unknown aspects and a project development markup to cover planning, design, construction management, inspection, and administration costs.

Each CIP project was assigned a prioritization score based on weighted criteria identified by OLWS. Criteria include asset criticality and condition, customer criticality, regulatory mandates, relationship to other projects, ability to leverage outside funding, level of service, alignment with OLWS Board goals and adopted plans, public interest, and operations and maintenance effectiveness and efficiency. The recommended CIP takes prioritization scoring into account, but also strives to level spending which requires some deviations from strict adherence to prioritization scores. The total value of the CIP is $159,893,000. The CIP projects are divided into collections, treatment, and planning projects and are summarized in Table ES-4, 5, and 6. Additional details on the CIP can be found in Chapter 7.0 of this WWMP.

Table ES-4. Collections System CIP Projects

Project ID	Project Description	Prioritization Rank	Opinion of Probable Cost	Fiscal Years
C-1	LS 5 Basin RDII Reduction	1	$3.02M	2023-24
C-2	LS 2 Basin RDII Reduction	1	$4.95M	2024-25
C-3	LS 6 Basin RDII Reduction	1	$495K	2024-25
C-4	Influent LS Basin RDII Reduction	1	$7.17M	2025-27
C-5	LS 4 Basin RDII Reduction	5	$205K	2026-27
C-6	LS 3 Basin RDII Reduction	6	$8.37M	2031-32
C-7	Ongoing Condition Rehab	7	$25.7M	2033-52
C-8	Trunk A Upsizing	13	$11.9M	2028-30
C-9	Trunk B Upsizing	13	$10.4M	2029-31
C-10	Trunk 2A Upsizing	15	$1.9M	2030-31
C-11	Trunk C Upsizing	16	$144K	2031-32
C-12 to 20	Current 6-yr CIP projects	Various	$14.3M	2023-52
	Collection Projects Subtotal		**$88.4M**	

Table ES-5. Treatment System CIP Projects

Project ID	Project Description	Prioritization Rank	Opinion of Probable Cost	Fiscal Years
T-1,2,4,5,6,7,8&11	Secondary Treatment Upgrades for SND/A2O	2,10,11	$3.5M	2026-30
T-3	Replace aeration blowers	4	$160k	2024-25
T-9&10	Rehab secondary clarifiers 1&2 and RAS Control Center	3,9	$3.7M	2024-29
T-12	Tertiary Filtration Facility	1	$12.0M	2023-25
T-13	Digester Blower Replacement	4	$170k	2023-26
T-14,15	UV Disinfection Rehab	12,17	$2.5M	2023-52
T-16,17	Influent Lift Station Rehab	25,28	$1.2M	2026-28
T-18,19,20 21,22	Headworks Improvements	16,21,24,30	$3.7M	2033+
T-23	WWTP Air Piping Inspection	13	$80k	2023
T-24,25	GBT and TWAS Refurbishment	13	$325K	2026
T-26	Solids Handling Upgrades	8	$35M	2033+
T-27	W3 Sodium Hypochlorite Replace	29	$150k	2031
T-28	Secondary Clarifier 3&4 Rehab	6	$3.7M	2033+
T-29	Ongoing Electrical Upgrades	26	$2.3M	2023-52
T-30	Plant Drain LS Rehab	7	$120K	2026
	Treatment Projects Subtotal		**$69.2M**	

Table ES-6. Planning CIP Projects

Project ID	Project Description	Prioritization Rank	Opinion of Probable Cost	Fiscal Years
P-1	5-yr Cycle WWMP Updates	-	$2.2M	2027,32 & beyond
	Planning Projects Subtotal		**$2.2M**	

Next Steps

Treatment System Projects

A total of **30 treatment system projects** were identified as part of this wastewater master plan. Some of the recommended projects overlapped with current projects that are in the 2023-2028 OLWS 6-year CIP and have been modified accordingly. Although each project was assigned a unique prioritization score, the schedule for implementation for some projects can be grouped together to reduce costs and improve the ability to design and construct holistically. The highest priority project is T-12 which will provide a new tertiary treatment facility to improve reliability in meeting new waste discharge permit limits, particularly for TSS. A summary of the existing projects is provided below in Table ES-7.

Table ES-7. Projects from Existing Treatment CIP

Project Number	Capital Project Description
T-1,2,4,5, 6, 7, 8 & 11	**Secondary Treatment Upgrades for SND/A2O:** Adding density and improving controls to the existing aeration system, modifying the mixed liquor return system, and other improvements will allow the WWTP to address capacity constraints and provide the ability to meet potential future nutrient discharge limits.
T-3	**Replace Aeration Blowers:** Current aeration blower replacement is needed to provide reliable operations. This project is in the current OLWS CIP.
T-9,10	**Rehab Secondary Clarifiers 1 & 2 and RAS Control Center:** Recent condition assessment conducted by OLWS identified the need to rehab the secondary clarifiers.
T-12	**Tertiary Filtration Facility:** A new treatment process will improve reliability to meet new waste discharge permit limits.
T-13	**Digester Blower Replacement:** Current digester blower replacement is needed to provide reliable operations. This project is in the current OLWS CIP.
T-14,15	**UV Disinfection Upgrades:** Ongoing replacement of UV bulbs and upgrades to the flow control gates are necessary.
T-16,17	**Influent Lift Station Rehab:** Pump replacement and other improvements are necessary to provide reliable operations. This project is in the current OLWS CIP.
T-18,19,20 21,22	**Headworks Improvements:** Upgrades to screen seals in channel, access to head cell, providing a 3rd mechanical screen, and other improvements at the headworks will improve operations.
T-23	**WWTP Air Piping Inspection:** Inspection and identification of necessary repairs to the air piping is needed for reliable operations. This project is in the current OLWS CIP.
T-24,25	**GBT and TWAS Refurbishment:** A refurbishment of the existing GBT unit and replacement of TWAS pumps are necessary to provide reliabile operations.
T-26	**Solids Handling Upgrades:** A new solids handling building south of existing Digesters 3 & 4 and the replacement of Digesters 1 & 2 will provide improved reliability and operations for solids handling.
T-27	**W3 Sodium Hypochlorite Replace:** Replacement of the system is needed for reliable operations.
T-28	**Secondary Clarifier 3&4 Rehab:** Rehabilitation of mechanical elements are needed for reliable operations.
T-29	**Ongoing Electrical Upgrades:** Plant staff typically replace sensitive electrical equipment, such as variable frequency drives, to provide reliable operations.
T-30	**Plant Drain Lift Station Rehab:** Pump replacement and other improvements are necessary to provide reliable operations. This project is in the current OLWS CIP.

AT A GLANCE

Over the next 30 years, OLWS has significant investments necessary to deliver the expected level of service to customers. A combination of funding for capital projects, adjustments to SDCs, and increases in rates will be needed.

Collection System Projects

A total of **11 collection system projects** were identified as part of this wastewater master plan, which were added to supplement the existing nine projects identified by OWLS during their previous CIP process. The highest priority projects are projects C-1 through C-4, which focus on RDII reduction to alleviate the risk of SSOs. Each RDII project will include smoke testing to identify and remove any cross connections contributing inflow, flow metering to current and final levels of RDII, and rehabilitation of wastewater mains, service laterals, and manholes to reduce infiltration. The work of these projects is focused on poor condition infrastructure that needs to be replaced and has the potential to reduce the need for upsizing pipes within the collection system.

Table ES-8. Collection System CIP Projects for Addressing Capacity and Condition-Based Deficiencies

Project Number	Capital Project Description
C-1	**LS5 RDII Reduction Pilot:** Smoke testing 35,000 LF of pipe; flow metering at five locations (pre- and post-rehabilitation [rehab]); rehab of 173 LF of 6" pipe, 5,839 LF of 8" pipe, 2,556 LF of 10" pipe, and 215 LF of 12" pipe; rehab of six manholes (63 vertical feet [VF]); and rehab of 138 laterals from the main to the property connection.
C-2	**LS2 Basin RDII Reduction Program:** Smoke testing 165,414 LF of pipe; flow metering at 17 locations (pre- and post-rehab); rehab of 11,145 LF of 8" pipe, 304 LF of 12" pipe, 4 LF of 14" pipe, 251 LF of 18" pipe, 752 LF of 20" pipe, and 338 LF of 21" pipe; rehab of nine manholes (95 VF); and rehab of 198 laterals from the main to the property connection.
C-3	**LS6 Basin RDII Reduction Program:** Smoke testing 6,846 LF of pipe; flow metering at two locations (pre- and post-rehab); rehab of 171 LF of 8" pipe; rehabilitation of one manhole (11 VF); and rehab of 33 laterals from the main to the property connection. Scope is limited to OLWS-owned assets.
C-4	**ILS Basin RDII Reduction Program:** Smoke testing 207,931 LF of pipe; flow metering at 21 locations (pre- and post-rehab); rehab of 270 LF of 6" pipe, 12,724 LF of 8" pipe, 503 LF of 10" pipe, 250 LF of 12" pipe, 247 LF of 15" pipe, and 1,428 LF of 21" pipe; rehab of 17 manholes (179 VF); and rehab of 326 laterals from the main to the property connection.
C-5	**LS4 Basin RDII Reduction Program:** Smoke testing 2,335 LF of pipe; flow metering at one location (pre- and post-rehab); rehab of 491 LF of 8" pipe; rehab of one manhole (11 VF); and rehab of four laterals from the main to the property connection.
C-6	**LS3 Basin RDII Reduction Program:** Smoke testing 51,309 LF of pipe; flow metering at five locations (pre- and post-rehab); rehab of 19,504 LF of 8" pipe, 1,009 LF of 10" pipe, 1,788 LF of 12" pipe, and 996 LF of 15" pipe; rehab of 16 manholes (168 VF); and rehab of 428 laterals from the main to the property connection.
C-7	**Annual Condition Rehabilitation:** Annual budget for rehabilitating future Grade 5 and Grade 4 mains within the collection system. This project will take place after the RDII reduction programs and will address mains that developed Grade 5 and Grade 4 defects after the time of this master plan.
C-8	**Trunk Main A Upsizing:** Upsize Trunk Main A along the extents shown in Figure 5 10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 3,516 LF of 24", 240 LF of 27", and 3,202 LF of 30" gravity wastewater main. Depending on the effectiveness of the RDII reduction in Projects C-1 through C-6, this scope may be reduced.
C-9	**Trunk Main B Upsizing:** Upsize Trunk Main B along the extents shown in Figure 5 10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 362 LF of 15", 4,600 LF of 18", and 3,729 LF of 24" gravity wastewater main. Depending on the effectiveness of the RDII reduction in Projects C-1 through C-6, this scope may be reduced.
C-10	**Trunk Main 2A Upsizing:** Upsize Trunk Main 2A along the extents shown in Figure 5 10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 322 LF of 15" and 1,698 LF of 18" gravity wastewater main. Depending on the effectiveness of the RDII reduction in Projects C-2 and C 3, this scope may be reduced.
C-11	**Trunk Main C Upsizing:** Upsize Trunk Main C along the extents shown in Figure 5 10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 289 LF of 10" gravity wastewater main.

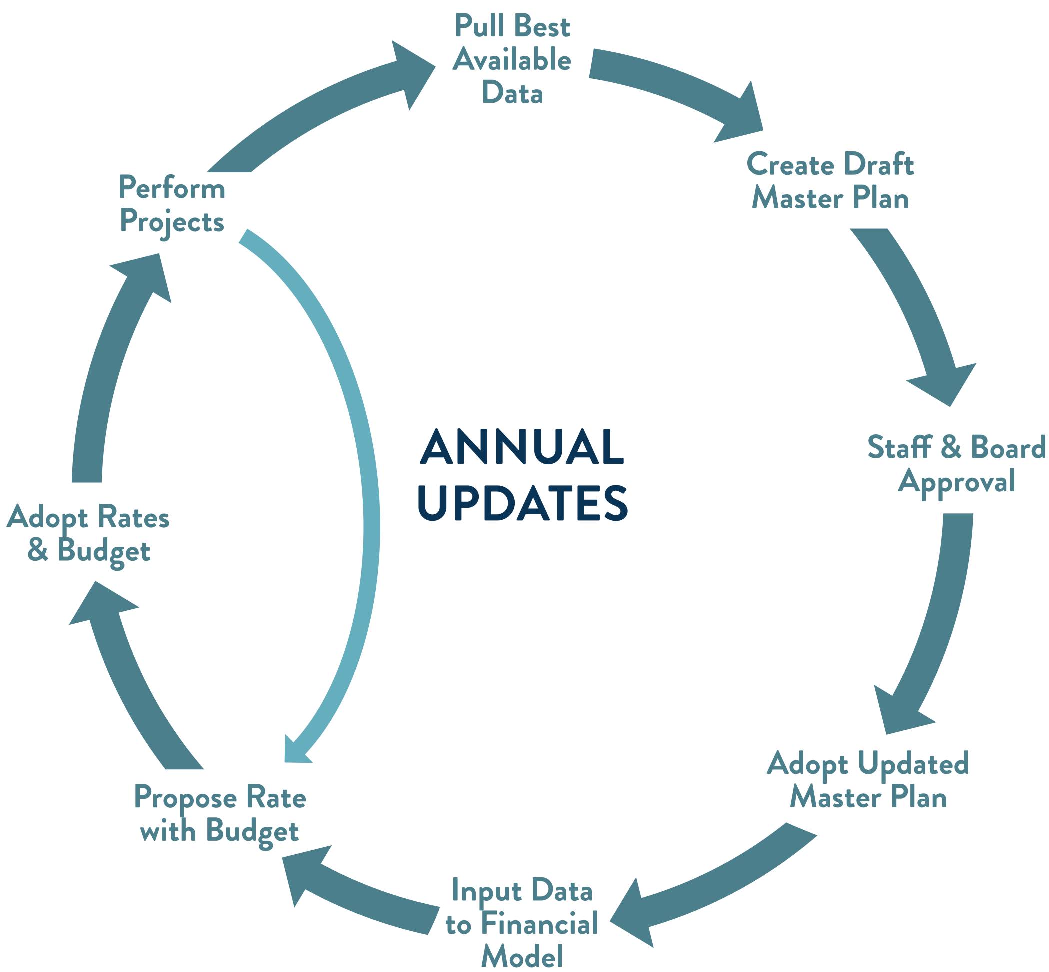
Planning Projects

WSC recommends an update to the WWMP on an approximate 5-year basis to refresh the CIP to improve the utility of the wastewater master plan. As time passes between each WWMP update, new regulations may be implemented, system conditions gradually deteriorate, and priorities for OLWS can shift. Updating the master plan every 5-years also requires less effort than developing a completely new master plan document. Project P-1 allocates budget every five years to provide an update to this wastewater master plan to facilitate future CIP development and reflect improvements made within the wastewater system. The next update will be particularly important as RDII reduction projects are completed and benefits of lower PWWFs can be assessed to determine the impacts on capacity and treatment system improvement recommendations.

AT A GLANCE

Over time, the system will change and new needs will arise. By updating the WWMP on a 5-year cycle, the plan will stay fresh and OLWS can stay ahead of financing needs.

Figure ES-3. Master Plan 5-Year Update Cycle



Staffing Considerations

Developing the WWMP has shown a need to conduct a detailed staffing analysis to determine OLWS' appropriate level of staff for current and future operations.

Staffing decisions come with many considerations that go beyond the scope of this WWMP. Individual project CIP budgets include project development costs and assume more automated processes, where appropriate. The recommended overall CIP accounts for some of the cost and should allow flexibility for OLWS to address staffing needs over the 30-year planning horizon as processes and equipment change.

Funding and Financing

OLWS will explore several options to fund the CIP including user fees, bonds, grants from outside agencies, and SDCs. The following sections will describe the potential for funding the recommended capital improvements through user fees and SDCs, bonds, or grants from outside agencies.

CIP Summary

The recommended CIP identifies approximately $160M in projects, with roughly 50% of the work to be completed within the next 10 years. An implementation schedule that provides for an average capital improvement budget of $8.0M per year for the next 10 years appears feasible but will likely require rate increases or additional funding mechanisms. Prioritization of projects is based upon the currently known deficiencies within the system. As continued inspections and assessments of wastewater mains, manholes, lift stations, and wastewater treatment plant facilities provide new information, there may be a need to adjust the prioritization and timing of the CIP.

1.0 Introduction

This introductory section includes a statement of the intended objectives of this planning document, a citation of the contract authorizing development of the plan, a list of the related documents and plans that influence or are influenced by this effort, and a brief description of Oak Lodge Water Services District (OLWS) and its environment.

IN THIS SECTION

- Objectives
- Authorization
- Relationship to Other Documents
- OLWS Overview

PREPARED BY:

WSC

1.1 Objectives

Oak Lodge Water Services (OLWS) contracted with Water Systems Consulting, Inc. (WSC) to develop a Wastewater Master Plan (WWMP) to guide the planning of capital project expenditures through a 30-year planning horizon. The WWMP provided herein serves as an update to the previous version that was prepared in 2007 and shall supersede that plan.

OLWS is committed to its customers to protect public health, provide excellent customer service, make smart investments and work to keep rates affordable, and keep local streams and rivers clean. During the process of preparing the updated WWMP, OLWS identified the following objectives in support of these commitments to their customers:

- Quantify the ability to add new customers and different types of customers within the service area;
- Understand the impacts current operations has on hydraulic and loading capacity of the Wastewater Treatment Plant (WWTP);
- Determine if additional facilities are required to meet current and future Oregon Department of Environmental Quality (DEQ) permit requirements;
- Identify best practices for inspection, operations and maintenance for OLWS' collection system;
- Develop a strategy for reducing rainfall derived infiltration and inflow (RDII);
- Develop a prioritized list of improvement projects, including anticipated costs, to address the deficiencies and assure capacity of the collection system and WWTP;
- Compare current staffing level to expected staff level with planned improvements and quantify adjustments by staff category; and
- Identify appropriate system development charges (SDC)s to support planned improvements and explore options for how SDCs may be assessed.

1.2 Authorization

OLWS has contracted with WSC as described in the Engineering Services Agreement with OLWS for the WWMP, executed on April 27, 2021. WSC has partnered with Brown and Caldwell (BC) to evaluate the WWTP and identify necessary improvements, SFE Global to provide flow monitoring services, Angelo Planning Group to prepare a buildable lands inventory, Leeway Engineering to provide smoke testing and RDII reduction support, West Yost to provide permitting support, and the FCS Group to assist in developing system development charges for the 30-year planning period.

1.3 Relationship to Other Documents

The WWMP will serve as a key piece of OLWS' long-range planning process and ongoing operations of their collection and wastewater treatment system, but also incorporates recommendations and considers the objectives of other planning efforts that have some overlap with the wastewater collection system. A partial list of related documents is included here, and a supplemental list of references is included in the References section at the end of this plan.

1992 Wastewater Master Plan (1992 WWMP) – The first comprehensive wastewater master plan for OLWS was prepared by Brown and Caldwell. The plan evaluated the collection system and wastewater treatment plant for what was then called the Oak Lodge Sanitary District over a 20-year planning period spanning from 1990 through 2010.

2007 Sanitary Sewer Master Plan (2007 SSMP) – The most recent WWMP for OLWS was prepared by CH2M Hill in 2007 and evaluated the collection and wastewater treatment system over a 20-year planning horizon.

2021 Design and Construction Standards – The most recent version of the OLWS design and construction standards for the sewer collection system provides guidelines for recommended improvements.

Capital Improvement Plan Fiscal Years 2023-2028 – The most recent OLWS 6-year capital improvement plan included 19 wastewater capital improvement projects planned for completion by fiscal year 2028. Wastewater projects were incorporated into the 30-year plan in this document.

2023 Clackamas County Department of Transportation Paving Plan – The County produces a 5-year Capital Improvement Program that identifies road improvement projects. With a 5-year moratorium on excavations within newly paved roadways, the plan will aid in prioritizing wastewater collection work ahead of planned road projects.

Clackamas County Comprehensive Plan – The County's comprehensive plan establishes land use designations within the North Urban Area that includes the OLWS wastewater service area. The potential future growth within the OLWS wastewater service area is estimated based on the land use designation for properties.

2.0 Existing Wastewater System

This section describes the existing OLWS wastewater collection and treatment system including the service area boundary, the basins within the collection system, the inventory of assets, the current operations and maintenance program, and data systems.

IN THIS SECTION

- Existing Service Area
- Collection System Inventory
- Wastewater Treatment
- Maintenance Activities and Programs
- Data Systems and Information Management

PREPARED BY:

WSC

Brown AND Caldwell

2.1 Existing Service Area

The following section summarizes the OLWS wastewater system service area location, soils, climate, population, land use, and service area.

2.1.1 Location

The OLWS wastewater service area is located within northwestern Clackamas County and serves the communities of Oak Grove, Jennings Lodge, and portions of the Cities of Milwaukie and Gladstone. The service area is bordered by the City of Milwaukie to the north, the Willamette River to the west, the City of Gladstone to the South, and Clackamas County to the east as shown in Figure 2-1. A significant portion of the City of Gladstone is connected to the OLWS collection system. The City of Gladstone owns and operates these pipes outside of the OLWS service area (Figure 2-1 and Figure 2-2) while OLWS is responsible for the treatment of the flows from these pipes at their WWTP. Additional information about the City of Gladstone's responsibilities is include in Section 3.1.2.

The collection system is divided into six collection system basins defined by the downstream lift station and shown in Figure 2-2. The service area is largely built out with the primary growth over the next 30 years anticipated to come through residential infill.

2.1.2 Soils and Groundwater

Most of the OLWS service area is underlain by Columbia River basalt in the northeast and by lacustrine deposits in the southwest. The Columbia River basalts are responsible for the prominent ridges seen in the service area. Small areas within the service area are underlain by the Gresham Formation, which consists of poorly sorted and stratified coarse gravel and mud flow deposits. Areas along the Willamette River contain exposed sandy and gravelly alluvium. (CH2M Hill, 2007)

Most of the soils within the OLWS service area have poor infiltration potential for flood flows. These consist of silt loams, clay loams, sandy loams, loam, and river wash. The soils also have moderate to excellent treatment potential for removing metals or phosphorus from infiltrated stormwater. (CH2M Hill, 2007)

OLWS has received customer feedback of high groundwater tables and springs surfacing in the area near the Boardman Creek Wetlands complex and up to Oatfield Ridge. The presence of high groundwater tables here and throughout the collection system impacts infiltration during wet weather conditions.

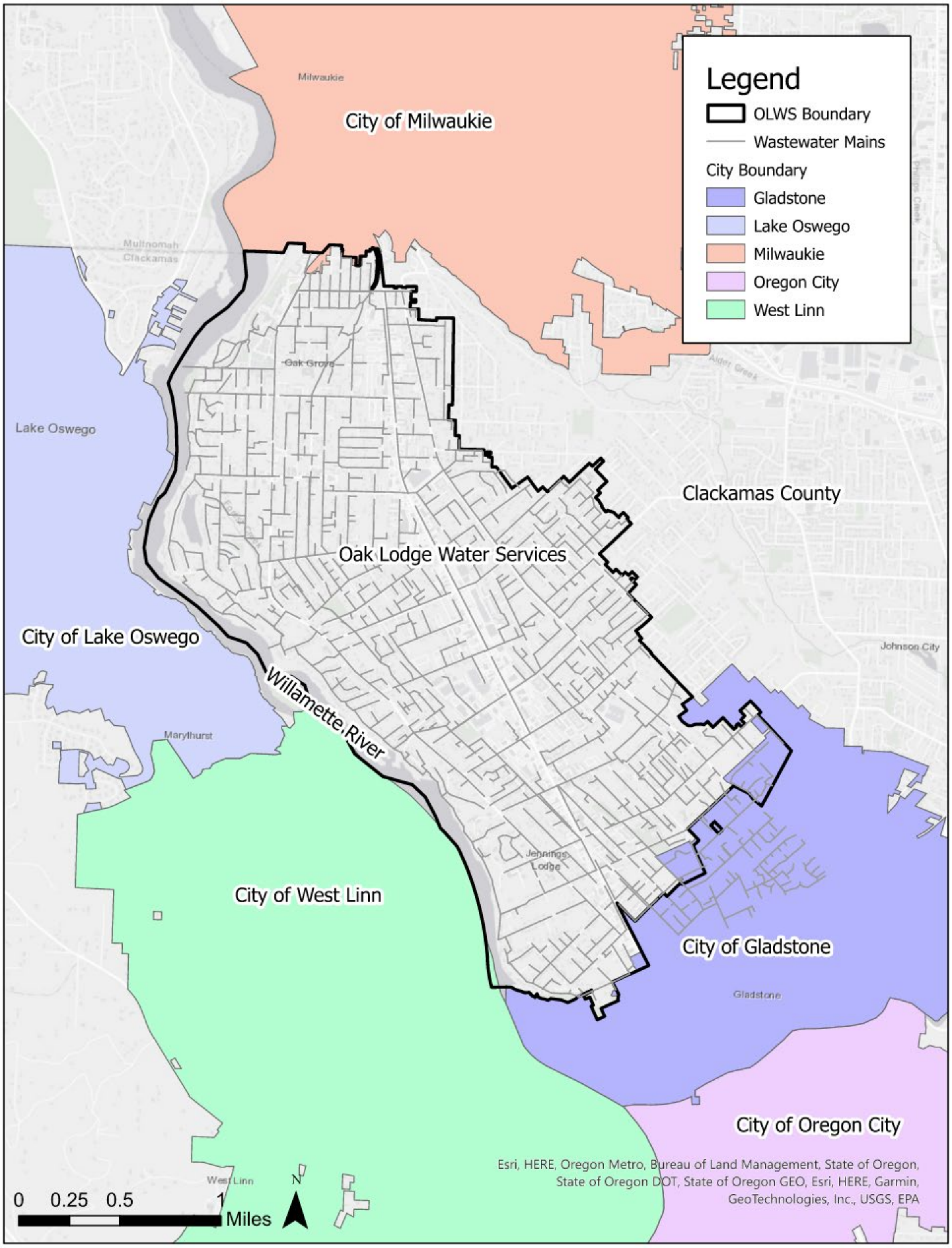


Figure 2-1: Location Map

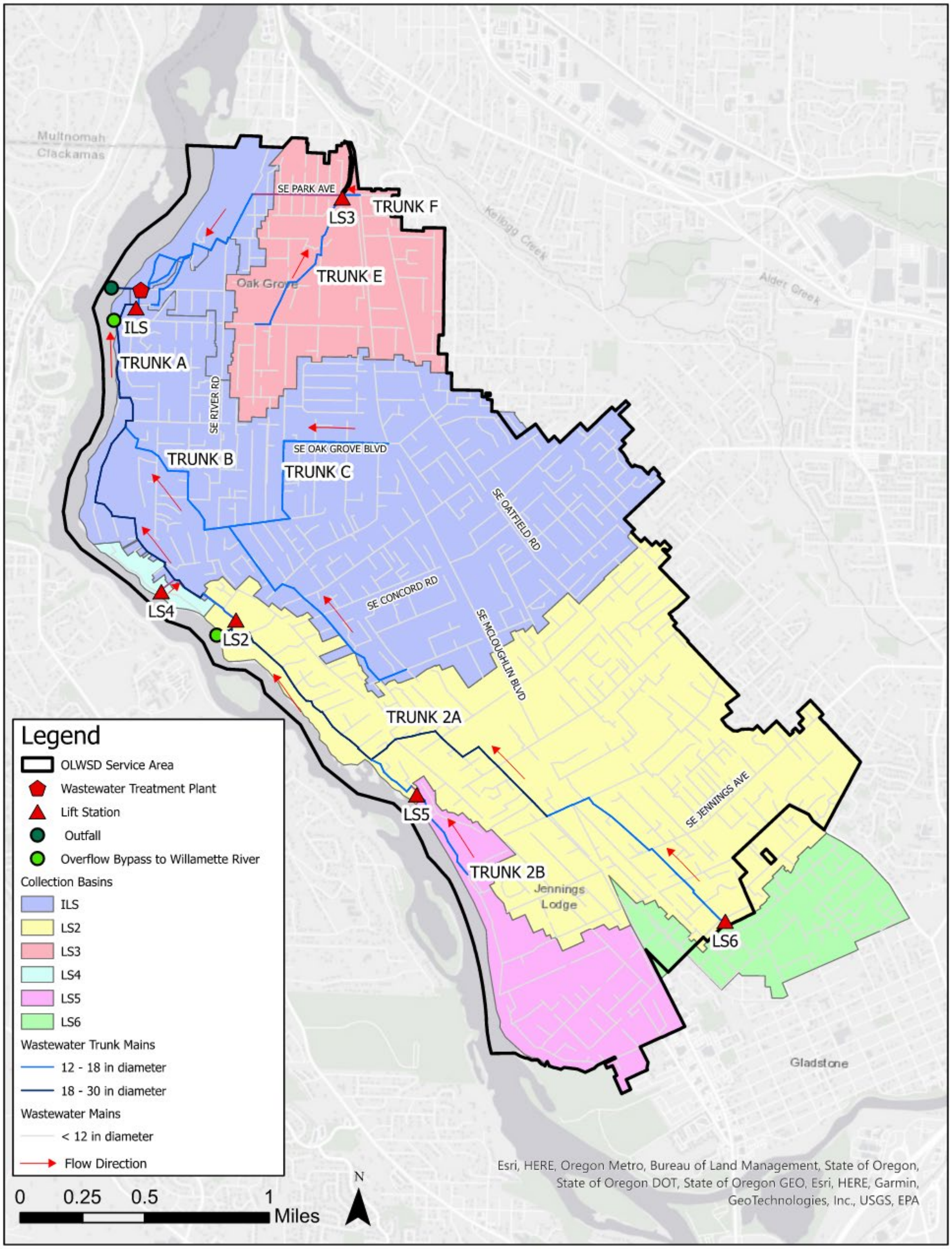


Figure 2-2: Oak Lodge Water Services' Service Area

2.1.3 Climate

The climate within the OLWS service area is characterized by warm summers with average high temperatures of about 78°F and mild winters with average temperatures above 40°F. On average, the service area receives 31.29 inches of rain per year, with over 70% of this occurring between October and March. During these high rainfall months there is potential for groundwater recharge while in the remainder of the year the evaporation exceeds precipitation. (Weather-US, 2021) The significant amount of rain contributes to rain derived infiltration and inflow (RDII) within the collection system.

2.2 Collection System Inventory

The OLWS wastewater collection system consists of service laterals, sewer pipes, manholes, pump stations, and force mains that convey raw wastewater from customers to the WWTP. The following sections describe and inventory the collection system.

2.2.1 Gravity Pipes and Manholes

Based on the most recent Geographic Information System (GIS) data from OLWS, the OLWS existing wastewater collection system, which includes portions owned by the City of Gladstone, is composed of the following.

- The total system (including the City of Gladstone) is comprised of approximately 99 miles of active gravity wastewater mains, 2,331 active manholes, 408 active cleanouts, and 7,548 service laterals excluding private facilities such as privately-owned manholes.
- The City of Gladstone owns 6.6 miles of these gravity mains, 168 manholes, and 28 cleanouts
- Service laterals are owned by the respective homeowner, and 7,407 of the laterals are located within the OLWS service area.

The gravity pipe throughout the system ranges in size from 4-inch to 30-inch diameter, with 87% of the gravity pipe being 8-inches or smaller. A majority of the pipe (84%) is asbestos cement or concrete pipe. The distribution of pipe length by diameter is shown in Table 2-1 and the distribution of pipe material is shown in Figure 2-3.

Table 2-1: Gravity Pipe Summary

Pipe Diameter (in)	OLWS-Owned Total Pipe Length (LF)	Gladstone-Owned Pipe Length (LF)	Total Pipe Length (LF)	Proportion of System
4	106	0	106	<1%
6	7,411	1,673	9,084	1.7%
8	411,296	33,098	444,394	85.4%
10	13,800	0	13,800	2.7%
12	18,629	0	18,629	3.6%
14	2,212	0	2,212	<1%
15	8,081	0	8,081	1.6%
18	5,205	0	5,205	1.0%
20	5,861	0	5,861	1.1%
21	9,324	0	9,324	1.8%
24	3,136	0	3,136	<1%
30	646	0	646	<1%
Unknown	21	0	21	<1%
Total	**485,728**	**34,771**	**520,499**	**100%**

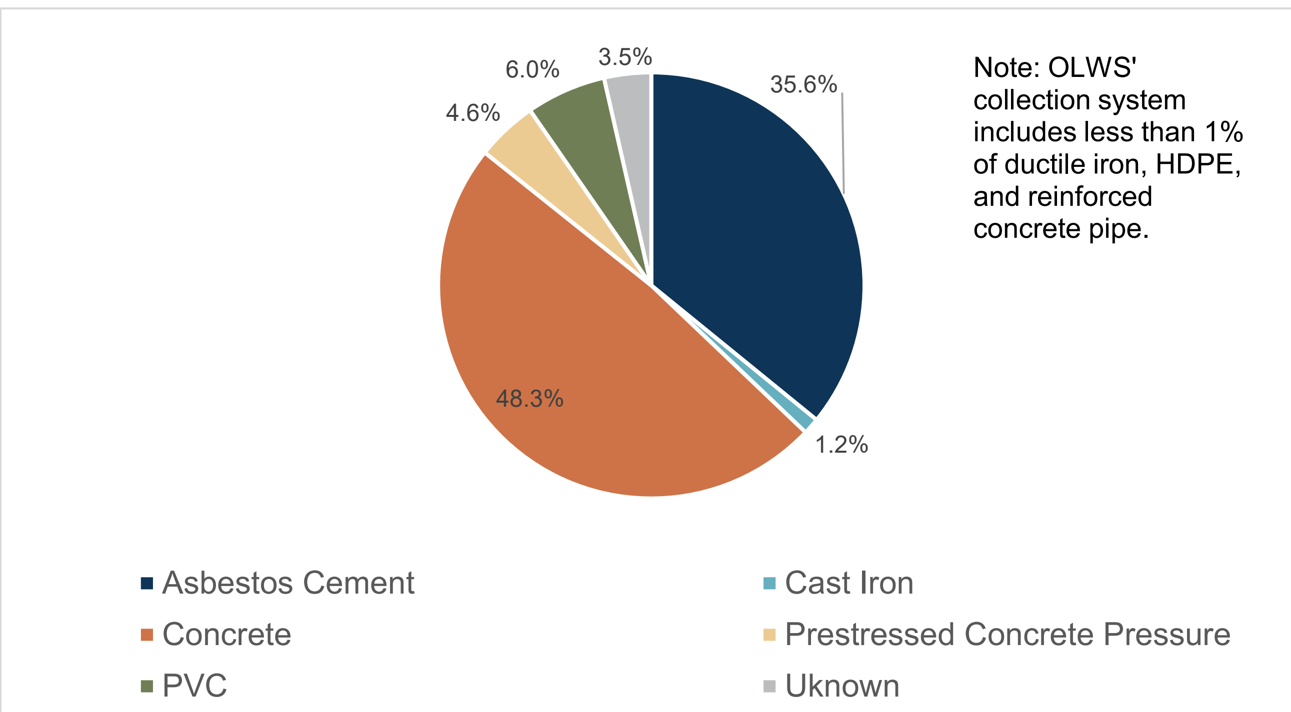


Figure 2-3: OWLS-Owned Pipe Material Distribution on a Length Basis

2.2.2 Lift Stations and Force Mains

Based on the GIS data provided by OLWS, the OLWS collection system currently includes six lift stations (including the Influent Lift Station [ILS] to the WWTP) and 5,408 linear feet (LF) of force main. Table 2-2 provides a summary of several operational parameters with respect to individual pump stations.

Table 2-2: Lift Station Summary Table

Pump Station	Station Location	Construction Date	Year of Latest Upgrade	No. of Pumps	Firm Capacity (gpm)	Horsepower per Pump (hp)	Type
ILS	WWTP	1974	2012	5	13,888[1]	4 @ 100 1 @ 60	Variable Speed
LS2	SE Oak Shore Ln and SE Risley Ave	1958	2002	3	3,400[2]	40	Variable Speed
LS3	SE Park Ave and SE 27th Ave	1961	2002	2	2,240[3]	125	Variable Speed
LS4	End of SE River Forest Ln	1961	2007	2	139.8[4]	5	Constant Speed
LS5	South end of SE Walta Vista Dr	1961	2022	2	640[5]	15	Constant Speed
LS6	SE Glen Echo Ave and SE Addie St	1961	2003	2	800[6]	5	Constant Speed

gpm=gallons per minute

[1]ILS firm capacity value derived from the Water Reclamation Facility Improvements record drawings dated March 2012

[2]LS2 firm capacity value derived from the Cornell Pumps 6NHTH pump curve and associated system curve

[3]LS3 firm capacity value derived from the Cornell Pumps 8NNT pump curve and associated system curve

[4]LS4 firm capacity value derived from the NP3102 pump curve and associated system curve

[5]LS5 firm capacity derived from the LS5 design plans dated February 2021

[6]LS6 firm capacity derived from Pioneer Pump SC66S12 and Cornell Pumps 6NHTA pumps curves and associated system curves

2.3 Wastewater Treatment

OLWS owns and operates a WWTP that treats wastewater collected from the service area and discharges treated effluent into the Willamette River. The WWTP currently provides secondary treatment with aeration basins and secondary clarifiers operating as a modified Ludzack-Ettinger (MLE) process. In preparation for analysis of the current and future needs for the WWTP, Brown and Caldwell (BC) has prepared the following sections to satisfy Oregon Department of Environmental Quality (DEQ) guidelines for preparing a wastewater facility planning document including:

- Description of the historical improvements to the WWTP
- Description of the existing WWTP including detailed design data with a summary of treatment processes
- Condition assessment of the major existing WWTP assets and projection of remaining service life
- Performance evaluation of equipment, treatment processes, and components at the WWTP

Detailed information on each of these topics can also be found in Appendices A, B, and C.

2.3.1 WWTP History

The plant was constructed in 1960 and has been upgraded since that time. A summary of the WWTP improvements is provided in Table 2-2.

Table 2-2: History of WWTP Improvements

Year	Improvement
1960	Plant constructed with 1.5 mgd capacity. Includes primary and secondary treatment (activated sludge) and anaerobic digestion.
1970	Capacity expanded to 2.0 mgd
1973	Capacity expanded to 4.0 mgd
1981	Influent screening and rock trap added
1986	Fine-bubble aeration added
1995/1996	Replace secondary clarifiers and install new return and waste activated sludge pumping facilities
1999	New outfall and diffuser added
2002	New solids handling facility constructed. Included addition of belt filter press to dewater solids.
2005	Blowers upgraded
2012	Major plant upgrades including new influent and plant drain pump stations, headworks, aeration basins, interchange bioreactors, expanded aerobic digestion capacity, expanded secondary clarifier capacity, and ultraviolet disinfection
2017	Initiation of industrial pretreatment program including outfall mixing study

Year	Improvement
2020	Modifications to solids process to convert interchange bioreactors to additional aerobic digestion capacity

2.3.2 WWTP Description

OLWS owns and operates an activated sludge WWTP that serves approximately 30,000 customers within the service area. With less than 1 percent of users categorized as industrial, the influent is comprised primarily of domestic wastewater; treated effluent is discharged into the Willamette River. All flow enters the WWTP through an influent pump station.

Figure 2-4 shows a process flow schematic of the existing liquid and solid stream treatment systems.

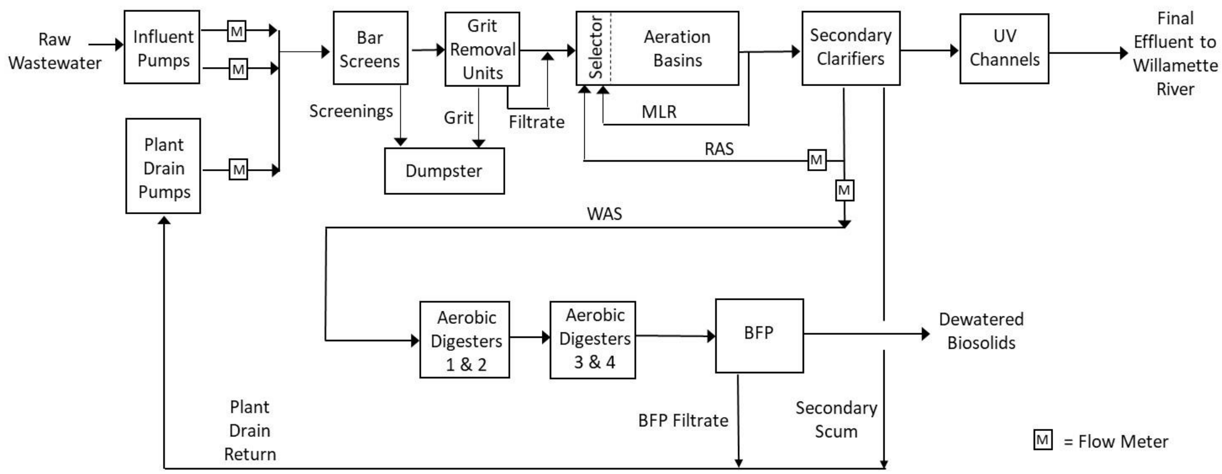


Figure 2-4. WWTP process schematic

(Note: The existing GBT [not shown above] could be used in the future to thicken WAS prior to digestion)

Figure 2-5 shows an aerial view of the current OLWS WWTP site and identifies major process facilities and other buildings.

Figure 2-5. Aerial view of WWTP with major facilities labeled

Table 2-3 summarizes design flows and loadings, as well as design data for the major unit processes.

Table 2-3. Major Equipment Design Data

Process Element	No. of Units	Design Value
Plant flow, mgd		
Average Annual Flow (AAF)	-	4.3
Average dry weather flow		3.5
Average wet weather flow		5.2
Max month, wet weather		10.5
Max day, wet weather		17.3
Max day, dry weather		8.6
Peak hour		18
Biochemical oxygen demand loading, pounds per day (ppd)		
Annual average	-	6,680
Max month, wet weather		7,440
Max week, wet weather		8,910
Max day, wet weather		11,090
Max month, dry weather		7,250
Max week, dry weather		8,790
Max day, dry weather		10,900
Total suspended solids loading, ppd		
Annual average	-	7,450
Max month, wet weather		8,390
Max week, wet weather		10,010
Max day, wet weather		13,290
Max month, dry weather		8.960
Max week, dry weather		10,070
Max day, dry weather		12,970
Total Kjeldahl nitrogen loading, ppd		
Annual average	-	994
Max month, wet weather		1,244
Max month, dry weather		1,354
Influent pumps	5	
Capacity, each, mgd		4 @ 5.5, 1 @ 3.5
Motor horsepower (hp), each		4 @ 100, 1 @ 60
Type		Adjustable speed
Plant drain pumps	2	
Capacity, each, mgd		1.75
Motor hp, each		25
Type		Adjustable speed

Process Element	No. of Units	Design Value
Influent mechanical screens	2	
Type		Multi-rake
Screen opening, in.		0.25
Hydraulic capacity, mgd, each		11.75
Manual bar screen		
Bar spacing, in.	1	0.25
Hydraulic capacity, mgd		11.75
Grit removal tanks	2	
Type		Eutek Head-Cell
Hydraulic capacity, mgd, each		11.75
Aeration basins	4	
Total length, ft		109
Total width, ft		35
Sidewater depth, ft		20
Liquid volume each, gallons		571,000
Aeration blowers	4	
Units	(3 duty, 1 stand-by)	High speed turbo (3), Hybrid Screw (1)
Type		
Max capacity (total (scfm @ psig)		5,473 @ 9.6
Min capacity (total), scfm @ psig		1,824 @ 9.1
Discharge pressure, pounds per square inch		9.7
Secondary clarifiers		
Diameter, ft		70
Sidewater depth, ft	4	18
Peak-hour surface overflow rate, gpd, ft^2		1,186
Max month, solids loading rate, ppd, ft^2		38
Ultraviolet disinfection		
Number of channels	2	
Lamp type		Low pressure, high intensity
Design peak flow capacity, mgd		22
Aerobic digesters, rectangular	2	
Dimensions, length x width, ft, each		40 x 80
Sidewater depth, ft		18
Volume, each, gallons		431,000
Aerobic digesters, circular	2	
Diameter, ft		35
Sidewater depth, ft		1 @ 25, 1 @ 25
Volume, each, gallons		1 @ 185,400, 1 @ 189,000
Belt Filter Press	1	
Hydraulic capacity, gallons per minute		120
Solids loading capacity, pounds per hour		500

Additional details on the existing WWTP can be found in Appendix A.

2.3.3 WWTP Condition

BC reviewed documentation from prior projects and other records available for the OLWS WWTP in preparation for completing a condition assessment for the WWMP. BC also performed a site visit and visual inspection on October 20, 2021, to assess the physical condition, functional integrity, and operability of equipment at the WWTP. A summary of condition assessment findings is provided in Appendix A.

2.3.4 WWTP Historical Performance

The BC reviewed plant data from 2016 to 2021 to assess historical trends of flows and loadings received by the plant and to compare them with design values. Operating data for the activated sludge system and effluent data were also reviewed to assess performance. The following is a summary of information from the OLWS WWTP Historical Performance TM included as Appendix B to the WWMP.

Analysis of the historical plant data from 2016 to 2021 for the OLWS WWTP yields the following observations and conclusions:

- While average influent flows have remained relatively steady from 2016 to 2021, average BOD and TSS loadings have increased slightly.
- The data show occasional spikes in loadings and both BOD and TSS loadings have exceeded the design maximum day loadings a few times during the 6-year period examined.
- The annual average concentrations for both BOD and TSS are observed to have increased over the 6-year period, with a notable increase from 2017 to 2018.
- The plant effluent quality has almost consistently met permit requirements in the 2016 to 2021 period, with monthly average effluent BOD, CBOD, and TSS concentrations typically below 15 mg/L. The only exception occurred in January 2021, when the monthly average TSS concentration exceeded the permit limit.
- With the current permit containing a lower limit of 10 mg/L for both CBOD and TSS, the plant may not reliably meet the new limits, especially for TSS.
- Nitrification is occurring in the system, as measured effluent ammonia concentrations are typically below 8 mg/L. The extent of denitrification cannot be determined from the data, as nitrate is not measured.
- The generally good effluent quality for secondary effluent, even during periods of high sludge volume index (SVI), suggests there is adequate secondary clarifier capacity to accommodate any deterioration in sludge settling characteristics. However, it may not be adequate to consistently meet the current TSS limit of 10 mg/L during dry season period.

2.4 Maintenance Activities and Programs

The following subsections describes the routine maintenance activities OLWS staff perform on the collection system and WWTP.

2.4.1 Collection System

The OLWS collection system preventative maintenance program includes routine cleaning, root control, closed-circuit television (CCTV) inspections, and lift station maintenance. The operations staff has a goal to conduct CCTV on approximately 75,000 LF of wastewater mains each year (15% of the system). At the average rate of CCTV inspection, the entire system would be surveyed every 6.5 years. While there is not currently an industry standard recommendation for the frequency of CCTV inspections, an assessment interval of 5 to 10 years should allow significant structural defects to be identified before failure. Wastewater mains and manholes that are known to be in poor condition could be prioritized for shorter inspection intervals until repairs can be made. Several "high maintenance" wastewater mains, as shown in Figure 2-6, are cleaned on a more frequent quarterly schedule due to a history of fats, oils, and grease accumulation or root intrusion.

OLWS does not currently have a manhole inspection protocol. During the course of performing CCTV work on the collection system mains, operators will check the adjacent manholes for visible leaks or breaks. Any deficiencies observed will be reported and a task order will be created for repair. OLWS is currently in the process of developing a manhole inspection checklist to formalize the inspection process.

Lift stations are inspected twice per week. Operations staff visit each lift station site and check that systems are operating as expected. Force mains are not regularly inspected.

2.4.2 Wastewater Treatment Plant

BC met virtually with OLWS staff on September 1, 2021, to conduct a workshop to discuss WWTP operations. This OLWS WWTP Operations TM (included as Appendix C to the WWMP) summarizes information collected during this workshop, along with review of previous reports, historical data, and other discussions with OLWS staff. An assessment of each unit process is included in this TM which is provided in Appendix C. Projects to address recommended facility improvements to enhance operability and performance of the WWTP systems are included in the CIP provided in Chapter 7.0.

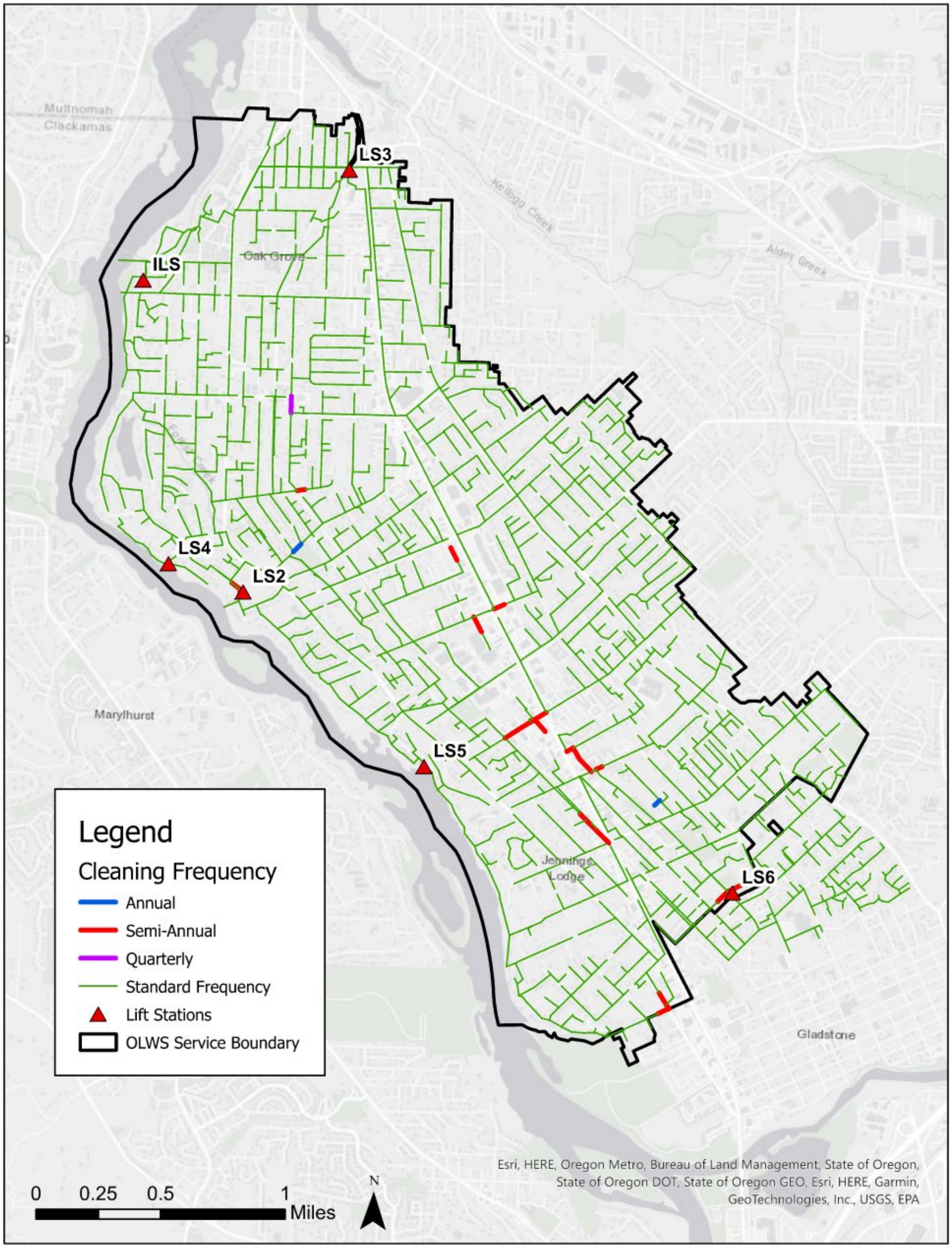


Figure 2-6: Mains Requiring Increased Maintenance

2.5 Data Systems and Information Management

OLWS maintains three primary data systems to organize and analyze physical attributes, maintenance requirements and condition assessment observations associated with the wastewater collection and treatment system: ArcGIS, GraniteNet and CentralSquare Enterprise Asset Management powered by Lucity (EAM).

The OLWS wastewater collection system GIS database is maintained by OLWS and includes a geographical representation of the wastewater collection system assets, including gravity pipes, force mains, manholes, cleanouts, and lift stations. Assets in the GIS database are populated with key attributes such as asset identification number, installation year, pipe diameter, and material type.

EAM is the primary wastewater asset management system that is used to track wastewater assets. The system is owned and maintained by the OLWS' asset management staff to ensure data is well maintained. Collection system and treatment plant staff enter data from the field to provide up-to-date records on asset condition and maintenance. EAM is a GIS based system that allows OLWS to maintain information about each asset, including attributes, descriptions, and maintenance history. Any changes made within the OLWS GIS database automatically syncs with EAM, allowing collection system and treatment plant operations staff to have access to real time updates. EAM is also used to schedule and generate work orders for the collection system and treatment plant operators to ensure issues are addressed in a timely matter.

GraniteNet is the OLWS pipeline inspection software. The software is compatible with the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP). OLWS uses this software to store CCTV videos for all gravity collection mains including the associated PACP condition scores. GraniteNet is linked to EAM to allow staff to easily generate work orders based on the cleaning and inspection work findings. Prior to using GraniteNet, OLWS utilized GraniteXP, which utilized several non-PACP scoring systems. As OLWS continues to CCTV their collection system, old scoring systems are being replaced with PACP scores.

OLWS operates and maintains a supervisory control and data acquisition (SCADA) system for the collection system lift stations and the WWTP. The SCADA system tracks run time and alarm conditions for each of the OLWS' six lift stations. OLWS does not own or operate any permanent flow meters within the collection system. Total flow into the WWTP is measured between two permanent flow meters on the discharge side of the ILS. Data is collected throughout the various treatment processes at the WWTP through SCADA and stored within a data historian located at the plant.

3.0 Regulations and Policies

This chapter describes the existing interagency agreements that OLWS currently maintains with adjacent wastewater providers and provides an overview of the regulatory rules and policies OLWS operates within.

IN THIS SECTION

- Interagency Agreements
- Rules and Regulations

PREPARED BY:

WSC

Brown AND Caldwell

3.1 Interagency Agreements

OLWS maintains three intergovernmental agreements (IGAs) for the collection and treatment of wastewater with the neighboring wastewater providers including Clackamas Water Environment Services (WES), the City of Gladstone, and the City of Milwaukie. Each IGA is briefly summarized below.

3.1.1 Clackamas WES

OLWS and Clackamas WES entered into an IGA for wastewater service in 1976 when OLWS was Oak Lodge Sanitary District and Clackamas WES was Clackamas County Service District No. 1. This IGA governs properties within each party's boundaries that are unable to be served by gravity wastewater mains due to natural topography but can be served by the other party. The IGA identifies these properties, establishes responsibility for collection, treatment, and maintenance, and establishes charges and payment.

In 1985, OLWS and Clackamas County entered into another IGA to streamline the ability for OLWS to expose and maintain collections facilities located underneath County roads. The IGA establishes notification requirements for work or repairs to OLWS infrastructure impacting County roads, waives the cost of permits and other fees associated with use or occupancy of County road rights-of-way, and establishes conditions for work impacting County roads.

In 2003, OLWS and Clackamas WES (then Clackamas County Service District No. 1, Tri-City Service District, and Surface Water Management Agency of Clackamas County) entered into an IGA for resource sharing. The IGA establishes conditions for sharing equipment and labor in both emergency and non-emergency situations.

In 2017, OLWS and Clackamas WES entered into an IGA following the formation of Oak Lodge Water Services (formerly Oak Lodge Water District and Oak Lodge Sanitary District) and the formation of WES (formerly Clackamas County Service District No. 1 and Tri-City Service District). This IGA establishes an urban services agreement that outlines the jurisdiction for each of the entities for providing wastewater and surface water management services.

3.1.2 City of Gladstone

OLWS and the City of Gladstone established an IGA in 1971 following a lawsuit after the city annexed a portion of the area served by Oak Lodge Sanitary District No. 2. This agreement is known as the Interim Agreement and was between the City of Gladstone, Oak Lodge Sanitary District, and Oak Lodge Sanitary District No. 2. OLWS currently encompasses the latter two entities. The Interim Agreement established conditions for payment, ownership of facilities, and maintenance of facilities.

In 1990, the Interim Agreement was modified to indicate that OLWS has the authority and responsibility for overseeing pretreatment programs within areas in the City of Gladstone that are outlined in the revised agreement. The agreement was modified again in 2019 to clarify monthly service charges and hook-up fees. This 2019 modified agreement has been extended multiple times, the latest of which was in December 2020.I

In 2022, a proposed IGA draft was developed between the City of Gladstone and OLWS that establishes responsibility of each party over Gladstone-owned mains that convey wastewater to the OLWS WWTP. Under this proposed agreement, the City of Gladstone is responsible for operation, maintenance, and any necessary improvements to these pipelines. OLWS is responsible for treating the wastewater conveyed through these pipes at their WWTP. Although the City of Gladstone does have an industrial pretreatment program, there are no industrial customers contributing wastewater to the portion of the system that connects to OLWS. It is anticipated the IGA will be finalized in 2023.

3.1.3 City of Milwaukie

OLWS and the City of Milwaukie have entered into an IGA governing areas at each party's boundaries that are unable to be served by gravity wastewater mains due to natural topography but can be served by the other party. The current version of this IGA was executed in April 2015 and shall be in effect for 10 years, with the option to renew for additional periods of 5 years if both parties agree. The IGA establishes which properties outside of each party's boundary are to be served by the other party, the rates of service, and the charges associated with adding new connections to the other party's system. Under the IGA, the City of Milwaukie is responsible for the operation, maintenance, and any required improvements of the City-owned mains. OLWS is responsible for treatment of the wastewater conveyed through these mains.

3.2 Rules and Regulations

The following rules and regulations are relevant to the OLWS wastewater collection and treatment systems.

3.2.1 Oregon Administrative Rule, Chapter 660

Oregon Administrative Rule (OAR) 660-11 states "a city or county shall develop and adopt a public facility plan for areas within an urban growth boundary containing a population greater than 2,500 persons. The purpose of the plan is to help assure that urban development in such urban growth boundaries is guided and supported by types and levels of urban facilities and services appropriate for the needs and requirements of the urban areas to be serviced, and that those facilities and services are provided in a timely, orderly and efficient arrangement…". (State of Oregon) The public facilities and services chapter of Clackamas County's Comprehensive Plan fulfills this requirement for Clackamas County. This comprehensive plan recognizes OLWS as having responsibility to operate, plan, and regulate the wastewater system for their service area.

3.2.2 Oregon Administrative Rule, Chapter 340

OAR 340 establishes the authority of the Oregon Department of Environmental Quality (DEQ). Under Division 42, total maximum daily loads (TMDLs) are authorized for pollutants in waters of the state that are listed in accordance with the Federal Water Pollution Control Act, Section 303(d). In September 2006, DEQ established TMDLs for the Willamette Basin, which includes the mainstem Willamette River. In April 2022, DEQ issued a new NPDES Waste Discharge Permit for OLWS, which is covered in Section 3.2.5.

3.2.3 Oregon Revised Statute, Chapter 223

ORS 223 establishes the framework for OLWS to impose SDCs for capital improvement projects resulting from growth and development within the OLWS service area. Under this statute, an SDC can be imposed upon a developer to fund the proportional share of expenses for capital improvements resulting from the increased demands the development puts on the system. SDCs can be improvement fees for costs associated with capital improvements that must be constructed as a result of the development, reimbursement fees for costs associated with modifying capital improvements already constructed or under construction when the fee is established to accommodate the development, or a combination of the two. Prior to establishing a SDC, OLWS must prepare a plan that identifies a list of capital improvement projects that OLWS intends to fund wholly or in part with the revenue from the SDC, the estimated cost of the project, timing, and the percentage of costs eligible to be funded by the SDC. This WWMP will serve as this plan. SDCs are further discussed in Chapter 7.0.

3.2.4 Oregon Revised Statue, Chapter 450

ORS 450 governs all sanitary districts and authorities within the state of Oregon. This statute establishes the powers of OLWS including those to construct, operate, and maintain a wastewater collection system and wastewater treatment plant, the power to compel all residents and property owners within the OLWS service area to connect to their collection system, and the power to levy service charges for operating and maintaining their system. This statute also establishes the rules surrounding governance of OLWS including those regarding the election of a board, the qualifications for board members, the power of the board, and the ability to adopt regulations and ordinances.

3.2.5 NPDES Permit

The NPDES permit program was established by the Clean Water Act in 1972 to address water pollution by regulating point source discharges to waters of the United States. NPDES permits do this primarily by establishing effluent limitations for discharging into receiving waters. These limits can be both technology-based and water quality-based.

The U.S. EPA has delegated Oregon's DEQ to administer NPDES permit program in Oregon. on behalf of the federal government. In April 2022, DEQ issued a new NPDES Waste Discharge Permit (#100986) for OLWS that establishes permit requirements for the operation of wastewater collection and treatment and for the discharge of treated wastewater to the Willamette River. The discharge limits for the carbonaceous BOD_5 and TSS are summarized in Table 3-1.

Table 3-1: NPDES Permit Waste Discharge Limits

Parameter	Average Effluent Concentrations		Monthly Average (lb/d)	Weekly Average (lb/d)	Daily Maximum (lb/d)
	Monthly (mg.L)	Weekly (mg/L)			
May 1 – October 31					
Carbonaceous BOD_5	10	15	490	740	980
TSS	10	15	490	740	980
November 1 – April 30					
Carbonaceous BOD_5	30	45	2,600	3,900	5,200
TSS	30	45	2,600	3,900	5,200

The NPDES Permit includes additional limits for E. coli bacteria, pH, Carbonaceous BOD_5 and TSS permit removal, and temperature in the form of an excess thermal load.

3.2.6 National Pretreatment Program

The Environmental Protection Agency's (EPA) national pretreatment program is a component of the NPDES program and outlined under 40 code of federal regulations (CFR) §403.8. Under this program, local municipalities are authorized to perform permitting, administrative, and enforcement tasks for discharges into their publicly owned treatment works (POTWs). The goal of the program is to protect POTW infrastructure, protect worker health and safety, protect the biological processes at the treatment facility, protect receiving stream water quality, and enable beneficial use of biosolids.

40 CFR §403.8 applies to any POTW with a total design flow greater than five (5) million gallons per day (gpd); POTWs with design flow of less than 5 million gpd are also required to develop a pretreatment program if circumstances warrant. Schedule E of OLWS' NPDES Permit includes specific requirements for implementing the pretreatment program OLWS' pretreatment program requirements are outlined in the OLWS Rules and Regulations dated January 15, 2021. All industrial users are required to comply with federal categorical pretreatment standards, state requirements and the local limits for contaminants identified in the regulations.

3.3 Potential Future Regulatory Considerations

To support long-term planning, particularly for the WWTP, West Yost prepared a white paper to forecast and identify potential future regulations that could impact the OLWS wastewater system. The following regulatory issues are still in the development stage, but should be monitored by OLWS for potential future requirements that could be incorporated into an NPDES permit upon renewal:

- Per and Poly fluoroalkyl Substances (PFAS). EPA has issued a roadmap that identifies several actions that are planned between 2021 and 2024 to address the risk posed by these chemicals. NPDES permit-related actions include establishing monitoring requirements, restricting PFAS discharges from industrial sources, publishing recommended ambient water quality criteria for PFAS, and finalizing risk assessments for two of the PFAS compounds of concern (PFOA and PFOS) in biosolids. Future restrictions could affect the land application of biosolids.
- Coliphage criteria. In 2015, EPA published a review of coliphages as a possible indicator of fecal contamination for surface waters. While EPA has not published draft coliphage criteria and to date, has not defined a schedule for publishing, this topic is often listed as an EPA priority. Effluent limits based on coliphage criteria are likely still several years away, however the application of the criteria could affect the disinfection technology used at the WWTP.
- Nutrients. Nutrients are a key issue at the state and national level and the OLWS WWTP discharges into a portion of the Willamette River that is listed for biocriteria. The next downstream portion of the Willamette River is listed for both biocriteria and harmful algae blooms. DEQ has not evaluated the conditions in the river to determine if it is nitrogen or phosphorous limited. However, upstream tributaries have been found to be phosphorous limited. Because of the multitude of point and non-point sources that contribute nutrients to the Willamette River basin, a TMDL process will be necessary to define waste load allocations and establish future treatment requirements. OLWS should consider the incorporation of nutrient removal technology (both phosphorous and nitrogen) to WWTP processes in the 30-year WWMP planning period.
- Wet Season Operations. Bypass, which is defined as an intentional diversion from any portion of the treatment facility, is allowed for essential maintenance provided effluent limits are not exceeded. NPDES permits continue to include a requirement prohibiting bypass of any portion of the treatment facility except when it is unavoidable to prevent loss of life, personal injury or severe property damage. This is not a significant issue for OLWS as the WWTP has the hydraulic capacity to treat wet weather flows and does not bypass secondary treatment facilities.

Additional details on the existing regulatory framework for the WWTP and considerations for future regulations are provided in Appendix D.

4.0 Wastewater Flows and Loads

The following sections of this chapter identify the existing wastewater flows within the OLWS collection system and WWTP and describe the method for projecting future flows. The chapter will cover determination of the existing system flow through the analysis of flow monitoring results, water consumption billing records, and land use data; projected future flows using the OLWS' updated buildable lands inventory (BLI); and comparison with anticipated population growth projections. Based on the flow analysis, wastewater treatment plant flows and loadings were developed.

IN THIS SECTION

- Elements of Total Wastewater Flow
- Base Wastewater Flows
- Wet Weather Flows
- Flow Summary
- Treatment Plant Flows and Loadings

PREPARED BY:

WSC

4.1 Elements of Total Wastewater Flow

To evaluate the hydraulic performance of the wastewater collection system, the volume of wastewater flow entering the system must be estimated. Wastewater flows consist of three general components: base wastewater flow (BWF), groundwater infiltration (GWI), and rainfall derived infiltration and inflow (RDII), as shown in Figure 4-1.

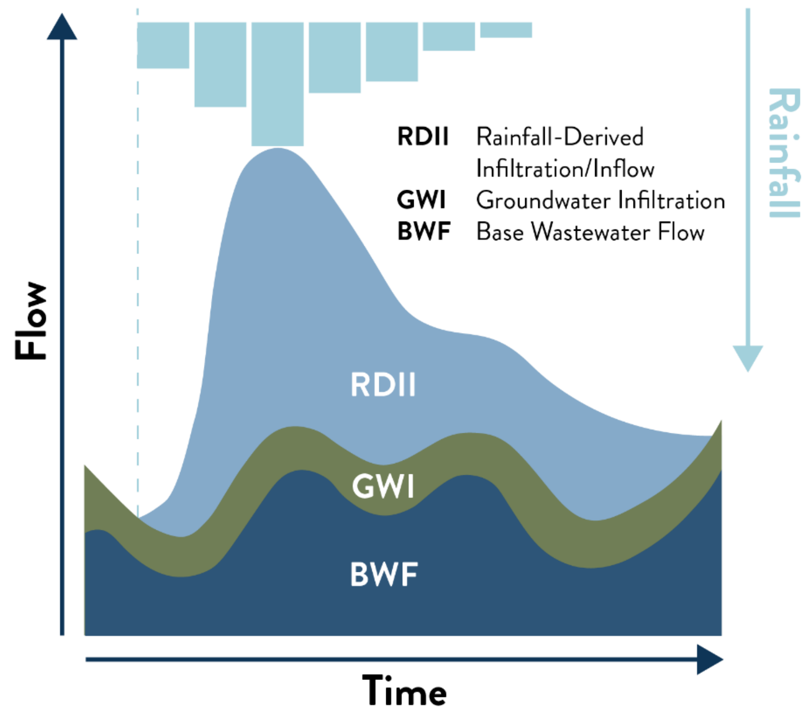


Figure 4-1: Components of Wastewater Flow

Base Wastewater Flow: Represents wastewater flow entering the system from service connections under normal conditions (i.e., no rain). BWF typically follows a diurnal pattern based on customer's water consumption patterns with typical peaks in the morning and the evening.

Groundwater Infiltration: A form of flow that consists of groundwater entering the wastewater collection system through faulty pipe joints, cracks in the pipe, and cracks in manhole walls. GWI occurs when the groundwater table is higher than the pipe invert, varies based on the level of the groundwater table, and is often seasonal due to the groundwater table fluctuating throughout the year. GWI is relatively constant over a short time period as the fluctuations in groundwater elevation outside of precipitation events are relatively slow. GWI allocation within OLWS' collection system is further discussed in Section 4.3.2.

Rainfall-Derived Infiltration and Inflow: Represents the portion of wastewater flow that results from inflow and infiltration following a rainstorm. Inflow occurs when stormwater rapidly flows into the wastewater collection system during and following a rain event, such as through holes in manhole covers or from storm drain cross connections. Infiltration occurs when rain temporarily saturates the soil surrounding wastewater pipes during and for a period after a storm, and infiltrated stormwater seeps into the wastewater pipes through faulty pipe joints, cracks in the pipe, and cracks in the manhole walls.

4.2 Base Wastewater Flows

The following sections describe the methods used to identify existing and future BWF.

4.2.1 Existing Base Wastewater Flow

The calculation of the BWF was derived from dry weather flow monitoring at the OLWS WWTP that was spatially distributed across the service area proportional to wintertime water use derived from billing records. The following sections describe the methods used to develop diurnal curves for BWF and the allocation of those flows across the collection system.

4.2.1.1 Total Base Wastewater Flow

The total volume of BWF can be calculated using dry weather flow data for the collection system captured as the sum of the WWTP Influent Lift Station (ILS) flow meters, located on the discharge side of the influent pumps. The pump controls maintain a water surface elevation in the ILS wet well within a 4-foot range by adjusting pump speeds using variable frequency drives and turning on additional pumps to run in parallel and keep up with variations in the influent flow coming into the wet well. Thus, the totalized hourly pump discharge volumes divided by time during dry weather are representative of the hourly flow rates entering the WWTP from the collection system.

To determine the total BWF, the available ILS flow data and rain gauge data collected at the WWTP were analyzed to identify periods with good flow meter data and dry weather. Dry weather was defined as periods with no active rain and no rain for a 14-day period prior to the start date of the selected time window. Upon reviewing rainfall and flow meter data, the window of July 8, 2021 through July 28, 2021 was selected as the representative dry weather period and the average flow over this time was calculated to be 1.85 million gallons per day (mgd). Analysis across a longer time period found that the average daily flow at the WWTP in the month of August, historically the month with the minimum flow within the calendar year, was 1.86 mgd from 2019 to 2021. Based on these data, the current (2022) total BWF across the OLWS service area is assumed to be 1.85 mgd.

4.2.1.2 Diurnal Curves

Once the total BWF was determined for the collection system, diurnal multipliers were assigned to each hour to estimate the variability of the wastewater flow over a typical day. Using the hourly data from the ILS flow meters during the dry weather period, WSC identified a diurnal curve factor for each hour by dividing the average flow from that hour by the average daily flow. The diurnal curve was developed by multiplying each hourly factor by the average dry weather flow and plotting the results over time. The resulting diurnal curve pattern and peak flows are shown in Table 4-1 and Figure 4-2. Additional information can be found in Appendix E– Model Development TM.

Table 4-1: Peaking Factors

Average Dry Weather Flow (MGD)	Peak Diurnal Multiplier	Minimum Diurnal Multiplier
1.85	1.31	0.52

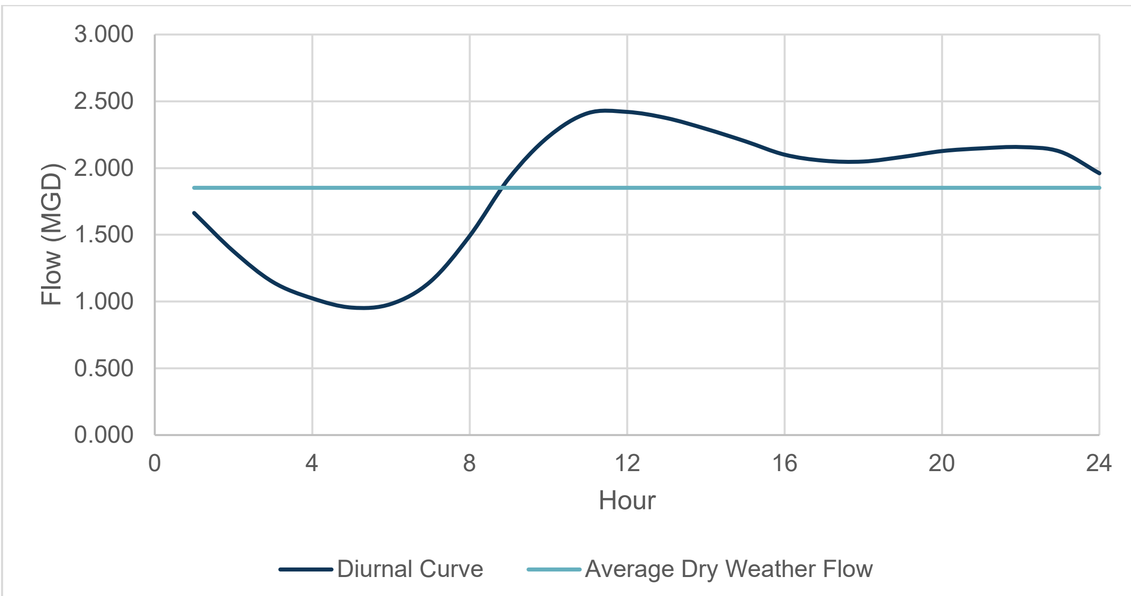


Figure 4-2: Diurnal Curve for Collection System Flow

Total flow and diurnal curves calculated for the dry weather period in 2021 were checked against WWTP data from 2019, prior to the COVID-19 pandemic, to determine if current flows demonstrated any notable changes in diurnal wastewater generation patterns that might indicate a shift in household water use. No significant variations were identified between the 2019 and 2021 diurnal curves so the calculated hourly peaking factors were applied to estimate current and future wastewater generation throughout the day.

4.2.1.3 Wastewater Generation Factors

Because wastewater connections do not have flow meters, the allocation of wastewater flows geospatially across the OLWS service area and between different types of land use zoning classifications was completed using wet weather potable water consumption which makes up the vast majority of base wastewater flows in the winter months. The process of doing this is summarized in Figure 4-3.

The water consumption data included monthly consumption for 7,218 customer connections (6,743 parcels) within the OLWS water service area. Water billing records were not available for parcels within the City of Gladstone, as these are not served by the OLWS water system. Billing data associated with fire service meters and open space parcels was excluded from the analysis as these special cases of water use do not contribute flows to the wastewater collection system. The water consumption for each account was averaged from December through March over the past 3 years to provide an estimate of average daily winter water usage for each account.

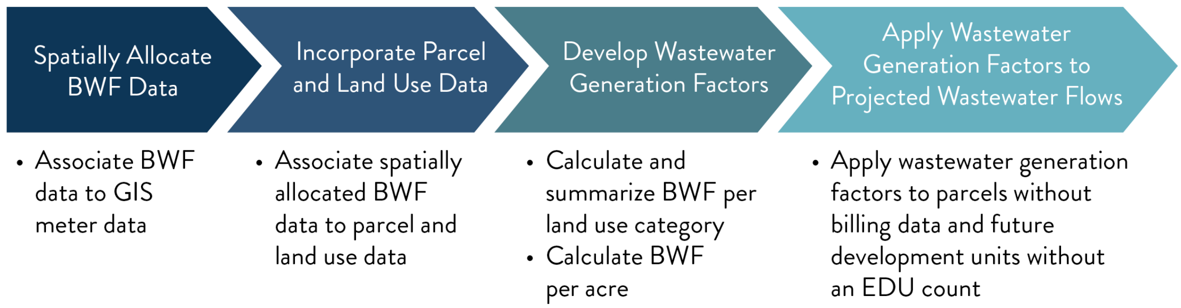


Figure 4-3: Allocation of Wastewater Flows

Not all water used gets flushed down the drain afterwards. Some, for instance, may be used outdoors for washing or irrigation and there may be minor leakages from premise pipes on the customer side of the meter. The portion of water used that contributes flow to the wastewater collection system, expressed as a percentage, is applied to the average daily winter water usage to estimate the volume of BWF generated from each metered water account. These water to wastewater conversion percentages vary slightly according to land use and were determined by iterating around typical values by land use until the predicted BWF aligned with the actual BWF. For this project, the following ranges were used based on typical values and iterations:

- Single Family Residential: 90% of water use returns as wastewater
- Multi-Family Residential: 96% of water use returns as wastewater
- Non-Residential: 95% to 100% of water use returns as wastewater

The multi-family residential and non-residential properties have higher water to wastewater percentages as these land uses typically have less landscaping and irrigation piping relative to the total water consumption.

The metered water consumption and the water to wastewater conversions were used to estimate BWF for all parcels with an OLWS water connection. As previously mentioned, water consumption records were not available for all wastewater customers within the OLWS wastewater service area as some of these parcels receive water from the City of Gladstone. Wastewater customers outside of the water service area were assumed to contribute BWF at a rate equivalent to the average rates calculated across all customers in the same land use category that have metered water accounts.

Wastewater generation flow factors for each land use type were developed to project flows for customers without water billing records as well as for future development. Flow factors were developed using the following process:

1. Establish water to wastewater conversion percentages for each land use type based on typical values by land use (discussed above).
2. Apply the water to wastewater conversion percentages to all parcels with water meter records (6,743 parcels) to estimate the BWF in these parcels.
3. Sum the total flow by land use type and the total area by land use type. Calculate each wastewater generation factor by dividing the total BWF for that land use by the total area of that land use. Each average wastewater generation flow factor is in terms of gallons per acre per day (gpad).
4. Estimate wastewater flow in the remaining 1,496 parcels without water billing data by multiplying the parcel's area by the appropriate wastewater generation flow factor.
5. Iterate water to wastewater conversion percentages (and thus wastewater generator flow factors) until the estimated BWF is within 0.1 percent of the total BWF at the WWTP of 1.85 mgd.

The wastewater generation factors are provided in Table 4-2 and summarized comprehensively in column E of Table 4-4.

Table 4-2. Wastewater Generation Factors

Land Use Type	Wastewater Flow Factor (gpad)
General Commercial (GC)	975
Neighborhood Commercial (CN)	710
Light Industrial (IL)	600
Mixed Use -Low Density (MUR3)	129[1]
Mixed Use – Moderate Density (MUR7)	2,439[1]
Parks and Open Space (POS)	80
Multifamily – Very Low Density (MFR1)	1,306
Multifamily – Moderate Density (MFR3)	3,500
Single Family – ½ acre (SFR2)	225
Single Family – 10,000 SF (SRF3)	396
Single Family – 9,000 SF (SFR4)	414
Single Family – 7,000 SF (SFR5)	581
Single Family – 6,000 SF (SFR6)	738

gpad = gallons per acre per day

[1]Mixed use wastewater flow factors have a high sensitivity as there was only 1 parcel of MUR3 and 1 parcel of MUR7 within the service area.

Wastewater flows can also be described in terms of an equivalent dwelling unit (EDU). An EDU is a unit of measure that represents the typical demand on OLWS facilities from a typical single-family dwelling and is associated with an average gallons per day (gpd) flow. To determine the flow per EDU, the BWF for all single-family residential land use zones with metered potable water connections was divided by the total number of dwellings associated with each account within the OLWS billing system. The flow per EDU is provided in Table 4-3.

Table 4-3. Wastewater Flow per Equivalent Dwelling Unit

Land Use Type	Total BWF Calculated from Water Meter Records (gpd)	Number of EDUs	Average Flow per EDU (gpd)
Single Family – ½ acre (SFR2)	5,153	38	136
Single Family – 10,000 SF (SRF3)	460,342	3,475.5	132
Single Family – 9,000 SF (SFR4)	84,427	630	134
Single Family – 7,000 SF (SFR5)	255,829	2,036.5	126
Single Family – 6,000 SF (SFR6)	11,379	81	140
Total All Single-Family	817,129	6,261	131

BWF = base wastewater flow gpd = gallons per day EDU = equivalent dwelling unites

The calculated flow per EDU can be used with population data to calculate total system flows. Population projections based on United States Census data estimate the average household within the OLWS service area consists of 2.36 people (see Section 4.2.3). In addition, the wastewater flow per person is typically estimated at 55 gallons per capita per day (gpcd). This value is consistent with published values for residential wastewater generation per capita, including a similar estimate within the Clackamas Water Environment Services' (WES) Sanitary Sewer Master Plan of between 54 and 67 gpcd within the WES service area (WES, 2019).

The purpose for calculating EDU flow rates is to support growth analysis for future buildout of the system. Land use estimates are based on zoning and acreage, and typically estimate the number of units the land can support. By knowing the flow per unit (EDU) the correlation between available land and wastewater flow rates can be determined, as described in Section 4.2.5.

A summary of the total existing BWF and resulting EDUs across each land use type is provided in Table 4-4. As described above, the existing wastewater flow was geospatially allocated across the OLWS wastewater service area within a collections system hydraulic model in accordance with winter weather potable water meter data (where available) and land use classifications. Additional information on the spatial allocation of flows and the calculation of wastewater generation factors are included in Appendix E– Model Development TM.

Table 4-4. Existing Wastewater Flows in 2022 within the Oak Lodge Water Services Wastewater Service Area

Wastewater Generation Factors

Column		A	B	C	D	E	F	G	H	I
Column Formula				C=A*B				G=E*F	H=C+G	I=H/136
Land Use Code	Land Use Classification	Winter Water Consumption from Billing Records (gpd)[1]	Water to Wastewater Conversion (%)	Estimated BWF Based on Water Meter Data (gpd)	Area with Water Meter Data (Acres)	Wastewater Generation Factor[2] (gpad)	Area without Water Meter Data (acres)	Estimated BWF Based on Land Use (gpd)	Total Existing BWF (gpd)	Equivalent Dwelling Units (EDUs)[3]
Residential										
SFR2	Single Family – ½ acre tax lot	5,726	90	5,153	22.9	225	0.6	129	5,282	40
SFR3	Single Family – 10,000 sq ft lot	511,491	90	460,342	1,163.1	396	82.1	32,523	492,865	3,762
SFR4	Single Family – 9,000 sq ft lot	93,808	90	84,427	203.8	414	12.5	5,158	89,585	684
SFR5	Single Family – 7,000 sq ft lot	284,254	90	255,829	440.6	581	31.8	18,455	274,283	2,094
SFR6	Single Family – 6,000 sq ft lot	12,643	90	11,379	15.4	738	168.1	124,037	135,416	1,034
MFR1	Multifamily – Very low Density	196,715	96	188,847	143.1	1,306	19.8	25,879	214,725	1,639
MFR3	Multifamily – Moderate Density	157,202	96	150,914	39.0	3,500	31.3	109,447	260,361	1,987
	Residential Subtotal	1,261,839		1,156,891	2,027.9		346.1	315,628	1,472,517	11,240
Non-Residential										
CG	General Commercial	310,799	96	298,367	302.7	975	44.5	43,372	341,739	2,609
CN	Neighborhood Commercial	1,372	100	1,372	2.3	710	0	0	1,372	10
IL	Light Industrial	16,092	100	16,092	33.3	600	5.2	3,145	19,237	147
MUR3	Mixed Use – Low Density	125	95	119	0.9	129	0	0	119	1
MUR7	Mixed Use – Medium Density	13,939	95	13,242	5.4	2,439	0	0	13,242	101
POS[4]	Parks and Open Space (Includes Schools)	5,149	95	4,892	56.1	80	9.8	781	5,673	43
	Non-Residential Subtotal	347,476		334,084	400.7		59.5	47,297	381,382	2,911
	Total	1,609,315		1,490,975	2,428.6		405.6	362,926	1,853,899	14,151

[1] Daily winter water consumption was calculated from the average water meter records from December-March between 2018-2020 within the OLWS water service area.

[2] Wastewater generation factors were iteratively adjusted from values calculated within the water service area to obtain a total BWF for the collection system within 0.1% of the 1.85 MGD observed at the WWTP in July 2021.

[3] The total number of EDUs includes all parcels within OLWS' wastewater service area. The number of EDUs for non-residential customers is calculated specifically for this master plan.

[4] The POS land use code is the zoning code associated with schools. The water use and subsequent wastewater load in the table is representative solely for schools served by OLWS. Parks and other open spaces have been omitted even if they have water use as this is all assumed to be outdoor water use that will not contribute to the wastewater collection system.

gpd = gallons per day BWF = base wastewater flow gpad = gallons per acre per day EDU = equivalent dwelling unit OLWS = Oak Lodge Water Services mgd = million gallons per day WWTP = wastewater treatment plant

4.2.2 Buildout Lands Inventory

To assess the capacity for future residential and commercial capacity within the Oak Lodge service area, a Buildable Lands Inventory (BLI) was prepared by Angelo Planning Group for this master plan. The BLI investigated three potential avenues for growth within the OLWS' wastewater service area: buildout development of vacant and partially vacant properties (4.2.2.1), infill development as a result of middle housing additions (4.2.2.2), and commercial property redevelopment (4.2.2.3). Each is described below, and the BLI Technical Memorandum is provided as Appendix F.

4.2.2.1 Buildout Development

Property data provided by Clackamas County was reviewed within the OLWS' wastewater service area to determine the vacant acreage within the OLWS wastewater service area that could support future development. Individual parcels were placed into three distinct categories:

- **Developed**. Includes parcels with less than ½-acre or which meet the criteria to be considered fully developed based on the size, zoning, and current level of development of the property.
- **Vacant**. Includes residential zoned lots with an existing improvement value of less than $10,000 and non-residential lots that could be rezoned for residential use.
- **Partially Vacant**. Includes parcels greater than ½-acre with an existing dwelling that could support additional residences, based on allowable developed density per land use zone.

The developable acreage of vacant and partially vacant properties was further analyzed to determine the net developable acreage. Vacant acreage with steep slopes exceeding 25% or environmental constraints associated with riparian or upland habitats were assumed to constrain the ability to develop and the developable acreage was adjusted accordingly. A summary of the review of parcel data is provided in Table 4-5.

Table 4-5. Summary of BLI Vacant Parcel Analysis

Development Status	Number of Lots	Gross Acres	Vacant Acres	Net Developable Acreage	Future Residential Unit Capacity
Residential					
Developed Land	7,733	2,098.1	0	0	0
Partially Vacant	475	429.4	232.1	200.4	1,018
Vacant	227	91.0	63.0	57.7	308
Non-Residential					
Developed	308	301.3	0	0	0
Vacant	11	6.9	4.9	4.3	0
Totals	8,754	2,926.7	300	262.4	1,326

[1] Parcel analysis taken from Buildable Land Inventory Technical Memorandum (Angelo Planning Group, 2022)

4.2.2.2 Middle Housing

In 2019 the Oregon State Legislature passed House Bill (HB) 2001 which contains numerous provisions related to the development of "middle housing", defined as duplexes, triplexes, quadplexes, townhomes, and cottage clusters. HB 2001 requires that middle housing development be allowed on all residential lots that allow a single family detached dwelling with discretion given to local jurisdictions regarding the approved siting and design. Based on conversations with Clackamas County, the following assumptions were made to account for increased densification from middle housing allowed due to the passing of HB 2001:

- **Buildout Development Middle Housing.** The development of vacant or partially vacant properties could be middle housing rather than detached single family homes. To account for this potential, 25 percent of vacant or partially vacant properties are assumed to develop at an increased density.
- **Infill Development of Single-Family Properties.** Approximately 5 percent of developed parcels zoned for single-family land use will add an average of 1.5 additional units per parcel.

To account for increased densification due to middle housing allowed by HB 2001, the OLWS service area has the capacity for an additional 809 residential units. The calculation for the number of additional residential units was developed using parcel data provided by Clackamas County and is explained in more detail within the BLI TM provided in Appendix F.

4.2.2.3 Commercial Redevelopment

In discussions with Clackamas County, several parcels in the vicinity of the SE Park Avenue Transit Station were identified for an increased potential of redevelopment to provide multifamily housing. The County is considering changes to zoning maximums to allow up to 60 units per acre near the transit station. The BLI study found nearly 10 acres of underutilized parcels adjacent to the transit station that could redevelop and provide an additional 400 residential units. The BLI study also indicated a potential for additional commercial redevelopment throughout the service area, but this would require additional zoning changes and it is not clear which, if any, commercial properties would be most likely to develop. Given the challenges in predicting the location and nature of these future zoning changes, only the redevelopment around the transit center is included in the BLI estimates of additional housing unit capacity.

4.2.3 Population Estimates

The Portland State University (PSU) Population Research Center provides annual estimates of population within the OLWS water system service boundary each year based on available census data. The most recent estimate is for the year 2020 and the estimate was completed in May of 2021. Estimates are based on the April 1, 2010 census data, with each subsequent year based on a statistical estimate for population as of July 1st of each year. The 2020 census demographic and housing characteristics data is scheduled to become available in 2023 and will allow PSU to update the annual population estimates. WSC has estimated the populations statistics through 2022 based on the average growth rates in the PSU estimates. The estimated historical population data from 2010 to 2022 for the OLWS service area is provided in Table 4-6 below.

Over the 10-year period from 2010 to 2020, the population is estimated to have grown at an average annual rate of 0.4 percent within the OLWS water service area. The OLWS water service area has not experienced substantial growth over the past decade.

The PSU Population Research Center also provides forecasts, research and analysis of population and demographics across the state of Oregon and has prepared future population forecasts within the OLWS water service area through the year 2050. Populations forecasts for OLWS are provided in 5-year increments, beginning with the estimated population for 2025, in Table 4-7.

The population forecasts indicate a gradual reduction in persons per household and annual growth rate over the next 30 years. A total of 1,431 new households are forecast to be added within the OLWS water service area between 2022 and 2050. Note that the water service area is smaller than the wastewater service area, which includes a portion of the City of Gladstone.

Table 4-6. Portland State University Annual Historical Population Estimates for Oak Lodge Water Service Area

Year[1]	Population	Household Population	Households	Persons per Household	Annual Growth Rate
2010	27,340	26,932	11,323	2.38	NA
2011	27,433	27,025	11,345	2.38	0.3%
2012	27,494	27,086	11,365	2.38	0.2%
2013	27,549	27,141	11,388	2.38	0.2%
2014	27,608	27,200	11,413	2.38	0.2%
2015	27,654	27,246	11,478	2.37	0.2%
2016	27,820	27,412	11,548	2.37	0.6%
2017	27,950	27,542	11,626	2.37	0.5%
2018	28,072	27,664	11,701	2.36	0.4%
2019	28,313	27,905	11,827	2.36	0.9%
2020	28,459	28,051	11,889	2.36	0.5%
2021[2]	28,575	28,166	11,938	2.36	0.4%
2022[2]	28,692	28,281	11,987	2.36	0.4%

[1] 2010 Census data allocated to service area. Years 2011 through 2020 estimated population on July 1st by PSU Population Research Center.

[2] WSC estimate based on average growth rate of 0.41% between 2010 and 2020 PSU data.

Table 4-7. Future Population Forecasts for Oak Lodge Water Service Area

Year	Population	Household Population	Households	Persons per Household	Annual Growth Rate
2025	29,383	28,939	12,274	2.36	0.57%
2030	30,118	29,647	12,597	2.35	0.50%
2035	30,706	30,209	12,848	2.35	0.39%
2040	31,069	30,547	13,031	2.34	0.24%
2045	31,455	30,910	13,226	2.34	0.25%
2050	31,833	31,264	13,418	2.33	0.24%

[1] Forecasts provided by Portland State University Population Research Center (May 2022).

4.2.4 Future Population Growth Summary

The BLI results indicate a potential capacity for 2,535 additional residential units within the OLWS wastewater service area, compared to a forecasted increase of 1,431 additional households from the PSU Population Research Center. The PSU forecasts are limited to the 2019 water service area boundary though, while the wastewater service area boundary that formed the basis for the BLI includes the northwestern portion of the City of Gladstone. Although the two approaches represent different boundary conditions, they can be compared in terms of annual growth rate. The PSU forecasts through 2050 assume an average annual growth rate of 0.4 percent, while the BLI would result in an average annual growth rate of 0.77 percent if the full development capacity was realized by 2052, or 30 years from the writing of this chapter.

The capacity for additional residential housing units identified in the BLI appears to be more conservative than the PSU forecasts for the year 2050, but not excessively so. For the purposes of projecting future wastewater system loading within the OLWS service area, WSC recommends using the assumption that the full BLI capacity will be developed by the year 2052. A summary of the assumed growth is provided in Table 4-8.

Table 4-8. Population and Growth Projections for Wastewater Master Plan.

Projected Growth by 2052	Population	Households	Annual Growth Rate
Additional Buildout Development	3,129	1,326	--
Additional Middle Housing Densification	1,909	809	--
Additional Commercial Redevelopment	944	400	--
Totals	**5,982**	**2,535**	**0.77%**

4.2.5 Buildout Base Wastewater Flow

The BLI identified which parcels will have future development and infill. To determine buildout BWF, the wastewater generation factor per EDU (Table 4-3) was applied to the additional units identified in the BLI. Parcels without new development or redevelopment were assumed to have the same loading as their existing load. Parcels with additional units were assigned a new load that was the sum of the existing load and the load associated with the additional units. For the purposes of estimating buildout loads, all new residential units were assigned a load of 131 gpd/EDU per Table 4-3. A summary of the additional buildout flows is provided in Table 4-10 and a summary of all flows is provided in Table 4-9.

While the majority of the growth in the OLWS wastewater service boundary is anticipated to come from residential households, there were also 11 commercial and light-industrial vacant properties that are not expected to be rezoned to residential use but could be developed in the future. Buildout flows were estimated for these parcels using the appropriate land use zoning wastewater generation factors per acre (Table 4-4). Additional information on the buildout loading can be found in Appendix E – Model Development TM.

Table 4-9. Existing and Projected Buildout Wastewater Flows for OLWS Wastewater Service Area - 2022 to 2052

Existing and Projected Future Flows

Land Use Code	**Land Use Description**	**Existing BWF (gpd)**	**Existing EDUs**	**Additional Buildout BWF (gpd)**	**Future Middle Housing BWF (gpd)**	**Commercial Redevelopment BWF (gpd)**	**Total Additional Future BWF (gpd)**	**Total Existing and Future Buildout BWF (gpd)**	**Total Existing, Future Buildout, and Middle Housing BWF (gpd)**	**Total Existing, Future Buildout, Middle Housing, and Commercial Redevelopment BWF (gpd)**	**Buildout EDUs**
SFR2	Single Family – ½ acre tax lot	5,282	40	2,620	950	0	3,570	7,902	8,852	8,852	68
SFR3	Single Family – 10,000 sq ft lot	492,865	3,762	88,425	51,054	0	139,479	581,290	632,344	632,344	4,827
SFR4	Single Family – 9,000 sq ft lot	89,585	684	20,305	11,004	0	31,309	109,890	120,894	120,894	923
SFR5	Single Family – 7,000 sq ft lot	274,283	2,094	29,344	27,271	0	56,615	303,627	330,898	330,898	2,526
SFR6	Single Family – 6,000 sq ft lot	135,416	1,034	7,336	9,380	0	16,716	142,752	152,132	152,132	1,161
MFR1	Multifamily – Very low Density	214,725	1,639	21,091	5,175	0	26,266	235,816	240,991	240,991	1,840
MFR3	Multifamily – Moderate Density	260,361	1,987	4,585	1,114	0	5,699	264,946	266,060	266,060	2,031
	Residential Subtotal	**1,472,517**	**11,240**	**173,706**	**105,948**	**0**	**279,654**	**1,646,223**	**1,752,171**	**1,752,171**	**13,376**
CG	General Commercial	341,739	2,609	3,560	0	52,400	55,960	345,299	345,299	397,699	3,036
CN	Neighborhood Commercial	1,372	10	0	0	0	0	1,372	1,372	1,372	10
IL	Light Industrial	19,237	147	1,599	0	0	1,599	20,836	20,836	20,836	159
MUR3	Mixed Use – Low Density	119	1	0	0	0	0	119	119	119	1
MUR7	Mixed Use – Medium Density	13,242	101	0	0	0	0	13,242	13,242	13,242	101
POS	Parks and Open Space (Includes Schools)	5,673	43	0	0	0	0	5,673	5,673	5,673	43
	Non-residential Subtotal	**381,382**	**2,911**	**5,159**	**0**	**52,400**	**57,559**	**386,541**	**386,541**	**438,941**	**3,350**
Totals (gpd)		**1,853,899**	**14,151**	**178,865**	**105,948**	**52,400**	**337,213**	**2,032,764**	**2,138,712**	**2,191,112**	**16,726**

BWF = base wastewater flow gpd = gallons per day EDU = equivalent dwelling unit

Table 4-10: Additional Loading at Buildout

Additional Unit Source	Additional Residential Units	Additional Residential Flow (gpd)	Additional Non-Residential Flow (gpd)[1]	Additional Load at Buildout (gpd)[2]
Buildout Development	1,326	173,706	5,159	178,865
Middle Housing	809	105,948	0	105,948
Commercial Redevelopment	400	52,400	0	52,400
Total	2,535	332,054	5,159	337,213

[1] Non-residential future flows were estimated using appropriate wastewater generation factors in Table 4-2 & Table 4-4.
[2] All residential units were assigned a load of 131 gpd/EDU

gpd = gallons per day

4.3 Wet Weather Flows

Determining the wet weather flow consisted of establishing the level of GWI, developing hydrographs (RTK parameters) for modeling RDII response to a monitored rain event, selecting an appropriate design storm, and estimating RDII under the design storm conditions. Flow monitoring throughout the collection system was used to establish parameters for determining these elements of wet weather flow.

4.3.1 Flow Monitoring

Flow monitoring was conducted at eight locations (Figure 4-4) within OLWS' collection system from December 18, 2021 through February 28, 2022 to capture data on wet weather flows. Flow monitoring locations were strategically selected to balance the need for a constant minimum depth of flow required for the meters yet subdividing the service area sufficiently to identify areas where higher volumes of GWI and RDII are entering the system. Additional information on the flow monitoring procedures and analysis of the flow monitoring data can be found in Appendix G – Flow Monitoring TM.

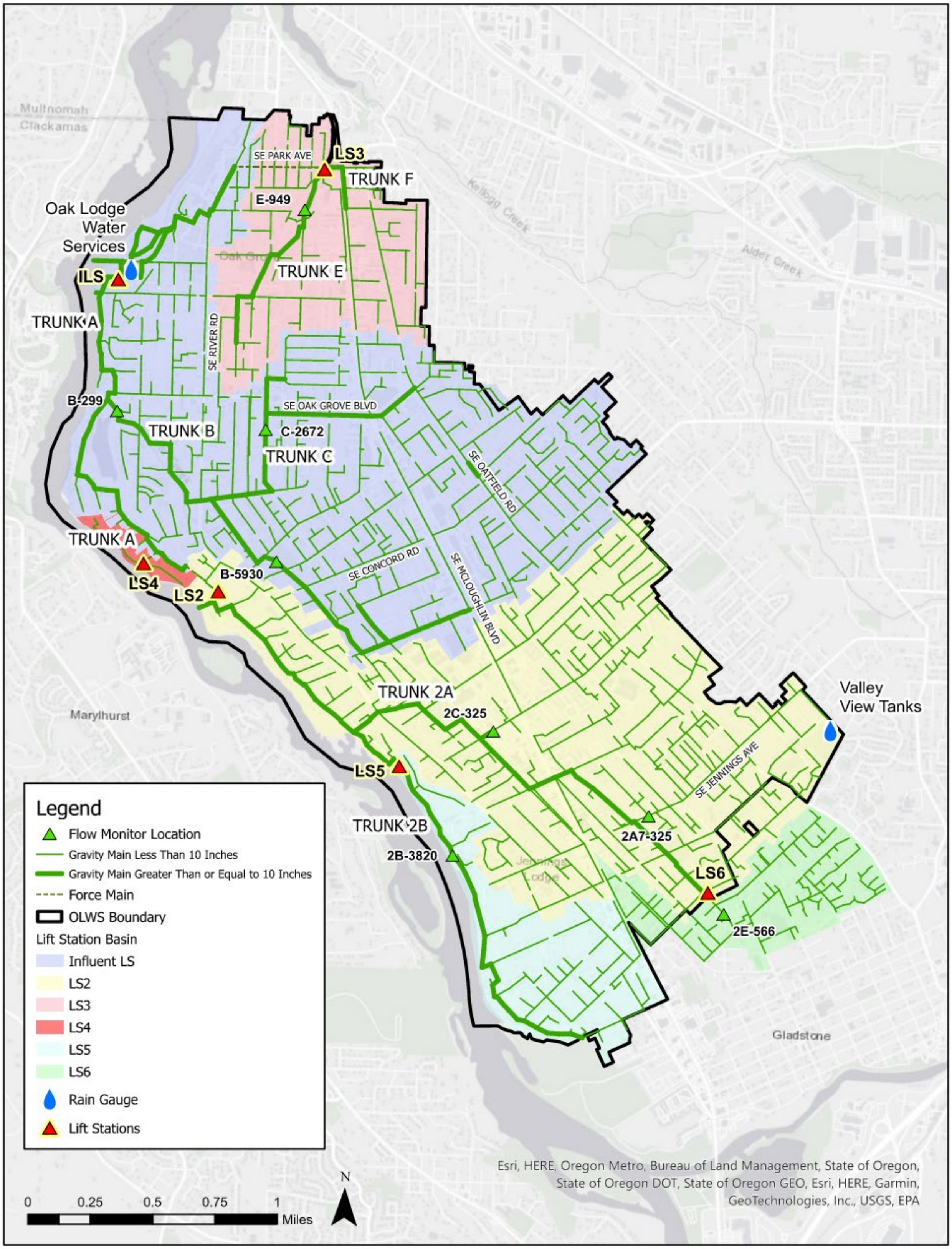


Figure 4-4: Flow Monitor Locations

4.3.2 Groundwater Infiltration

The elevation of the groundwater table within OLWS' service area fluctuates seasonally. During the winter months the elevation is increased and can cause additional GWI to enter the collections system piping when the groundwater elevation rises above the invert elevations of the pipes and manholes. To determine the volume of GWI entering the system during the wet season, the average daily wet weather flow at the ILS was calculated during the wet winter months for a period where no rainfall occurred. Average daily wet weather flow during no rain was then compared to the BWF to determine the portion of the flow that can be attributed to GWI. The winter period of January 23 - 29, 2022 was selected to perform the calculation as no rain fall was observed during this time period, good flow meter data was available for the total wet weather flow at the WWTP from ILS meters, and good flow monitoring data was available within the collection system.

To estimate total GWI for the collection system, the BWF was subtracted from the wet weather flow during the period of no rainfall in January 2022. To better understand how the GWI contribution is spread throughout the collection system, the modeled BWF at each of the flow monitoring locations was subtracted from the daily average wet weather flows during this dry period. The ratio of GWI to BWF was applied to any areas that were not captured with flow monitoring data and minor adjustments were made so that the total observed GWI across the system correlated to the total flow at the WWTP during the same period. A summary of the GWI allocation by basin is shown in Table 4-11. For the purposes of the hydraulic model, the total GWI for a basin was spread equally amongst all the manholes within that basin.

GWI is anticipated to remain relatively constant over time unless significant improvements to large portions of the collection system are implemented. The volume of GWI is dependent upon the depth of the groundwater table as well as the condition and extents of the collection system. Anticipated growth within the OLWS wastewater service area is primarily infill and will not substantially increase the extents of the system. As the collection system ages and condition of individual assets deteriorate, the volume of GWI is expected to increase. OLWS plans to make repairs to the collections system based on ongoing condition assessments such that the rate of repairs that reduce GWI will offset the rate of degradation of existing piping such that in total across the collection system there will be no significant increase in the amount of GWI over time. For the assumption of constant GWI over time to remain appropriate, OLWS must continuously assess and repair pipes and manholes with observed condition deficiencies.

Table 4-11: Estimated Groundwater Infiltration

Basin	Estimated GWI (gpd)	Estimated GWI (gpad)
ILS	143,576	154.1
LS2	489,438	655.2
LS3	232,881	1,040.2
LS4	9,789	783.6
LS5	110,216	736.5
LS6	63,846	437.4
Total	**1,049,746**	**474.8**

gpd = gallons per day   gpad = gallons per acre per day
The ILS Basin represents all piping served solely by the ILS as shown in Figure 4-4

4.3.3 Wet Weather Hydrograph Development

Wet weather flow monitoring was used to capture rainstorm data and understand how flows within the OLWS collection system respond to a storm. The goal of this monitoring was to capture a system stressing rain event to understand RDII within OLWS's collection system. According to ADS Environmental, "system stressing events are typically more than one inch of rainfall in a 24-hour period." (Gettring More From Flow Monitoring - Interpreting Sewer Flow Data to Yield the Maximum Benefit, 2005) Table 4-12 shows the results of the top storms captured during the monitoring period.

Table 4-12: Top Five Rain Events (24 Hour) by Total Rain During Wet Weather Flow Monitoring

Period	Total Rain (inches)	Peak Rain Intensity (inches per hour)
January 2, 2022 6:00 pm – January 3, 2022 6:00 pm	1.65	0.33
February 27, 2022 11:55 pm – February 28, 2022 11:55 pm	1.31	0.34
January 5, 2022 8:35 am – January 6, 2022 8:35 am	0.96	0.12
December 23, 2021 10:00 pm – December 24, 10:00 pm	0.88	0.31
January 19, 2022 1:35 am – January 10, 2022 1:35 am	0.55	0.06

The RTK (note this is not an acronym) unit hydrograph method (RTK method) was used to estimate the impacts of RDII on the collection system flows. The RTK method uses a series of three triangular unit hydrographs to model an observed RDII hydrograph based on flow monitoring data (Figure 4-5). The first unit hydrograph models the rapid response to the rain event and includes primarily inflow into the collection system. The second unit hydrograph models the medium response that includes both inflow and infiltration components. The third unit hydrograph models the slow response to the rain event and includes infiltration, which can persist long after the storm has ended. The combination of the three unit hydrographs creates the modeled total RDII hydrograph. (A Toolbox for Sanitary Sewer Overflow Analysis and Planning (SSOAP) and Applications)

Each unit hydrograph is defined by three parameters:

- R – Fraction of rainfall falling that enters the collection system as RDII.
- T – Time to peak RDII flow (measured in hours)
- K – Ratio of the time of recession to the time of peak flow

These parameters were iterated using typical values until the modeled hydrograph aligned with the hydrograph from the storm beginning on January 2, 2022, at 6:00 pm. This storm was selected as it had the largest volume of rain over a 24-hour period while having the second highest peak rain intensity. These two factors made it the storm with the largest RDII response.

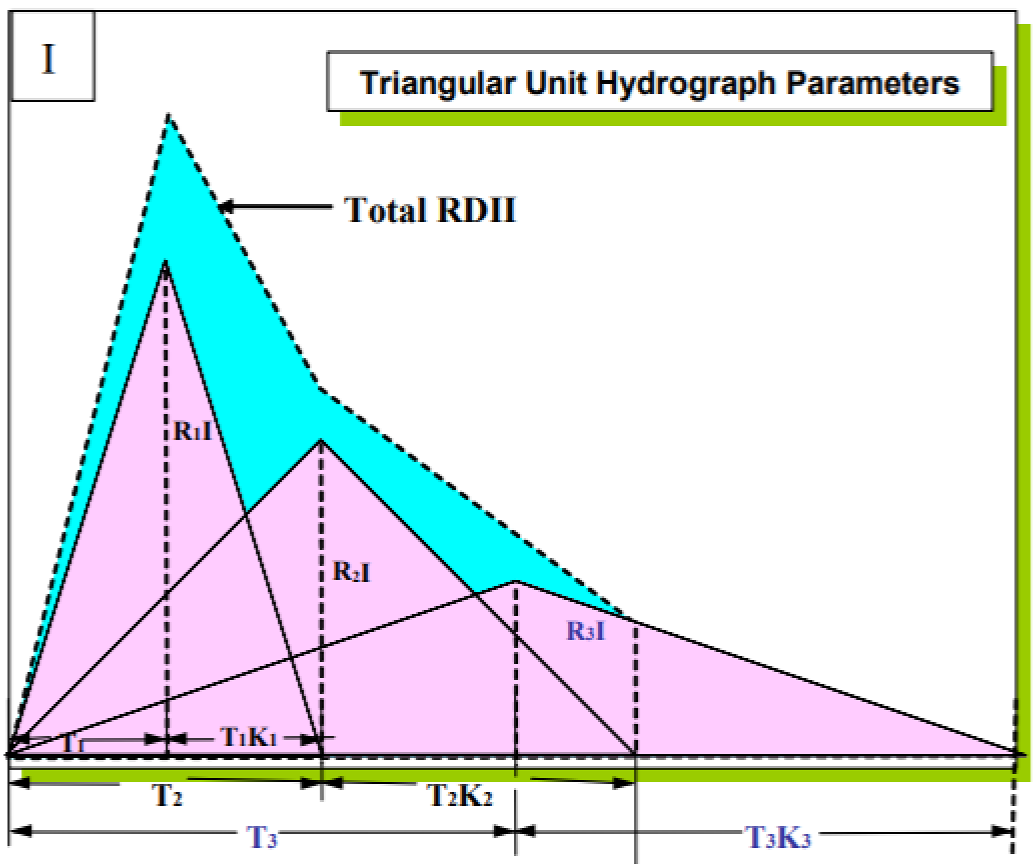


Figure 4-5: RTK Unit Hydrograph Parameters (A Toolbox for Sanitary Sewer Overflow Analysis and Planning (SSOAP) and Applications)

4.3.4 Establishing Wet Weather Performance

The desired level of wet weather performance must be selected to evaluate the collection system's ability to handle wet weather flows under both existing and future conditions. This is done by selecting a storm to design around, which is specified based on the quantity of rain over a set time period. Selecting the size of this storm is the responsibility of the owner of the collection system, but the Oregon Department of Environmental Quality (DEQ) provides guidance as to what is acceptable. According to Oregon Administrative Rule (OAR) 340-041-0009 (7) and (8), all sanitary sewer overflows (SSOs) are prohibited. However, DEQ may withhold enforcement action for a SSO that occurs during larger storm events, defined as a 10-year storm, 24-hour duration for summer months and a 5-year storm, 24-hour duration for winter months. Based on this guidance, the OLWS selected a 5-year storm, 24-hour duration for the design storm as this aligns with DEQ guidance for winter conditions. A 5-year storm, 24-hour duration has a total of 3.0 inches of rain over 24 hours and follows the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) (formerly Soil and Conservation Service [SCS]) 24-hour, Type IA distribution. (J.F. Miller, 1973) Figure 4-6 shows a comparison of the 10-year and 5-year storm hyetographs for reference.

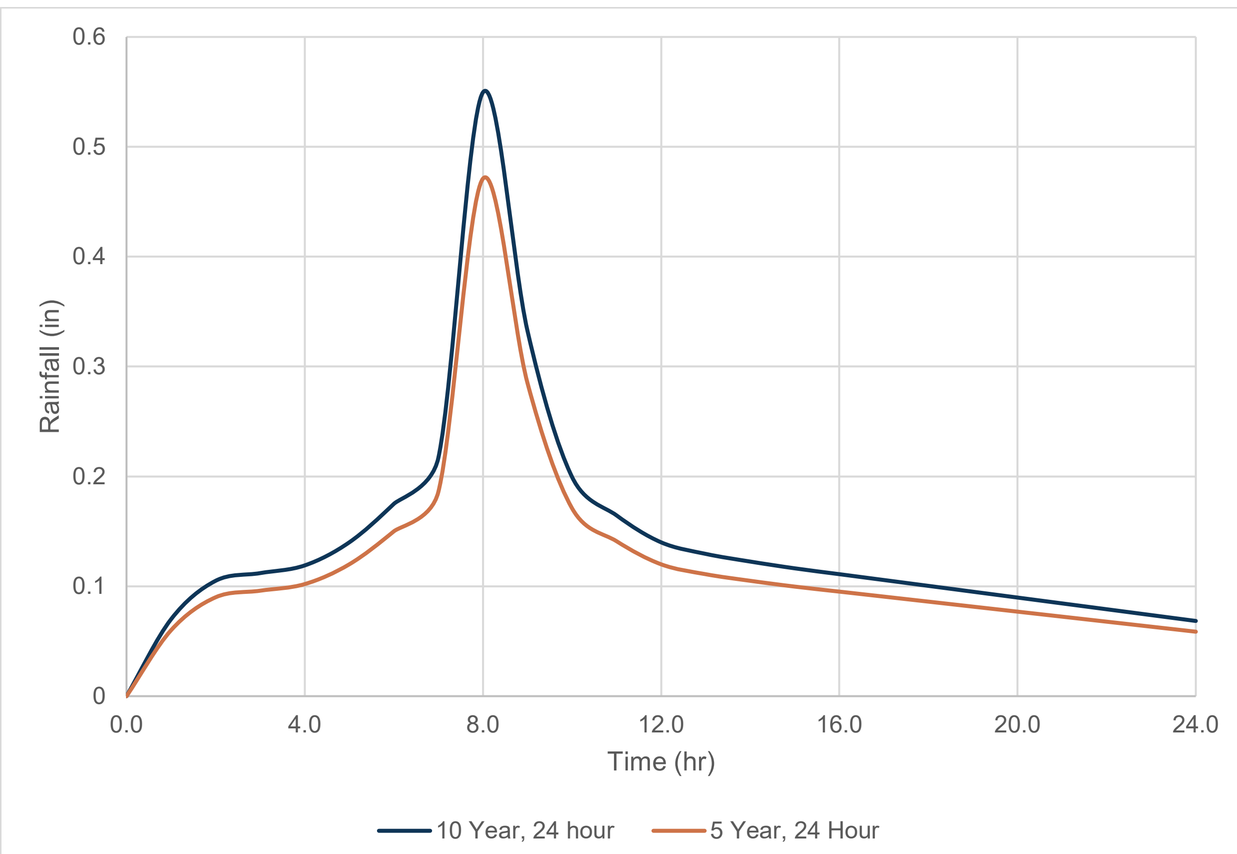


Figure 4-6: Comparison of Storm Hyetographs

WSC reviewed publicly available rain gauge information from the City of Portland's Harney Rain Gauge located at 2033 SE Harney Street, located 2.5 miles north of the OLWS service area. Over the past decade, from 2012 through 2022, there have been four storms that have exceeded 2.5 inches of rain in a 24-hour period, and one of which (the November 19, 2012, event) reached a total of 3.15 inches of rain over 24 hours. In terms of peak intensity, two of the four storms (November 19, 2012, and December 7, 2015 storms) reached a peak intensity greater than 0.5 inches of rainfall in an hour. Based on the review of the last decade of rainfall data near the OLWS wastewater service area, the selection of the 5-year 24-hour design storm appears to reflect the magnitude and intensity of observed storms within the past decade.

4.3.5 Rainfall Derived Inflow and Infiltration

RDII was determined by subtracting the BWF and GWI from the peak wet weather flow (PWWF) under design storm conditions. The design storm was modeled by importing the design storm hyetograph from Figure 4-6 and shifting the start of the storm so the peak rainfall aligns with the peak daily diurnal dry weather flow and applying the RTK parameters identified for each monitoring area. More information on the hydraulic model is included in the Model Development TM in Appendix E. The resulting RDII for each lift station basin is presented in Table 4-13.

Table 4-13: Existing Peak Wet Weather Flow and RDII

Basin[1]	BWF and GWI at PWWF (gpd)	PWWF Modeled Design Storm (gpd)	Peak RDII (gpd)	Peaking Factor of PWWF to BWF and GWI
ILS	1,340,546	9,145,679	7,805,133	6.8
LS2	1,156,516	3,982,899	2,826,383	2.7
LS3	501,618	2,303,420	1,801,802	4.6
LS4	14,621	68,217	53,596	4.7
LS5	234,457	911,600	677,143	3.9
LS 6	193,259	1,093,178	899,919	5.7

[1] Basins are as shown in Figure 4-4
gpd = gallons per day BWF = base wastewater flow GWI = groundwater infiltration PWWF = peak wet weather flow RDII = rainfall derived infiltration and inflow

Sub-basins within the OLWS wastewater service area are commonly compared in terms of the ratio, or peaking factor, between the PWWF and the BWF and GWI. However, this method does not normalize for the size of the basin nor the amount of rainfall. A better method for evaluating RDII is to determine the amount of peak RDII produced per acre of contributing area, as this normalizes the RDII by the basin size. The contributed area is calculated by assuming that a buffer area within 100 feet of every pipe within the basin will contribute to RDII within the system. The peak RDII per acre is provided for each basin in Table 4-14.

Table 4-14: RDII Calculated for Contributing Area By Basin

Basin	Peak RDII (gpad)	Contributing Area (acres)
ILS	8,377	931.8
LS2	3,783	747.0
LS3	8,048	223.9
LS4	4,290	12.5
LS5	4,525	149.6
LS6	6,166	146.0
System Average	**6,362**	**2,210.8**

gpad = gallons per acre per day   RDII = rainfall derived infiltration and inflow

For the purpose of estimating future flows in this master plan, the system-wide RDII volume is assumed to remain constant between existing and buildout conditions. RDII is a function of the volume of rainfall, the total geographical extents of the collection system, and the condition of the collection system. Under both existing and buildout conditions, the same design storm is used for the evaluation so the volume of rainfall across the geographical area remains constant. Similarly, with the majority of the anticipated growth within the OLWS service area coming from infill development there will not be significant geographic expansion resulting in contributing area and total volume of rainfall. The condition of the collection system will degrade over time, causing an increase in RDII if periodic repairs are not completed. For the purposes of establishing future flows, WSC has made the assumption that OLWS will maintain an appropriate level of repairs to the collection system to at least offset, if not reduce, the amount of RDII. Further discussion of the extents and recommendations for repairs to achieve RDII reductions are provided in Chapter 5.0 of this WWMP.

4.4 Flow Summary

A summary of the current and future wastewater flows within the collection system is provided in Table 4-15. BWF was determined through analyzing water billing data and land use data to develop factors for predicting wastewater flow. Growth in the total wastewater flows over the 30-year planning horizon from 2022 through 2052 is anticipated to be solely from growth in the BWF, which assumes that all buildable lands are developed by 2052 and assumes a certain amount of infill densification resulting from commercial redevelopment and high-density residential development.

The design criteria for the collection system are based on conveying all flows associated with a 5-year, 24-hour winter storm, which is the threshold at which DEQ will impose regulatory action. The flows associated with this storm are used to evaluate the capacity of the collection system to achieve the design criteria for freeboard and SSOs that are identified in Chapter 5.0. The resulting PWWF at the WWTP in the model under this design storm is shown in Table 4-15.

Table 4-15: Summary of Wastewater Collection System Flows

Year	Equivalent Dwelling Units (EDU)	Base Wastewater Flow (gpd)	Peak Wet Weather Flow (gpd)
2022 – Existing	14,151	1,853,899	17,504,994
2052 - Buildout	16,726	2,191,112	17,956,410

In the evaluation of the WWTP, the highest PWWF observed over the six years of available data occurred when a smaller antecedent storm with approximately 1 inch of total rainfall occurred in the 24 hours prior to a larger 24-hour storm with two or more inches of total rainfall. In order to better align with historic PWWF at the plant, a revised hyetograph (Figure 4-7) was generated to include an antecedent storm of 1.26 inches of rainfall in the 48-hours prior to the 5-year, 24-hour design storm. The antecedent storm hyetograph was generated based on storm data from the flow monitoring period and represents an actual 48-hour storm in the OLWS service area.

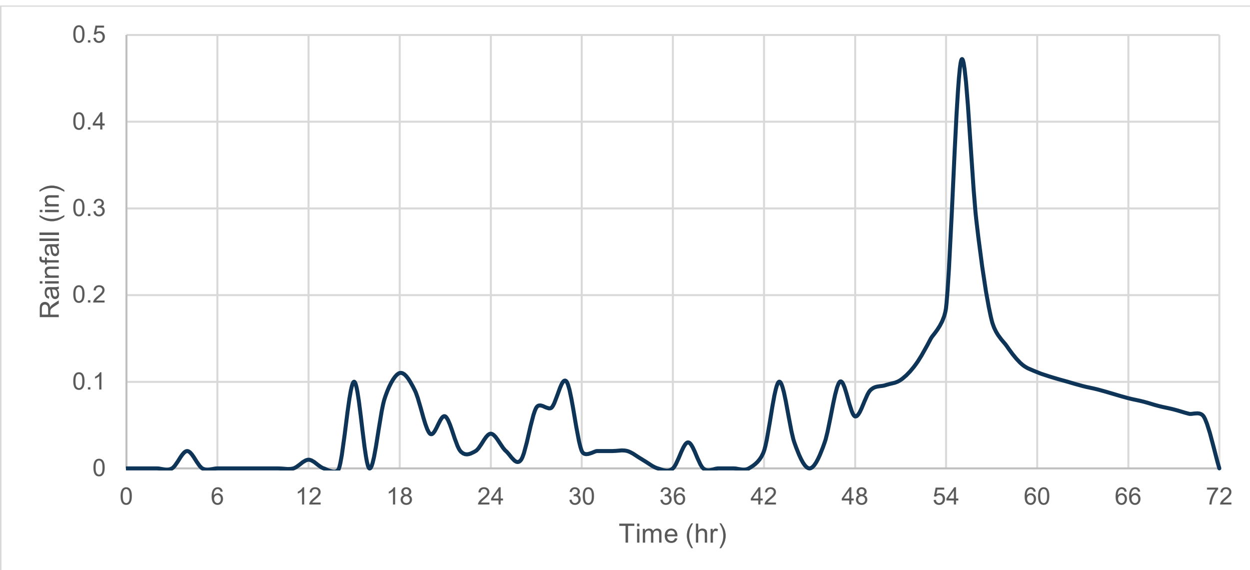


Figure 4-7: 5-Year, 24-Hour Storm with Antecedent Rainfall Hyetograph

Using the revised hyetograph with antecedent rainfall, revised PWWF values were estimated at the WWTP for performing the WWTP analysis. These are summarized in Table 4-16.

Table 4-16: Summary of Wastewater Flows for WWTP Analysis

Year	Equivalent Dwelling Units (EDU)	Base Wastewater Flow (gpd)	Peak Wet Weather Flow (gpd)
2022 – Existing	14,151	1,853,899	19,059,887
2052 - Buildout	16,726	2,191,112	19,522,181

4.5 Treatment Plant Flows and Loadings

To evaluate existing capacity and future expansion needs at the WWTP, other flow quantities besides base and peak wet weather flows as well as plant influent BOD and TSS loadings were developed from historical plant data and base flows given in Table 4-16 above. The following summarizes the historical data review and development of the design flows and loadings to the WWTP.

4.5.1 Historical Flows and Loadings

OLWS provided plant data from 2016 to 2021 for development of the flow and loading unit factors. The following flows were calculated for each individual year (if applicable, based on the timescale of the data provided):

- Minimum month flow – Monthly average flow for the month in each year with the lowest average flow in each year. This is assumed to correspond to the base wastewater flow developed above and given in Table 4-15.
- Average dry weather flow (ADWF) – Average flow from May to October period, as defined in the plant's National Pollutant Discharge Elimination System (NPDES) permit. Note that this is different from the average dry weather flow defined in Section 4.2 above.
- Average annual flow (AAF) – Average flow for each year
- Average wet weather flow (AWWF) – Average flow from November to April period, as defined in the NPDES permit.
- Maximum month dry weather flow (MMDWF) – Monthly average flow for the month with the highest average flow during dry weather period.
- Maximum month wet weather flow (MMWWF) – Monthly average flow for the month with the highest average flow during wet weather period.
- Peak day flow (PDF) – Daily average flow for the day with the highest average flow calculated based on the 5-year 24-hour design storm
- Peak hour flow (PHF) – Assumed to correspond to the peak wet weather flow shown in Table 4-15 based on the 5-year 24-hour design storm.

Table 4-17 summarizes the influent flows and loads and calculated peaking factors based on the 2016 to 2022 data. The peaking factors were used to calculate future flows and loads discussed below.

Table 4-17: WWTP Historical Flows and Loadings and Peaking Factors

Year	2016	2017	2018	2019	2020	2021	Average
Flows (mgd)							
Min month	1.94	2.13	1.91	1.83	1.96	1.79	1.93
ADWF	2.44	2.53	2.17	2.25	2.24	2.06	2.28
AAF	3.61	3.98	3.37	2.88	2.94	3.31	3.35
AWWF	4.79	5.43	4.57	3.51	3.64	3.91	4.31
MMDWF	3.96	3.38	2.73	2.68	2.66	2.54	2.99
MMWWF	6.05	7.87	6.68	4.54	5.23	6.09	6.08
Min month/ADWF	0.80	0.84	0.88	0.81	0.88	0.87	0.85
ADWF/AAF	0.67	0.64	0.64	0.78	0.76	0.62	0.69
AWWF/ADWF	1.97	2.15	2.10	1.56	1.62	1.90	2.03[1]
MMDWF/ADWF	1.62	1.34	1.26	1.19	1.19	1.23	1.36[1]
MMWWF/ADWF	2.49	3.11	3.08	2.02	2.33	2.95	2.91[1]
BOD Loadings (lb/d)							
Average annual	4,240	4,010	4,890	4,920	4,760	5,200	4,670
MM Dry Weather	4,680	4,820	4,480	5,710	4,740	6,660	5,080
MM Wet Weather	4,870	4,820	7,990	5,880	5,440	6,820	5,970
MMDW/AA	1.10	1.06	0.92	1.16	1.00	1.28	1.09
MMWW/AA	1.15	1.20	1.63	1.20	1.14	1.31	1.27
TSS Loadings (lb/d)							
Average annual	4,080	3,960	4,860	4,700	4,590	4,960	4,530
MM Dry Weather	4,760	4,470	5,140	5,080	4,800	5,540	4,970
MM Wet Weather	4,890	5,110	7,970	6,030	5,830	6,840	6,110
MMDW/AA	1.17	1.13	1.06	1.08	1.05	1.12	1.10
MMWW/AA	1.20	1.29	1.64	1.28	1.27	1.38	1.34

[1] Average calculated from 2016 to 2018 and 2021 data as the ratios for 2019 and 2020 are noticeably lower than for the other years.
mgd = million gallons per day lb/d = pounds per day MM = maximum month AA = annual average

4.5.2 Plant Flow and Loading Projections

BOD and TSS loading projections are used to assess the WWTP treatment process capacity and future upgrade and expansion needs. Loadings were calculated by applying per EDU loading rates to the projected EDUs from Section 4.4 and load peaking ratios from historical plant data summarized in Table 4-17 above. For the WWTP, flow parameters including ADWF, AWWF, and maximum month flows are often used in conjunction with loadings to evaluate and size the treatment unit processes. The following methodology and assumptions were used to develop the projected flows and loadings:

- Per EDU BOD and TSS loading rates were calculated from existing (2022) EDU of 14,151 and the average of the 2019 to 2021 annual average loadings. These are calculated to be 0.350 and 0.336 pounds per EDU per day for BOD and TSS, respectively. It was assumed that these unit loading rates would remain the same through 2052.
- 2022 and 2052 annual average BOD and TSS loads were calculated from the 2022 EDU of 14,151 and 2052 EDU of 16,726, respectively, and the per EDU loading rates.
- The maximum month dry weather and wet weather loads were then calculated from the annual average loads using the load peaking factors calculated from historical data.
- 2022 and 2052 AAF, ADWF, AWWF, MMDWF, MMWWF were calculated from the base wastewater flows of 1.85 and 2.19 mgd, respectively, and the flow peaking factors calculated from historical data. Peak day and peak hour flows were derived from the hydraulic model for the 5-year 24-hour storm as discussed above.

Table 4-18 summarizes the 2022 and 2052 projected flows and loads. The design flows and loads previously projected for the year 2030, as described in “Technical Memorandum: Basis of Capacity OLWS WRF Improvements Project” (CH2M Hill, October 2, 2013), were also included. Comparing the projected 2052 flows and loads with the original design flows and loads (for 2030) indicates lower values for the current projections except for peak hour flow and maximum month wet weather BOD load. The lower loading projections result in a reduction in required treatment capacity for some of the unit processes or a delay in the need for expansion to increase capacity, when compared to the original design.

Table 4-18: Summary of Treatment Plant Flows and Loads

Parameter	2030 Design (2013 TM)	2022	2052
Flow (mgd)			
Average dry weather	3.5	2.2	2.5
Average annual	4.3	3.2	3.5
Average wet weather	5.2	4.4	4.8
Max month dry weather	5.9	3.0	3.3
Max month wet weather	10.5	6.3	6.7
Peak day	-	15.1	15.5
Peak hour	18.0	19.1	19.5
BOD (lb/d)			
Annual average	6,680	4,950	5,850
Max month dry weather	7,250	5,400	6,380
Max month wet weather	7,440	6,290	7,440
TSS (lb/d)			
Annual average	7,450	4,750	5,620
Max month dry weather	8,960	5,230	6,180
Max month wet weather	8,390	6,370	7,530

5.0 Collection System Analysis

The following sections describe the evaluation of the wastewater collection system for both hydraulic capacity and structural condition. Where deficiencies were identified, recommendations for capital improvement projects have been provided and are summarized at the end of the chapter.

IN THIS SECTION

PREPARED BY:

WSC

5.1 Hydraulic Model Development

WSC developed a model of OLWS' wastewater collection system in SewerGEMS, Bentley's® GIS-based hydraulic modeling software, using updated system information provided by OLWS. The objective of the model development was to construct a model representative of OLWS' wastewater collection system for use in simulating and predicting the performance of infrastructure under an array of differing flow conditions. The model was calibrated using flow metering data and used to evaluate recommended capital improvements based on the deficiencies identified in the capacity analysis. Additional information on the model development and calibration is included in Appendix E – Model Development TM.

5.2 Hydraulic Capacity Evaluation

An evaluation of the capacity of the wastewater collection system was conducted. The first step included developing acceptable capacity performance criteria. These capacity criteria were then used in conjunction with the hydraulic model to identify capacity deficiencies in both gravity wastewater pipelines and lift stations that comprise the collection system.

5.2.1 Capacity Evaluation Criteria

In June 2022, OLWS and WSC conducted a workshop to review preliminary hydraulic modeling results and to discuss the desired criteria for evaluating the capacity of the collection system. Capacity evaluation criteria are necessary for identifying hydraulic capacity deficiencies within the existing collection system. The capacity evaluation criteria included the selection of a design precipitation event, the minimum acceptable freeboard between water surface elevations and manhole rims at peak flows, and capacity required in each lift station. The final evaluation criteria are presented in Table 5-1.

Table 5-1: Hydraulic Capacity Evaluation Criteria

Category	Evaluation Criteria
Model Peak Wet Weather Flow (PWWF)	Fir purposes of evaluating system capacity, PWWF will be based on the 5-year, 24-hour design storm timed to match peak RDII with daily diurnal peak dry weather flow.
Available Freeboard	Minimum 2 ft freeboard in each manhole during PWWF. Freeboard measured as distance between manhole rim elevation and the maximum water surface elevation. For manholes where 2 ft of freeboard is not feasible due to manhole depth, a maximum surcharge equivalent to 35% of the distance from the pipe invert to the manhole rim during PWWF was used.
Lift station firm capacity	Lift station capacity is equal to, or greater than, PWWF with largest pump out of service.
Permitted Outfalls	No sanitary sewer overflows at permitted outfalls within the collection system.

OLWS' evaluation criteria are consistent with the Oregon DEQ regulations. DEQ may withhold enforcement action for a sanitary sewer overflow (SSO) that occurs during larger storm events, which are defined as a 10-year, 24-hour duration storm for summer months and a 5-year, 24-hour duration storm for winter months. OLWS has elected to model the collection system capacity using a 5-year, 24-hour duration storm and not permit any SSO. The manhole freeboard and surcharge limits selected in the design criteria are considered conservative and will identify any manholes at risk of an SSO under these storm conditions. Similarly, lift stations are to be evaluated based on their firm capacity (defined as the capacity of the station with the largest pump out of service).

5.2.2 Capacity Deficiency

The hydraulic model was used to evaluate OLWS' collection system under dry and wet weather conditions. Loading was applied for existing and buildout conditions in accordance with the flows and loads outlined in Chapter 4.0. The following subsections describe deficiencies as defined by the evaluation criteria presented in the previous Section (5.2.1).

5.2.2.1 Existing Loading Conditions

The wastewater collection system was first modeled under OLWS' existing loading conditions for the PWWF condition and manhole water surface elevations were used to assess the capacity of the system gravity piping. Pipelines were assumed to be deficient if an adjacent manhole violated the available freeboard criteria. The results showing the manholes, and piping with insufficient capacity, in the model are shown in Figure 5-1. The model identified 81 manholes and 134 gravity pipelines (or approximately 3.6 percent of the total for both manholes and linear footage of wastewater mains in the OLWS service area) that violated the available freeboard criteria. Of these manholes, 36 were determined to overflow (SSO) in the PWWF condition, based on the model results.

Each lift station was evaluated to determine whether its firm capacity was greater than the PWWF. The firm capacity is defined as the lift station's capacity with the largest pump out of service. The results of the lift station analysis are shown in Table 5-2.

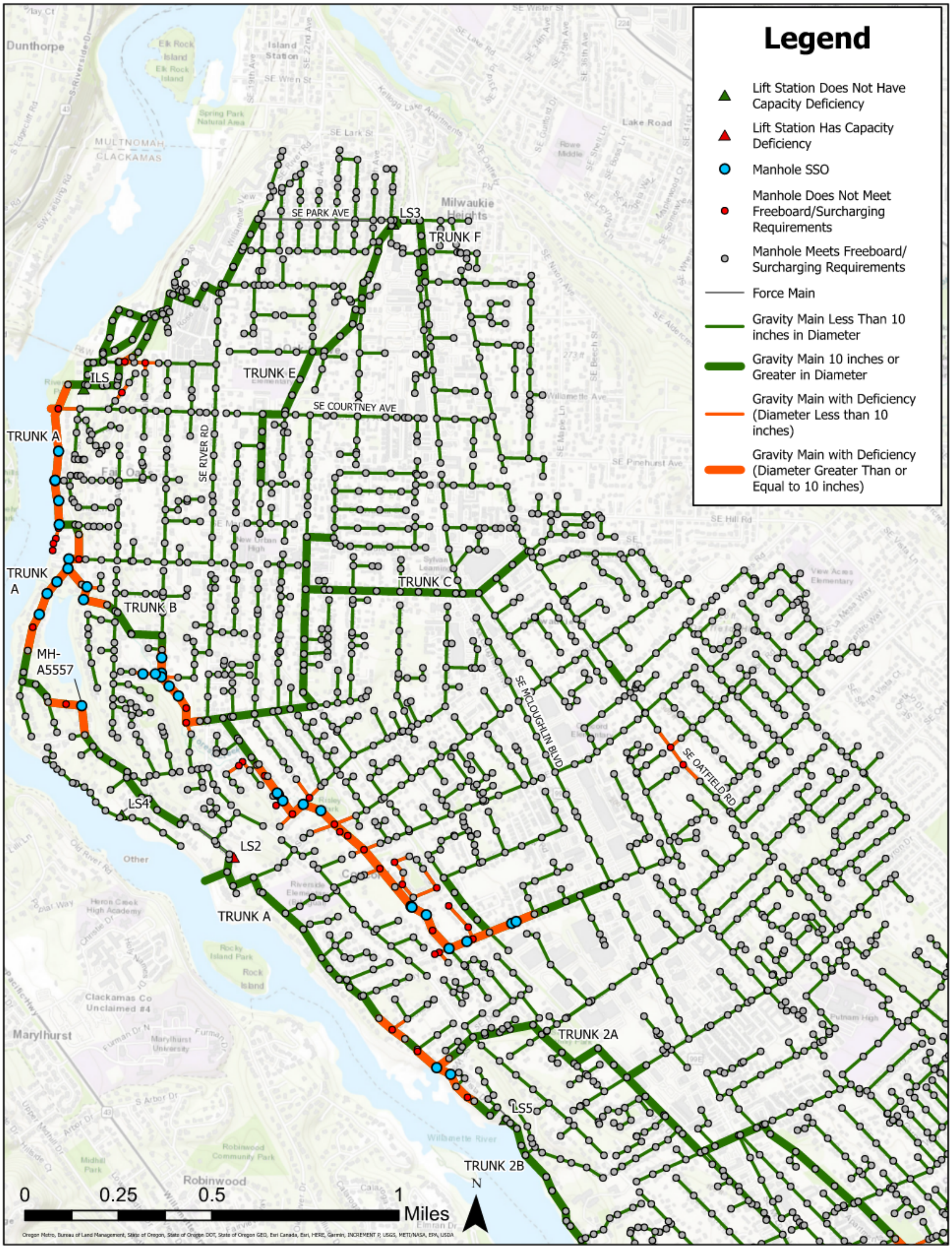


Figure 5-1: Existing Capacity Deficiencies Under PWWF Condition (Part 1)

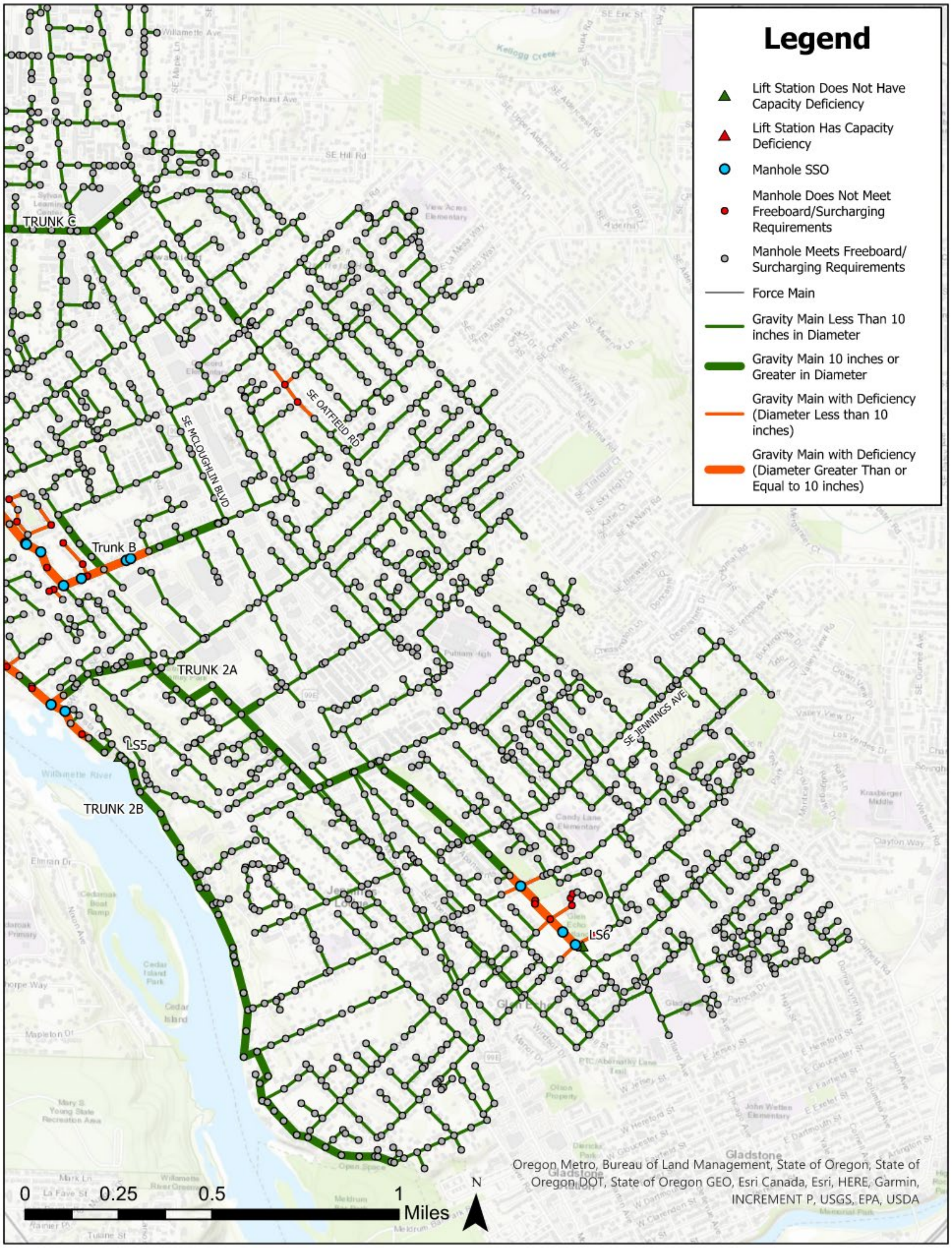


Figure 5-2: Existing Capacity Deficiencies Under PWWF Condition (Part 2)

Table 5-2: Lift Station Results Under Existing Loading

Lift Station (LS)	No. of Pumps	Firm Capacity with Largest Pump Out of Service (gpm)	Peak Wet Weather Flow (gpm)	Meets Design Criteria?
Influent Lift Station (ILS)	5	13,888[1]	12,156	Yes
LS2	3	3,400[2]	4,158	No
LS3	2	2,240[3]	1,600	Yes
LS4	2	139.8[4]	47	Yes
LS5	2	640[5]	633	Yes
LS6	2	800[6]	759	Yes

gpm=gallons per minute

[1]ILS firm capacity value derived from the Water Reclamation Facility Improvements record drawings dated March 2012

[2]LS2 firm capacity value derived from the Cornell Pumps 6NHTH pump curve and associated system curve

[3]LS3 firm capacity value derived from the Cornell Pumps 8NNT pump curve and associated system curve

[4]LS4 firm capacity value derived from the NP3102 pump curve and associated system curve

[5]LS5 firm capacity derived from the LS5 design plans dated February 2021

[6]LS6 firm capacity derived from Pioneer Pump SC66S12 and Cornell Pumps 6NHTA pumps curves and associated system curves

Based on comparison with the current design PWWF, LS2 has a capacity deficiency under the design storm conditions. The LS2, LS5, and LS6 basins all provide flow into LS2. As discussed in Chapter 4.0, these basins have high levels of GWI and RDII, which is the primary reason the flow exceeds the firm capacity of the station under PWWF conditions. Additionally, the existing collection system downstream of LS2 has a capacity deficiency, such that an SSO will occur at manhole (MH) A-5557 if LS2 pumps at the rated firm capacity of 3,400 gallons per minute (gpm) when system-wide flows are high during wet weather. An SSO at MH A-5557 results in a spill into a private residential property which presents a public health risk. To mitigate the damage caused by an SSO at the manhole, OLWS has placed a level sensor within MH A-5557 to detect when the water surface level is within 2 feet of the MH rim and send a signal to LS2 to reduce the speed of pumps and limit flows to 2,500 gpm. This temporary operational modification will divert flow into the Willamette River through an outfall from the LS2 wet well rather than allowing an SSO at MH A-5557 where the risk of human contact with raw sewage is significantly greater. The temporary modification was put in place to reduce impacts of an SSO while OLWS works towards a solution to the capacity deficiency.

When assessing the capacity of lift stations, a PWWF value that is less than the firm capacity indicates that no capacity deficiency exists. The firm capacity stated for each station is conservative and much lower than the actual capacity of the station.

5.2.2.2 Buildout Loading Conditions

The collection system was also modeled under OLWS' buildout loading conditions. The results of the model are shown in Figure 5-3. The model identified 83 manholes and 138 gravity mains that violated the available freeboard criteria. Of these manholes, 36 of them are expected to overflow under the design storm.

Additionally, each lift station was evaluated against the design criteria from Section 5.2.1 assuming no upgrades to the existing infrastructure. The results are presented in Table 5-3. In addition to LS2, LS5 becomes deficient under buildout conditions. High levels of RDII and GWI appear to be the primary driver behind the LS5 deficiency at buildout.

Table 5-3: Lift Station Results Under Buildout Loading

Lift Station	No. of Pumps	Firm Capacity with Largest Pump Out of Service (gpm)	Peak Wet Weather Flow (gpm)	Meets Design Criteria?
ILS	5	13,888[1]	12,470	Yes
LS2	3	3,400[2]	4,262	No
LS3	2	2,240[3]	1,688	Yes
LS4	2	139.8[4]	48	Yes
LS5	2	640[5]	662	No
LS6	2	800[6]	770	Yes

gpm=gallons per minute

[1]ILS firm capacity value derived from the Water Reclamation Facility Improvements record drawings dated March 2012

[2]LS2 firm capacity value derived from the Cornell Pumps 6NHTH pump curve and associated system curve

[3]LS3 firm capacity value derived from the Cornell Pumps 8NNT pump curve and associated system curve

[4]LS4 firm capacity value derived from the NP3102 pump curve and associated system curve

[5]LS5 firm capacity derived from the LS5 design plans dated February 2021

[6]LS6 firm capacity derived from Pioneer Pump SC66S12 and Cornell Pumps 6NHTA pumps curves and associated system curves

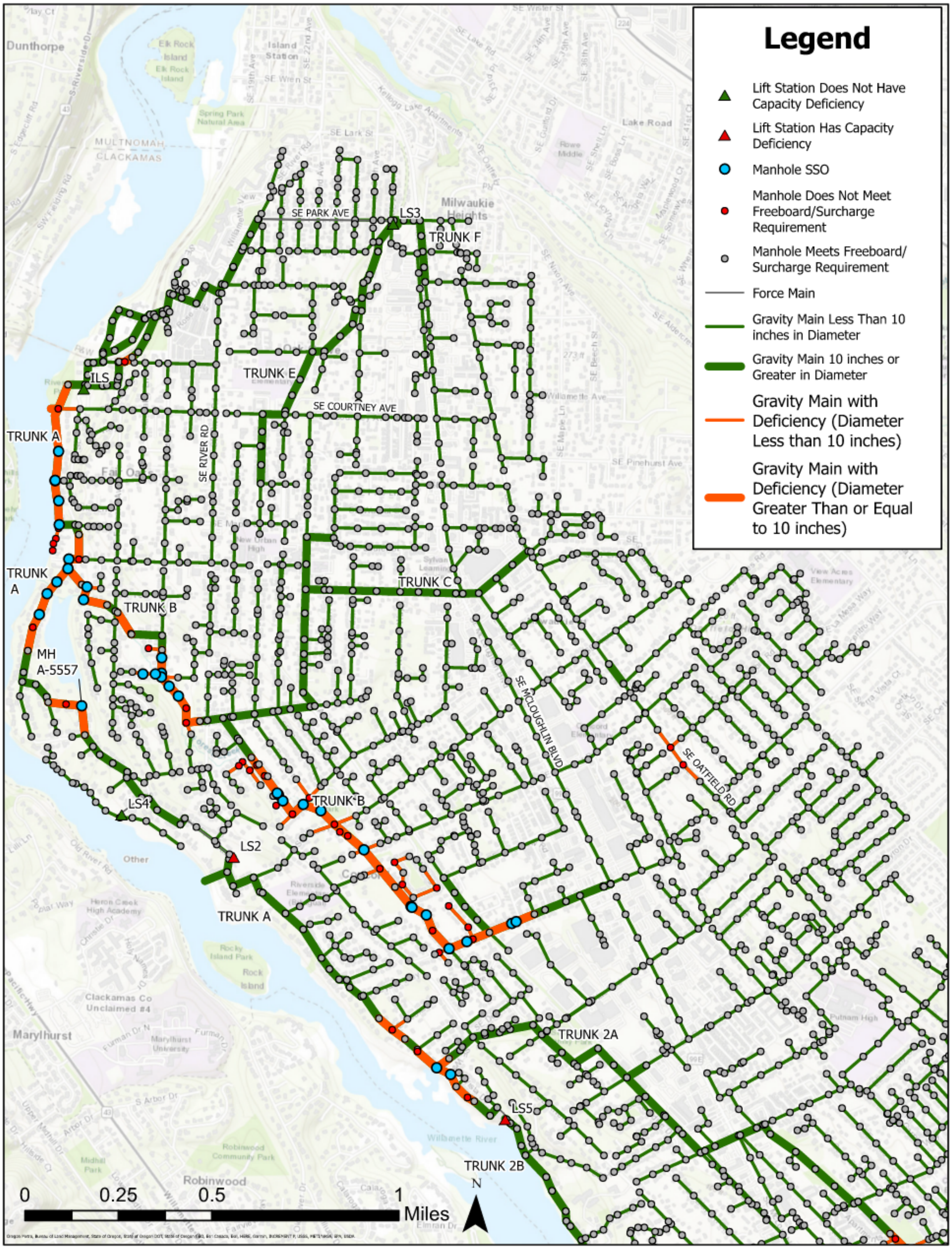


Figure 5-3: Buildout Conditions Results Under Design Storm (Part 1)

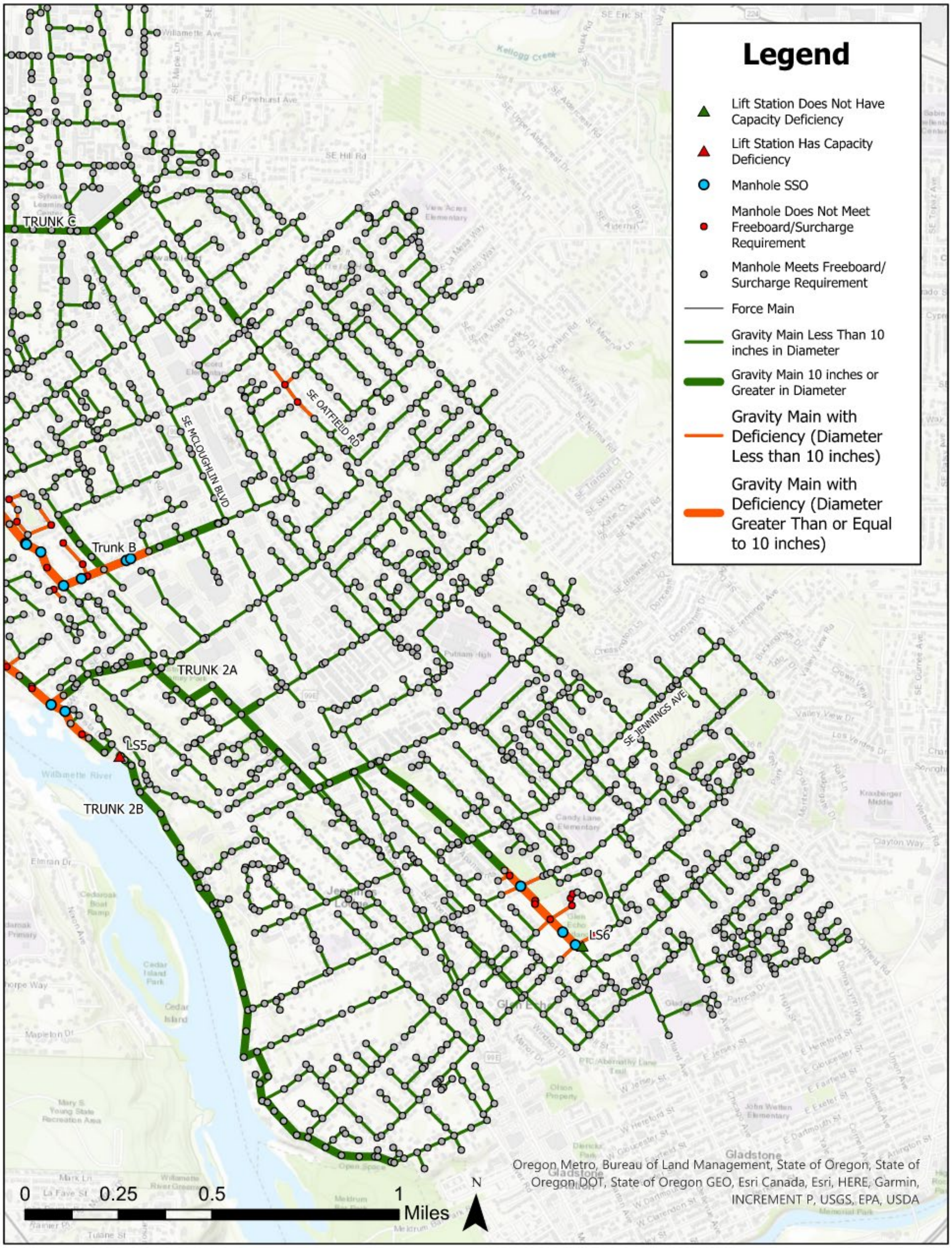


Figure 5-4: Buildout Conditions Results Under Design Storm (Part 2)

5.2.3 Recommended Capacity Improvements

The following subsections recommend capacity improvements for gravity pipelines and lift stations that were identified as having inadequate capacity.

5.2.3.1 Gravity Pipelines

As discussed in the previous sections, 83 manholes are anticipated to have insufficient freeboard under buildout conditions, including 36 with SSOs. Many of the deficiencies are within Trunk Main A and Trunk Main B or along the river front. For the purposes of addressing hydraulic deficiencies, WSC assumed the collection system would not divert any excess flow into the Willamette River so all proposed upsizing conveys all flow within the collection system to be conveyed to the WWTP. To address the freeboard deficiencies under buildout conditions, 82 pipes must be upsized. Within the hydraulic model, segments of wastewater mains were upsized one to two pipe sizes until the available freeboard criteria could be met at all manholes. These pipelines are identified in Appendix H and are shown in Figure 5-5. A summary of the size and total quantity of the new pipe is provided in Table 5-4.

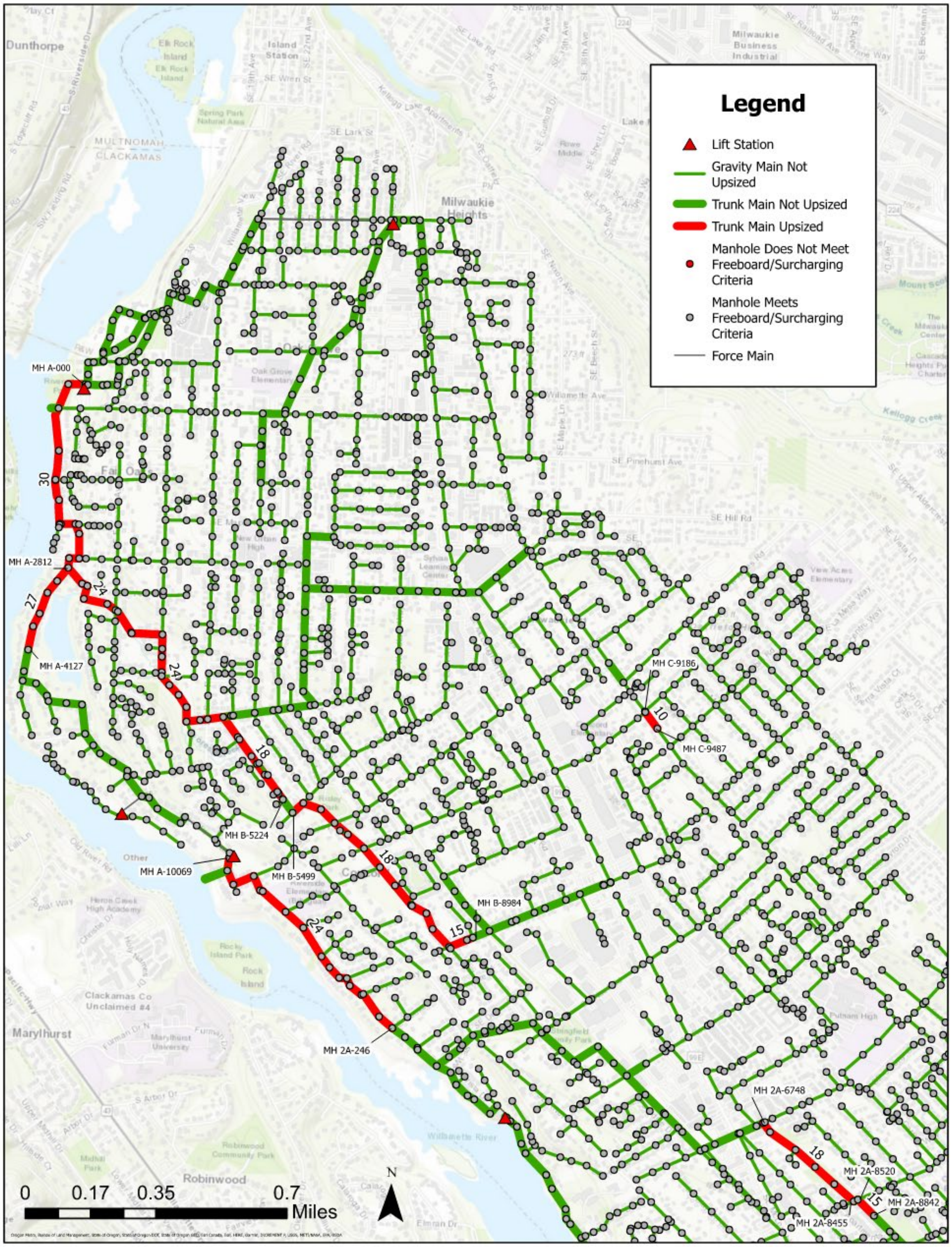


Figure 5-5: Recommended Gravity Main Upgrades (Existing and Buildout Loading)

Table 5-4: Upsized Pipe Summary

New Pipe Diameter (in)	Total Length (LF)
10	289.3
15	683.8
18	6,298.4
24	7,492.2
27	1,293.9
30	3,201.5
Total Linear Footage of Upsizing	**19,259.1**

All of the upsizing required to address capacity deficiencies occurs within the trunk mains of the collection system. These are larger diameter mains that collect flow from branches within the system and convey it to the WWTP via the ILS. Not only do the trunk mains convey large flows, which require more intensive bypassing for upsizing, but many of the trunks are located in areas where work is challenging. The upsizing required for Trunk Main A and Trunk Main 2A are largely located in easements through private property in areas with shallow rock. This makes accessing the mains more difficult, performing restoration work more complex following the installation, and requires greater levels of outreach to the community. Similarly, Trunk Main B consists of large numbers of easements through private property that will pose similar challenges. All of these factors contribute to making these upsizing projects very expensive.

5.2.3.2 Lift Stations

As discussed in Section 5.2.2.1, LS2 is deficient under existing loading conditions. OLWS currently has identified a project to reconstruct LS2 that will occur over Fiscal Years (FY) 2023 through 2024. As part of this project, the station's pumps will be replaced with new submersible non-clog pumps. These pumps should be upsized so the firm capacity of the new pumps will meet or exceed the PWWF at buildout (Table 5-3).

Under buildout loading conditions, LS5 becomes deficient. LS5 was recently rebuilt, and new pumps are not recommended at this time since the station has no deficiencies under existing loading conditions. However, as the station ages and the service area is built out, these pumps will need to be replaced with larger pumps to meet the PWWF. Based on linear growth, PWWF would equal the firm capacity in 2030, signaling the need to upgrade the pumps. As described in Chapter 4, the PWWF assumes that the volume of RDII will remain relatively constant. It is important to note that if condition deficiencies described in the Section 5.3 are not addressed, gradual deterioration will likely result in increased RDII and the firm capacity of LS 5 would be exceed sooner. Flows should be monitored to determine whether growth actually occurs as quickly as projected and that condition repairs are successful in maintaining or reducing RDII from current volumes.

The above upgrades may be able to be mitigated either partially or fully through RDII reduction in the basins upstream of each lift station as this would reduce the peak flow into the stations. RDII reduction is discussed in greater detail in Section 5.4.

5.3 Condition Assessment

The following sections describe the structural condition of the wastewater collection system and identify condition-based deficiencies that will need to be addressed.

5.3.1 Existing Condition Assessment Practices

This section describes the current assessment practices that are employed by OLWS along with a system for prioritizing repairs based on criticality.

5.3.1.1 Inspection Practices

Current OLWS collection system inspection practices for wastewater mains, manholes, and lift stations are detailed in Section 2.4.1.

5.3.1.2 Existing Project Prioritization

OLWS currently identifies necessary condition-based improvements based on CCTV results. Since the transition to EAM, all pipe videos are coded to NASSCO's PACP standards. Operations staff review the CCTV results and flag mains with Grade 4 and Grade 5 defects to be given a work order for repairs. According to the EPA, mains with Grade 5 and Grade 4 defects should be replaced within the next 5 to 10 years to minimize the risk of failure. (Environmental Protection Agency, April 2015) OLWS has not been repairing the Grade 4 and Grade 5 defect pipes at this rate, which has led to an accumulation of Grade 4 and Grade 5 defect pipes within the collection system. This method of prioritization effectively identifies mains with the highest likelihood of failure but does not have any way of prioritizing repairs based on criticality. Past operations staff did develop a ranking system for individual pipes that could be used to establish criticality and thus prioritize repairs, but staff turnover in the past 6 years has resulted in a loss of the underlying data required to use this system. To provide a means for prioritizing inspection and repairs within the collection system, a prioritization system is recommended in the following section that can be easily implemented going forward.

5.3.2 Recommended Renewal Strategy

A system for prioritizing wastewater mains will allow OLWS to identify the top priority pipes for inspection, repair or replacement during each budget planning cycle. The following sections describe a framework for using risk, defined by NASSCO's PACP Based Risk Management system as the product of consequence of failure (COF) and likelihood of failure (LOF), to prioritize mains for condition-based improvements within OLWS' collection system.

5.3.2.1 Consequence of Failure

Under NASSCO's PACP Based Risk Management system, COF is assigned on a scale of 1 to 6 and incorporates the economic, social, and environmental impact an asset would have if that asset were to fail. The recommended method for establishing COF based on readily available data within GIS will provide a viable COF score for each pipe segment that can be stored within the GIS database. The criteria described in Table 5-5 are proposed for use in establishing COF values, and the table indicates which triple-bottom-line impacts, or costs, are represented by each criteria. Each main was assigned a score of 1 to 6 for each of these criteria. The criteria were then weighted and normalized to create a composite COF score.

Table 5-5: COF Evaluation Criteria

Evaluation Criteria	Economic Cost	Social Cost	Environmental Cost
Pipe Diameter	X	X	X
Pipe Depth	X		
Road Type	X	X	
Land Use of Service Area		X	
Impact on Water Bodies			X

5.3.2.1.1 Pipe Diameter

One criteria that arguably has the most impact on the COF following a pipe failure is the volume of wastewater flow that is conveyed by an asset, as this will proportionally increase the magnitude and consequence of an SSO following a failure. Pipe diameter was selected to serve as a proxy for the volume of flow since the data is readily available for each pipeline and the pipe sizing is determined by the anticipated flow that must be conveyed. Pipe diameter thus can proportionally translate to each of the triple-bottom-line costs that would be incurred in an unplanned failure. It represents a relative measure of economic cost as the larger the main is, the greater the costs to OLWS for an unplanned replacement. If the pipe were to fail, the environmental cleanup costs will be relative to the volume of a SSO which is anticipated to be proportional to the pipe diameter. Larger pipes also present a greater risk of social impact as the extent of potential upstream service outages increase with pipe size. COF scoring criteria for pipe diameter are shown in Table 5-6. OLWS' pipes range in size from 4 inches in diameter to 30 inches in diameter.

Table 5-6: COF Score by Pipe Diameter

COF	Pipe Diameter (inches)
1	Pipe Diameter < 8”
2	8” ≤ Pipe Diameter < 10”
3	10” ≤ Pipe Diameter < 15”
4	15” ≤ Pipe Diameter < 20”
5	20” ≤ Pipe Diameter < 24”
6	Pipe Diameter ≥ 24”

5.3.2.1.2 Pipe Depth

Pipe depth is readily available within the GIS data and is established for each pipe using the greater depth from manhole rim elevation to top of pipe elevation between the upstream and downstream manholes. Like pipe diameter, pipe depth is representative of the magnitude of an economic cost following an unplanned failure. The depth of a pipe impacts the ability of OLWS' crews to address a main break in an unplanned emergency repair scenario, with deeper pipes requiring more resources and potentially outside contractors with appropriate excavation equipment. The deeper a main is, the more excavation, time, and effort is required to replace or repair the main. COF scoring criteria for pipe depth are shown in Table 5-7.

Table 5-7: COF Score by Pipe Depth

COF	Pipe Depth (ft)
1	Pipe Depth < 5’
2	5’≤ Pipe Depth < 7’
3	7’ ≤ Pipe Depth < 10’
4	10’ ≤ Pipe Depth < 12’
5	12’ ≤ Pipe Depth < 15’
6	Pipe Depth ≥ 15’

5.3.2.1.3 Road Type

The type of road in which a wastewater pipe is located is also proportional to the impact, both economic and social, of an unplanned failure. Economically, the type of road above a pipe impacts the level of traffic control, permitting, and pavement restoration required to complete the replacement or repair of the wastewater main during and after excavation. From a social perspective, replacing a pipe under a local, residential street impacts far less people than a pipe under an arterial street or highway. COF scoring criteria for road type are shown in Table 5-8.

Table 5-8: COF Score by Road Type

COF	Road Type
1	Unnamed Private Road/Driveway/Easement
2	Private Legally Named Road
3	Minor Residential Street
4	Neighborhood Collector
5	Arterial
6	Highway

To determine the type of road for each pipeline, the streets shapefile from Metro's Regional Land Information System (RLIS) is used, which provides detailed spatial data resources for the Portland Metro Area. Where a wastewater pipeline or manhole is located within multiple types of roads, such as in intersections, the COF score associated with the higher consequence road is assigned (i.e. it was given the highest of the COF values).

5.3.2.1.4 Land Use of Service Area

The land use of the area served by each pipeline is representative of the potential social cost an unplanned pipe failure would have on a community. Industrial users are often heavy water and wastewater users, so a failure on a pipeline serving industrial land use could impact a significant number of workers and other businesses that rely upon impacted industries. A wastewater main serving only single family residences may have significantly less impact on the community if the outage is isolated to only a few households. The predominant zoning of the upstream wastewater basin of each collection system asset is used to establish COF scoring. The COF scoring for the land use of the service area is presented in Table 5-8.

Table 5-9: COF Score by Land Use of Service Area

COF	Land Use of Service Area
1	None
2	Single Family Residential (9,000 ft^2 lot to ½ acre tax lot)
3	Single Family Residential (5,000 ff^2 lot to 7,000 ft^2 lot)
4	Multi-Family Residential
5	Commercial/Governmental
6	Industrial

5.3.2.1.5 Impact on Water Bodies

For the purposes of determining the environmental cost component COF of an unplanned failure that results in an SSO impacting a surface water, the distance to a surface water body is used to represent the level of impact from a pipe break. Distance to a water body is easy to determine within GIS, but may be misleading as the water body is only impacted if a SSO can reach the water via overland flow. Mapping of SSO flow paths from each manhole would be a more accurate way to identify potential environmental impacts to surface water bodies, but the level of effort to complete the necessary analysis within GIS is substantial. For the purpose of this WWMP, distance between collection system components and water bodies will be used to establish the COF score, but OLWS may determine that future improvements to map spill paths are worth the effort to assess environmental costs. COF scoring criteria for distances to water bodies as well as their qualitative impact are shown in Table 5-10.

Table 5-10: COF Scores Based on Distance from Water Bodies

COF	Distance to Water Body	Impact on Water Bodies
1	Greater than 150 ft	Insignificant Impact
2	Between 100 ft and 150 ft	Minimal Impact
3	Between 75 ft and 100 ft	Minor Impact
4	Between 50 ft and 75 ft	Moderate Impact
5	Between 25 ft and 50 ft	Major Impact
6	Less than or equal to 25 ft	Significant Impact

To determine the distances to water bodies, the hydrography GIS data available through Clackamas County's GIS data portal was used. The hydrography data consists of all lakes, rivers, and streams within Clackamas County, thus capturing the surface water bodies within the OLWS service area. Wastewater pipes were selected based on distance buffers to these water bodies and resulting selections were used to assign a COF score in accordance with Table 5-10.

5.3.2.1.6 Determination of Final COF Score

Once each collection main was assigned a COF score for each of the five categories, a weighted COF score was calculated using the weighting shown in Table 5-11. A weighted average was determined by multiplying each COF category score by its weighting factor and then dividing by the sum of the weighting factors (15). Each COF category is weighted to account for the fact that some criteria are anticipated to have a greater impact on the COF than others. Weighting factors for each COF category were assigned based on OLWS' staff input and can be adjusted in the future as new information becomes available. The final COF scores for each main are presented in Figure 5-6.

Table 5-11: COF Score Weighting

COF Category	Weighting Factor	Percentage of COF Score
Pipe Diameter	5	33.3%
Pipe Depth	3	20.0%
Road Type	2	13.3%
Land Use of Service Area	2	20.0%
Impact on Water Bodies	3	13.3%
Total	**15**	**100%**

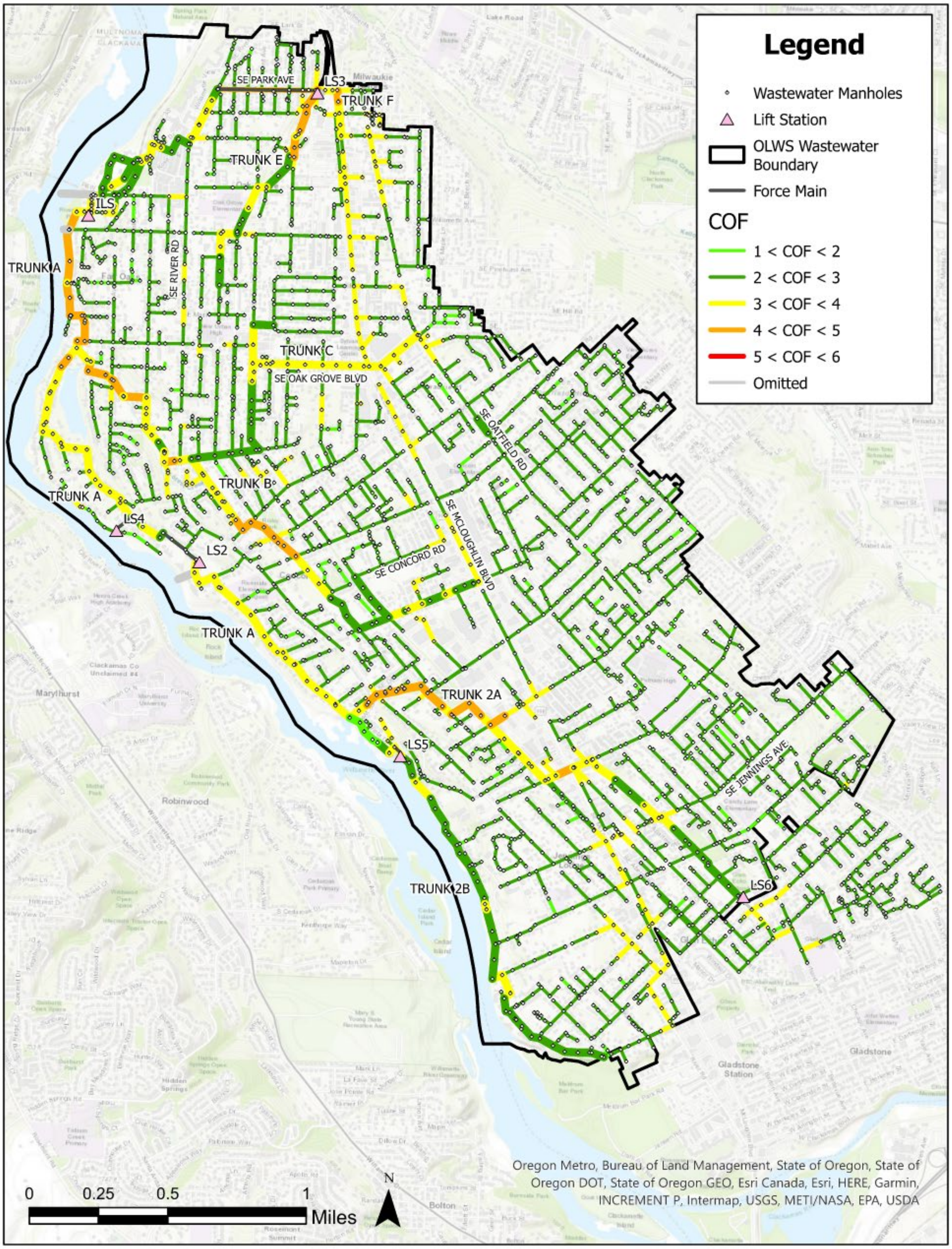


Figure 5-6: Consequence of Failure of Gravity Mains

5.3.2.2 Likelihood of Failure

The LOF factor is a calculated value that represents the probability a main will fail based on the main's physical condition. NASSCO has developed a system that utilizes PACP scores to determine a LOF factor to be used in calculating risk. OLWS has condition data for 2,526 (98%) of the collection system piping, however not all of the data is in PACP format. For the mains without PACP scores, OLWS has documented the quantity of various types of defects that can be used to create a composite PACP score by assigning the equivalent PACP score for that type of defect. For each defect category documented by OLWS, the range of PACP scores for this defect were evaluated and a median or conservative score was selected to approximate the equivalent PACP score. The OLWS scores did not have enough detail to determine the exact PACP defect score in many instances so a best approximation was used. A list of the scoring conversions used are shown in Table 5-12. These converted scores will allow for an equal comparison with those that have PACP scores.

5.3.2.3 Calculation of Likelihood of Failure

NASSCO's PACP Based Risk Management system determines LOF based on the main's PACP Quick Rating. A main's quick rating is a 4-digit code that is defined as follows:

- 1st digit – Highest grade defect identified in the PACP survey.
- 2nd digit – Frequency of occurrence for the highest-grade defect identified in the PACP survey. If the defect occurs more than nine times, a letter is used to represent the frequency based on NASSCO's standards.
- 3rd digit – Second highest grade defect identified in the PACP survey.
- 4th digit – Frequency of occurrence for the second highest-grade defect identified in the PACP survey. If the defect occurs more than nine times, a letter is used to represent the frequency based on NASSCO's standards.

To determine LOF, the first two numbers of the main's Overall Quick Rating are used. The scores are determined as follows:

- If the main has no defects (i.e. the Quick Rating is 0000), the LOF is assigned a value of 1.0.
- If the highest grade defect occurs no more than nine times, the LOF is the value of the first two numbers of the Quick Rating divided by 10. For example, a score of 4321 would have a score of 43/10 = 4.3.
- If the second character is a letter, replace the letter with a zero, divide the first two numbers of the Quick Rating by 10 and add 1.0. For example, a score of 5B35 would have a score of (50/10) + 1 = 6.0.

Using this methodology, a LOF score was established for each of the mains that had condition data within the OLWS collection system. The results are summarized in Figure 5-7. A significant portion of the system contains broken or fractured piping with a LOF score greater than 4.

Table 5-12: Recommended Scores for Mains without PACP Scores

OLWS Defect	Equivalent NASSCO PACP Defect Grade	Recommended Score	OLWS Defect	Equivalent NASSCO PACP Defect Grade	Recommended Score
Break in Pipe	Break – 4 Broken Soil or Void Visible - 5	5	Collapse	5	5
Cracks	Crack Circumferential – 1 Crack Longitudinal/Crack Spiral/Crack Hinge 2 – 2 Crack Hinge 3/Crack Multiple – 3 Crack Hinge 4 - 4	3	Fractures	Fracture Circumferential – 2 Fracture Longitudinal/Fracture Spiral/Fracture Hinge 2 – 3 Fracture Hinge 3/Fracture Hinge 4/Fracture Multiple – 4	4
Grease	≤ 10% → 2 > 10% to ≤ 20% → 3 > 20% to ≤ 30% → 4 > 30% → 5	3	Encrustation and Scale	≤ 10% → 2 > 10% to ≤ 20% → 3 > 20% to ≤ 30% → 4 > 30% → 5	3
Settled Deposits	≤ 10% → 2 > 10% to ≤ 20% → 3 > 20% to ≤ 30% → 4 > 30% → 5	3	Obstruction	≤ 10% → 2 > 10% to ≤ 20% → 3 > 20% to ≤ 30% → 4 > 30% → 5	3
Defective Joints	Joint Offset Medium Defective → 3 Joint Offset Large Defective → 4	3	Line Deviations	≤ 10% → 1 > 10% to ≤ 20% → 2 > 20% → 4	2
Deformation	≤ 5% → 4 >5% → 5	4	Infiltration	1 – 5 depending on type of infiltration (weeper, dripper, gusher, stain)	4
Defective Lining	3	3	Water Level +20%	No Score for Water Level	None
Defective Taps	3	3	Survey Abandoned	No Score for Survey Abandoned	None
Roots	1-5 Depending on Severity and Location within the Pipe (Fine, Medium & Root Ball; Joint, Connection, Barrel, Lateral)	3	Camera Underwater	4	4

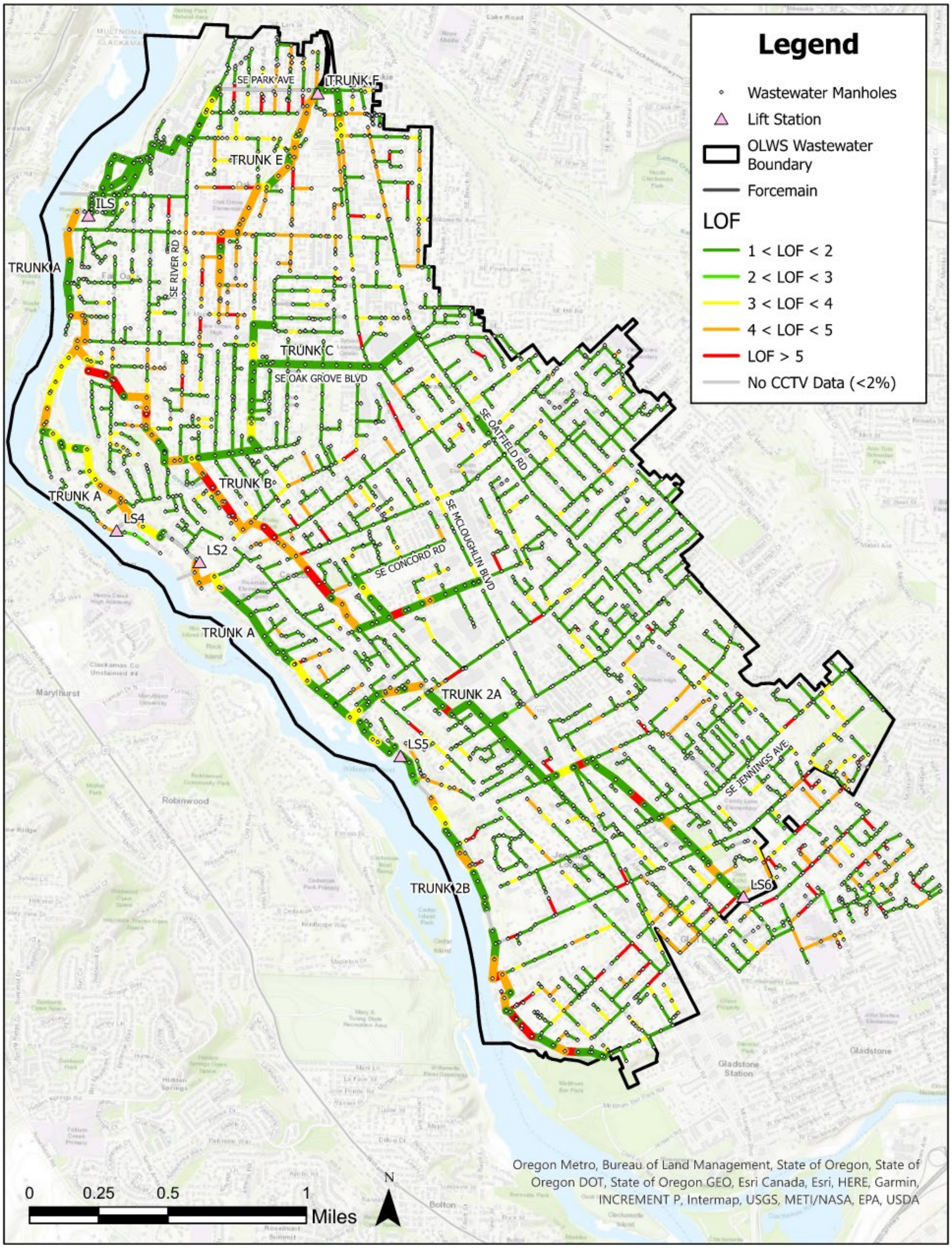


Figure 5-7: Likelihood of Failure for Gravity Mains

5.3.3 Risk

5.3.3.1 Collection System Piping

Collection piping risk is defined as the product of the COF and LOF scores for each main. Risk scores can be a useful tool for prioritizing repairs when resource limitations force prioritization decisions. However, risk scores alone should not be the sole driver for the timing of repairs. As discussed earlier, the industry best practice is to repair or replace all mains with Grade 5 or Grade 4 defects within 10 years of the defect being identified. These poor condition mains should be prioritized whenever possible. The risk scores can be used amongst the Grade 5 and Grade 4 defect mains to help prioritize which ones should be done if resources are limited. The resulting risk score map is provided in Figure 5-8.

WSC will provide all of the COF and LOF scores within a GIS database for OLWS to use going forward. The COF scores are established based on the geospatial and physical properties of each asset and are not anticipated to change. As CCTV inspections produce updated PACP scores for each wastewater main, OLWS will need a process for periodically updating the LOF score based on the latest PACP inspection data.

5.3.3.2 Lift Stations

A risk analysis was not performed on any of the lift stations as part of this WWMP. OLWS has already identified and programmed lift station rehabilitation and replacement projects into their most recent 6-year capital improvement plan (CIP). These improvements should reduce any major risks to the lift stations in the near term. Regular condition assessments should be conducted once rehabilitation and replacement of these stations is completed to monitor the status of equipment relative to the equipment’s useful life.

5.4 Rainfall Derived Infiltration and Inflow Reduction

5.4.1 RDII Reduction Basis

As discussed in Chapter 4.0 and Chapter 5.2.2 , the collection system has high levels of RDII that result in capacity deficiencies in LS2, LS5, and portions of Trunk A, Trunk B, Trunk C, and Trunk 2A. There are also a substantial number of pipes in the OLWS collection system with LOF scores of greater than 4, which indicate the potential presence of PACP Grade 4 and 5 defects. Given the high levels of RDII and the high number of Grade 4 and Grade 5 pipe defects within the collection system, there is an opportunity to implement an RDII reduction program that could address both capacity and condition-based deficiencies in a cost-effective manner.

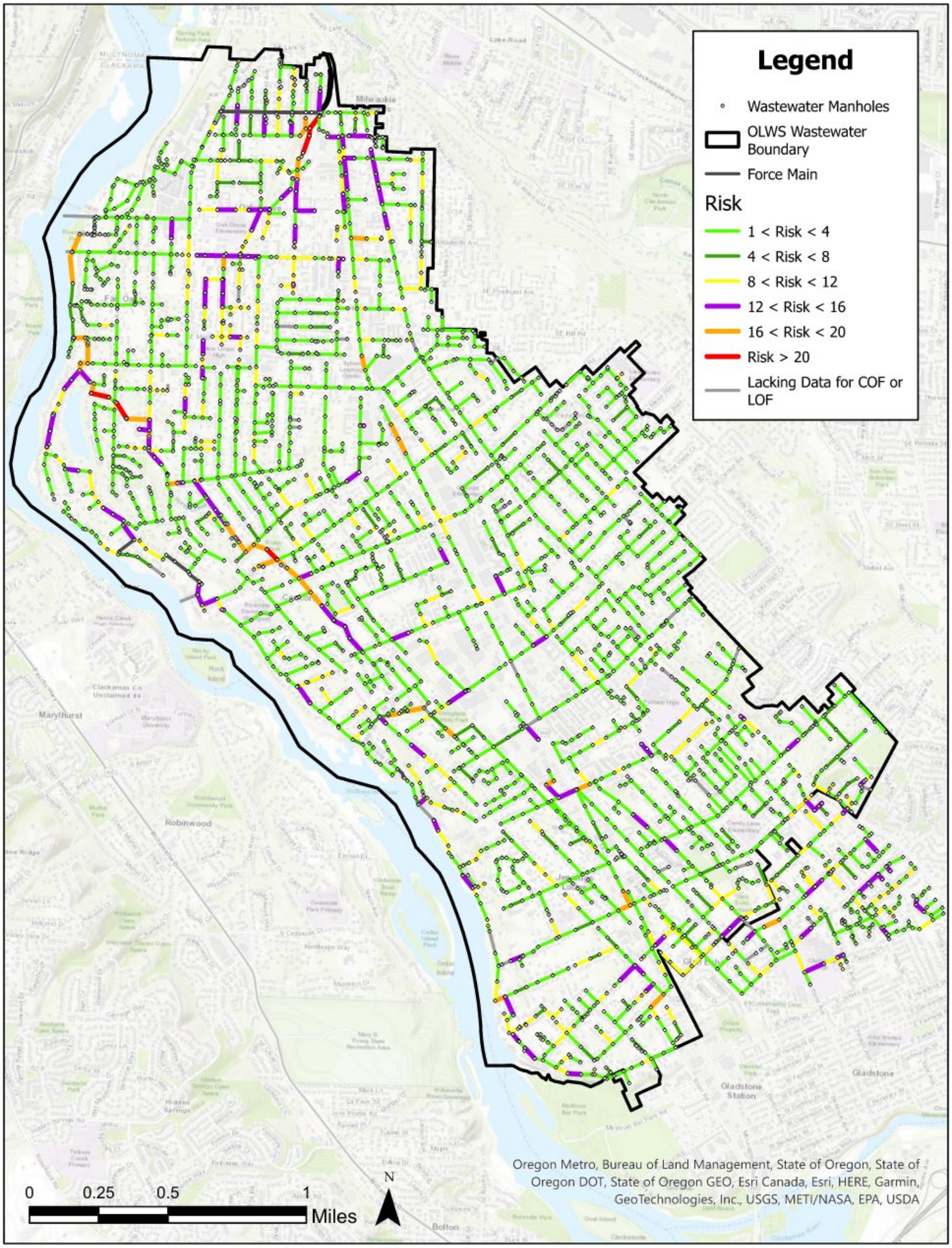


Figure 5-8: Risk within OLWS Collection System

An RDII reduction study in Sweet Home, Oregon identified various levels of RDII reduction possible by rehabilitating collection system mains and their corresponding laterals. (Brown and Caldwell, 2013) This study found that rehabilitating only the collection system mains resulted in a 20% reduction in RDII. When laterals were rehabilitated from the main to the property line in addition to the main rehabilitation, 30% reduction was achieved. This jumped to 65% reduction when laterals were fully rehabilitated from the main to the property. Further reduction in RDII is also achieved through manhole rehabilitation. Costs for RDII reduction (Table 5-13) were estimated by evaluating the cost to rehabilitate all pipes in the collection system and rehabilitate all laterals within the collection system to varying degrees and then applying the various RDII reduction percentages to determine the cost per gallon of RDII removed. These unit costs were then used to evaluate potential RDII reduction based on rehabilitation spending.

Table 5-13: RDII Reduction Values

Rehabilitation	RDII Reduction	Cost per gallon of RDII Removed
Rehabilitate Main Only	20%	$12.24
Rehabilitate Main and Laterals from Main to Property Line	30%	$14.39
Rehabilitate Main and Laterals from Main to Property	65%	$8.29

This method of estimating RDII reduction is likely underestimating the amount of RDII that can be removed through rehabilitation of the collection system, but this was the best method to attempt to quantify reduction given the data available. To fully understand RDII distribution throughout a collection system, flow metering data utilizing metering basins ranging from 10,000 to 15,000 linear feet (LF) upstream of the meter are recommended. (Gettring More From Flow Monitoring - Interpreting Sewer Flow Data to Yield the Maximum Benefit, 2005) In larger basins, the high RDII sources can get diluted by the areas with low RDII making it difficult to pinpoint the actual areas where RDII is high. Smaller flow metering basins run the risk of having insufficient flows for capturing metering data as well as add additional costs for having more meters. The flow metering done as part of this WWMP was sufficient for calibrating the hydraulic model but the metering basins were often much larger than the ideal RDII study range of 10,000 to 15,000 LF. As such, there is insufficient data to pinpoint where the most problematic RDII sources are.

By assuming the entire collection system is rehabilitated to achieve the cost per gallon of RDII removed, it is assumed that RDII is equally distributed amongst all mains within a collection system basin. In reality, the RDII will be more heavily concentrated in various subbasins as discussed above. More detailed flow metering will be required to understand where the most problematic areas are. They are likely areas where the groundwater table is high and the pipes are in poor condition, as this provides openings for the water to seep into the collection system, or where cross connections are entering the wastewater collection system rather than the stormwater collections system.

5.4.2 RDII Reduction Potential

Rehabilitating the entire collection system to address RDII would be extremely expensive and result in minimal value as mains in good condition would be rehabilitated along with those in poor condition. To maximize value, OLWS could target RDII reduction by rehabilitating all mains with Grade 5 and Grade 4 defects (LOF greater than 4). These mains should be rehabilitated or replaced within the next 10 years to maintain system performance. Focusing RDII work on these mains will maximize the value of OLWS' funds as it is work that is already needed.

To estimate the amount of RDII reduction, the RDII reduction percentages identified in Section 5.4.1 were applied to all the Grade 5 and Grade 4 defect mains within each collection system basin. The associated cost and amount of RDII reduction for each type of rehabilitation is provided in Table 5-14. Further RDII reduction can be achieved in City of Gladstone-Owned mains subject to finalization of the IGA (Section 3.1.2).

Table 5-14: Potential RDII Reduction from Rehabilitating Existing Grade 4/Grade 5 Defect Pipes

Basin	Rehabilitate Pipes Only		Rehabilitate Pipes Plus Laterals from Pipe to Right-of-Way		Rehabilitate Pipes Plus Laterals from Pipe to Property	
	Cost	Estimated RDII Removed (gpd)	Cost	Estimated RDII Removed (gpd)	Cost	Estimated RDII Removed (gpd)
ILS	$2,888,000	120,585	$5,028,000	181,845	$6,251,000	394,634
LS2	$2,215,000	92,484	$3,515,000	127,125	$4,258,000	268,813
LS3	$3,541,000	289,297	$6,351,000	441,348	$7,957,000	959,831
LS4	$72,000	3,006	$98,000	3,554	$113,000	7,134
LS5	$1,330,000	55,532	$2,236,000	80,868	$2,754,000	172,864
LS6 (OLWS-Owned)	$32,000	1,336	$249,000	9,005	$372,000	23,485

5.4.3 RDII Reduction Needs

To evaluate the potential benefits of a comprehensive RDII reduction program from a master planning perspective, key capacity deficiencies in the collection system were evaluated to determine if RDII reduction in the upstream service area could alleviate the need for capacity based projects (upsized pumps at lift stations and upsized mains within the collection system) identified in Section 5.2.3. Four key locations were identified that represent these capacity deficiencies in the collection system. These locations are summarized in Table 5-15 in order of ascending RDII reduction need and shown in Figure 5-9.

Table 5-15: RDII Reduction Needs

Location	Target Peak Wet Weather Flow		RDII Reduction Needed		Driver
	gpd	gpm	gpd	gpm	
Lift Station 5	921,600	640	31,680	22	Required reduction for flows to meet the firm capacity of the lift station under buildout loading.
Lift Station 2	4,896,000	3,400	1,241,280	862	Required reduction for flows to meet the firm capacity of the lift station under buildout loading.
Manhole A-5557	3,931,200	2,730	1,648,200	1,145	Shallow manhole on Trunk A that has experienced SSOs
Manhole A-778	11,000,000	7,639	3,735,990	2,594	Required reduction to not experience SSO in Trunk A

As discussed in section 5.2.3.2, LS5 will not meet the design criteria under buildout loading. In order to avoid upsizing the pumps, the PWWF entering LS5 must be reduced to the station's firm capacity of 640 gpm. The RDII reduction required to achieve this is 22 gpm (31,680 gpd), which should be achievable through rehabilitating the existing Grade 4 and Grade 5 mains within the basin (Table 5-14).

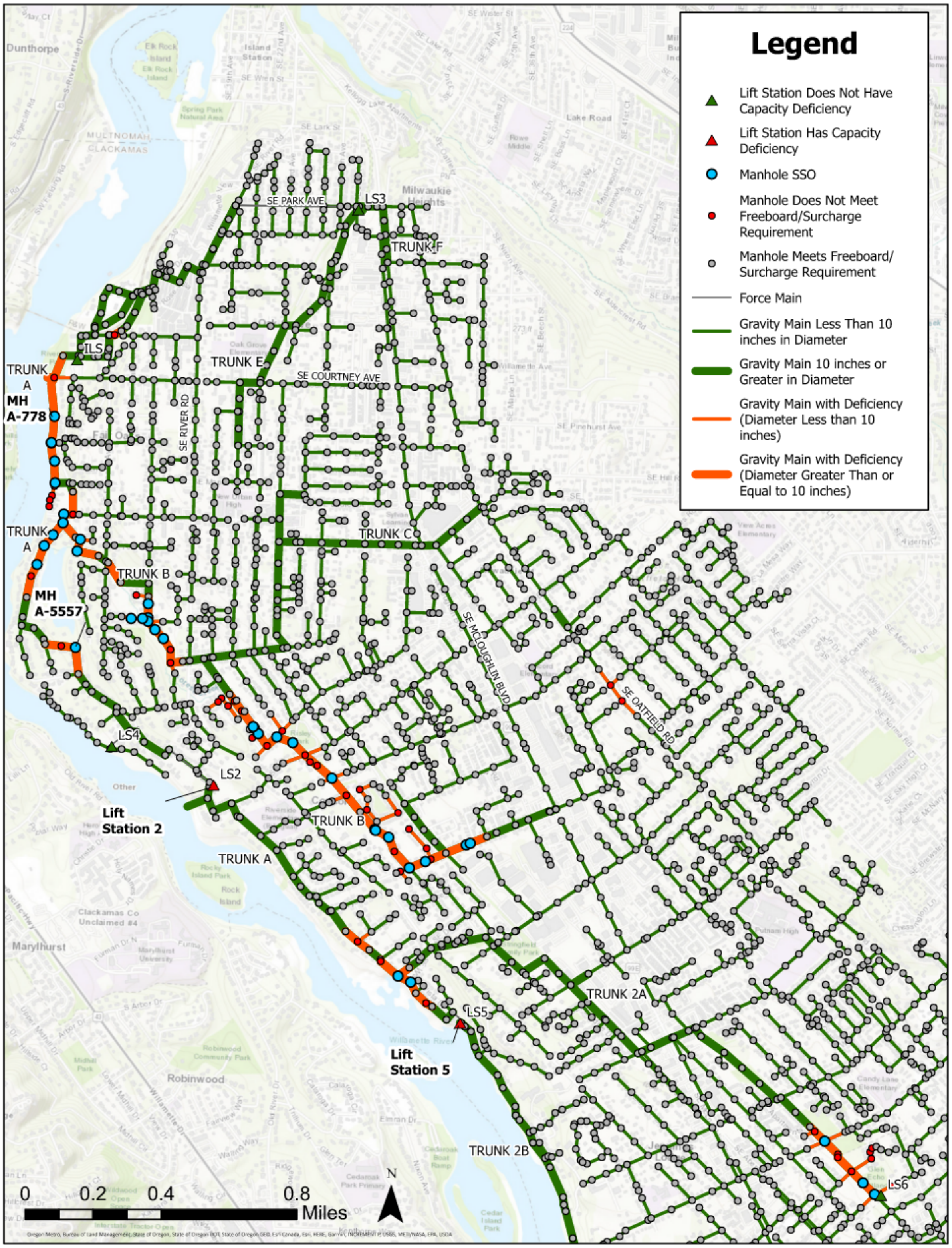


Figure 5-9: Key RDII Locations

Similarly, LS2 flows do not meet the design criteria at both existing and buildout conditions. Due to the layout of the collection system, the required 1,241,280 gpd reduction in RDII would need to be achieved through rehabilitation work in the LS2, LS5, and LS6 basins as all three of these basins send flow to LS2. Rehabilitating all OLWS-owned Grade 4 and Grade 5 mains within these three basins along with full lateral rehabilitation of the laterals on these mains is estimated to only reduce 466,162 gpd of RDII. This only accounts for OLWS-owned mains within the LS6 basin. Much of the poor condition pipe within the Lift Station 6 basin is owned by the City of Gladstone, so further RDII reduction (Table 5-14) is possible should the City of Gladstone repair their pipes in this basin. As stated in Section 5.4.1, the RDII metrics used in this master plan are conservative and additional reduction may be possible from lining these defective mains and their laterals if the defects are the primary source allowing infiltration to enter the collection system. Additional RDII reduction through the removal of cross connections and rehabilitation of poor condition manholes within these basins could result in the necessary RDII reduction being achieved. RDII reduction measures are recommended to be used prior to upsizing any of the pumps at LS2.

Manhole A-5557 is the location on Trunk A where SSOs have occurred during wet weather. Currently operations staff divert flow exceeding 2,500 gpm upstream of LS2 to the Willamette River when the water surface elevation in the manhole gets to within 2 feet of freeboard of the manhole rim to avoid a spill with a high potential for human exposure. Due to its location just downstream of LS2, the same rehabilitation work recommended for avoiding upsizing at LS2 described in the previous paragraph must also be done to reduce RDII at this manhole. Modeling has identified that backwater from mains surcharging further downstream in Trunk A also contributes to the SSO condition at this manhole. Rehabilitation work in the ILS basin should also help by alleviating the backwater contributing to the SSO condition. As previously discussed, the conservative metrics for RDII reduction used for this master plan do not predict enough RDII reduction to eliminate the need for upsizing pipe. However, actual levels of RDII reduction may be higher than predicted and additional RDII reduction could be achieved through the removal of cross connections and rehabilitation of poor condition manholes. RDII reduction measures are recommended to be used prior to upsizing any mains as the results of these efforts will reduce the amount of upsized pipe required and could possibly achieve the desired targets. Should RDII reduction not result in sufficient reduction of flows to avoid an SSO, Manhole A-5557 could also be raised to provide more freeboard as this manhole is located outside of the road.

Manhole A-778 represents the capacity limitations within Trunk A as this manhole has the lowest rim elevation within the trunk. To fully eliminate the need for upsizing Trunk A, 3,735,990 gpd (Table 5-15) of RDII reduction must be achieved in the upstream collection system. This level of RDII reduction is not anticipated, indicating that some level of upsizing will be required. However, this value has been identified as a target to provide insight into the level of upsizing required after all RDII reduction efforts have been completed.

5.5 Recommended Projects

Based on the analysis in this chapter, a list was developed of collection system projects to address the hydraulic and condition deficiencies within OLWS' collection system over the 30-year planning period. The projects are in addition to those already included in OLWS' current CIP.

As discussed at the start of this chapter, OLWS has established hydraulic capacity performance criteria for the collection system and there are numerous locations where those criteria cannot be met under existing and buildout conditions. As a first step towards correcting hydraulic capacity deficiencies, RDII reduction work is recommended in the basins upstream of the highest priority deficiencies within Trunk A that have resulted in recent SSOs. This RDII reduction work can be done as part of the necessary condition-based maintenance required in the collection system over the next 5 years.

Prioritizing RDII reduction projects will help OLWS to better determine the nature and geospatial distribution of RDII entering the collection system and the optimum approach reducing the volume of RDII within each basin. Each RDII reduction project recommended consists of smoke testing the entire collection system basin to find and remove any cross connections that are contributing inflow to the collection system. After addressing the cross connections, pre-rehabilitation flow metering is recommended to be deployed within the basin during the rainy season to (1) establish a baseline flow and wet weather response for measuring RDII reduction against and (2) better understanding how the RDII is geospatially spread throughout the basin. The number of flow meters selected will vary by basin size but are estimated assuming flow metering basins of 10,000 to 15,000 LF upstream of each meter as a best practice for RDII studies. After the initial flow metering is completed, rehabilitation should be done on all Grade 5 and Grade 4 defect mains within the basin and any of their associated laterals in poor condition to maximize the amount of RDII reduction achieved. Manholes connected to these mains should be assessed as part of this effort and any manholes in poor condition should be rehabilitated to support additional RDII reduction. Since manhole condition data was unavailable for the collection system, one manhole rehabilitation was assumed for every 1,500 LF of pipe rehabilitated based on past experience. After rehabilitation work is completed, flow meters should be deployed in the same locations during wet weather conditions to measure the new wet weather response and quantify the amount of RDII removed.

The recommended capital improvement projects for the collection system are presented in Table 5-16. These include RDII reduction projects for each collection system basin and the upsizing of mains to address the capacity deficiencies identified through the hydraulic modeling. The extent of upsizing required will depend on the effectiveness of the RDII reduction work. Due to the high level of variability associated with RDII reduction work, the upsizing projects are included in their entirety (assuming no RDII reduction) to provide a placeholder for costs. The extents of upsizing are anticipated to be significantly reduced following the RDII reduction work.

Table 5-16: Recommended Projects

Project No.	Capital Project Description
C-1	**LS5 RDII Reduction Pilot:** Smoke testing 35,000 LF of pipe; flow metering at 5 locations (pre- and post-rehabilitation [rehab]); rehab of 173 LF of 6” pipe, 5,839 LF of 8” pipe, 2,556 LF of 10” pipe, and 215 LF of 12” pipe; rehab of 6 manholes (63 vertical feet [VF]); and rehab of 138 laterals from the main to the property connection.
C-2	**LS2 Basin RDII Reduction Program:** Smoke testing 165,414 LF of pipe; flow metering at 17 locations (pre- and post-rehab); rehab of 11,145 LF of 8” pipe, 304 LF of 12” pipe, 4 LF of 14” pipe, 251 LF of 18” pipe, 752 LF of 20” pipe, and 338 LF of 21” pipe; rehab of 9 manholes (95 VF); and rehab of 198 laterals from the main to the property connection.
C-3	**LS6 Basin RDII Reduction Program:** Smoke testing 6,846 LF of pipe; flow metering at 2 locations (pre- and post-rehab); rehab of 171 LF of 8” pipe; rehabilitation of 1 manhole (11 VF); and rehab of 33 laterals from the main to the property connection. Scope is limited to OLWS-owned assets.
C-4	**ILS Basin RDII Reduction Program:** Smoke testing 207,931 LF of pipe; flow metering at 21 locations (pre- and post-rehab); rehab of 270 LF of 6” pipe, 12,724 LF of 8” pipe, 503 LF of 10” pipe, 250 LF of 12” pipe, 247 LF of 15” pipe, and 1,428 LF of 21” pipe; rehab of 17 manholes (179 VF); and rehab of 326 laterals from the main to the property connection.
C-5	**LS4 Basin RDII Reduction Program**: Smoke testing 2,335 LF of pipe; flow metering at 1 location (pre- and post-rehab); rehab of 491 LF of 8” pipe; rehab of 1 manhole (11 VF); and rehab of 4 laterals from the main to the property connection.
C-6	**LS3 Basin RDII Reduction Program**: Smoke testing 51,309 LF of pipe; flow metering at 5 locations (pre- and post-rehab); rehab of 19,504 LF of 8” pipe, 1,009 LF of 10” pipe, 1,788 LF of 12” pipe, and 996 LF of 15” pipe; rehab of 16 manholes (168 VF); and rehab of 428 laterals from the main to the property connection.
C-7	**Annual Condition Rehabilitation:** Annual budget for rehabilitating future Grade 5 and Grade 4 mains within the collection system. This project will take place after the RDII reduction programs and will address mains that developed Grade 5 and Grade 4 defects after the time of this master plan.
C-8	**Trunk Main A Upsizing:** Upsize Trunk Main A along the extents shown in Figure 5-10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 3,516 LF of 24”, 240 LF of 27”, and 3,202 LF of 30” gravity wastewater main. Depending on the effectiveness of the RDII reduction in Projects C-1 through C-6, this scope may be reduced.
C-9	**Trunk Main B Upsizing:** Upsize Trunk Main B along the extents shown in Figure 5-10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 362 LF of 15”, 4,600 LF of 18”, and 3,729 LF of 24” gravity wastewater main. Depending on the effectiveness of the RDII reduction in Projects C-1 through C-6, this scope may be reduced.
C-10	**Trunk Main 2A Upsizing:** Upsize Trunk Main 2A along the extents shown in Figure 5-10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 322 LF of 15” and 1,698 LF of 18” gravity wastewater main. Depending on the effectiveness of the RDII reduction in Projects C-2 and C-3, this scope may be reduced
C-11	**Trunk Main C Upsizing:** Upsize Trunk Main C along the extents shown in Figure 5-10 and Appendix H to address capacity deficiencies. Project scope includes the installation of 289 LF of 10” gravity wastewater main

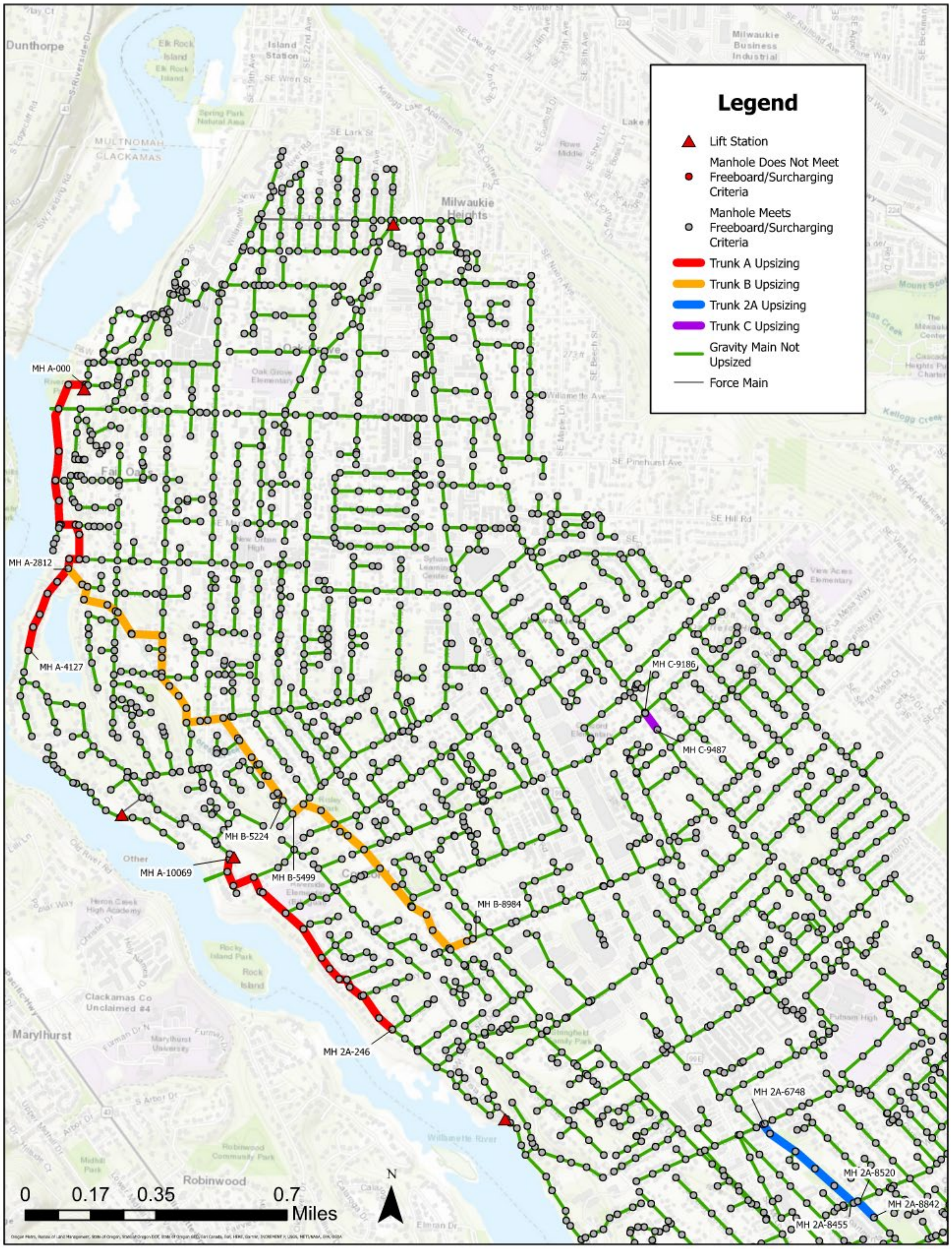


Figure 5-10: Proposed Main Upsizing

6.0 WWTP Assessment and Analysis

This chapter summarizes alternatives for maintaining, modifying, or replacing the existing liquid and solid stream treatment processes at the OLWS Wastewater Treatment Plant (WWTP). Brown and Caldwell (BC) developed each alternative to provide treatment for projected flows and loads over the planning horizon, anticipated regulatory requirements that may be implemented as part of future permit renewal and future build-out conditions. In addition, alternatives were identified to address age and condition related deficiencies based on remaining service lives of existing equipment and facilities.

This chapter describes the advantages and disadvantages of each of the alternatives, as well as anticipated performance and reliability. The chapter also includes recommendations that are incorporated into the Capital Improvement Plan (CIP) included in Chapter 7.0 of the Wastewater Master Plan (WWMP).

IN THIS SECTION

- Summary of Flows and Loads
- Capacity Assessment
- WWTP Alternatives Analysis
- WWTP Recommendations

PREPARED BY:

Brown AND Caldwell

6.1 Introduction and Objectives

This chapter summarizes and builds upon information documented elsewhere in this WWMP including:

- Chapter 2.0 Existing Wastewater System
- Chapter 4.0 Wastewater Flows
- Appendix A WWTP Description and Condition Assessment of Unit Processes
- Appendix B WWTP Historical Performance
- Appendix C WWTP Operations
- Appendix I WWTP Capacity Assessment
- Appendix J WWTP Alternatives Workshop Materials

The chapters and appendices listed above are intended to satisfy Oregon Department of Environmental Quality (DEQ) guidelines for preparing a wastewater facility planning document including:

- Description of the existing WWTP including detailed design data including a summary of treatment processes
- Condition assessment of the major existing WWTP assets and projection of remaining service life
- Performance evaluation of equipment, treatment processes, and components at the WWTP
- Capacity assessment of existing WWTP for the capability of reliably meeting current and potential future discharge permit requirements
- WWTP alternatives evaluation including:
    - Identification of viable alternatives for each treatment process including design criteria beginning with a summary of projected flows and loads
    - Initial screening of alternatives based on applicable design criteria for each treatment process and major assets
    - Evaluation of viable alternatives including a ‘present worth’ analysis
    - Recommendation for each treatment process to meet required performance and other criteria

6.2 Summary of Projected Flows and Loads

Table 6-1 summarizes the current and projected flows and loads for the design year of 2052. The flows and loads are used for the capacity assessment described in Section 6.3 and the alternatives analyses used in Sections 6.4 through 6.6.

Table 6-1: Summary of Projected Flows and Loads

Parameter	2022	2052
Flow (mgd)		
Average dry weather	2.2	2.5
Average annual	3.2	3.5
Average wet weather	4.4	4.8
Max month dry weather	3.0	3.3
Max month wet weather	6.3	6.7
Peak hour	19.1	19.5
BOD (lb/d)		
Annual average	4,950	5,850
Max month dry weather	5,400	6,380
Max month wet weather	6,290	7,440
TSS (lb/d)		
Annual average	4,750	5,620
Max month dry weather	5,230	6,180
Max month wet weather	6,370	7,530

The projected flows given in Table 6-1 were developed assuming that the system-wide RDII volume would remain constant between existing and buildout conditions as mentioned in Chapter 4.0. If the RDII reduction work was not performed such that the RDII volume increases, then flows to the WWTP would be higher. If the RDII reduction work results in an overall decrease in the RDII volume, then flows to the WWTP would be lower. Impacts to the loadings are expected to be minimal due to changes in the RDII volumes.

6.3 WWTP Capacity Assessment

A capacity assessment was conducted for the OLWS WWTP as part of the master planning efforts to identify the existing capacity constraints and timing of those constraints for each major treatment process. Wastewater characterization and calibration of the biological process models and plant-wide solids mass balance model were conducted to set up the tools that were used for the capacity assessment.

Both dry weather and wet weather plant operating conditions were evaluated. The conclusions of this assessment are summarized below by plant processes and timing. The overall conclusion is that the OLWS WWTP has sufficient capacity to treat the projected 2052 flows and loads but the facility would require upgrades of the aeration system for both the aeration basins and aerobic digesters and operation of the gravity belt thickener (GBT) as a dedicated thickening process. In addition, tertiary treatment is required to reliably meet the BOD and TSS limits included in the NPDES permit issued in 2022.

6.3.1 Summary of Capacity Constraints by Unit Process

Table 6-2 provides a summary of maximum capacities by treatment process.

Table 6-2. Maximum Capacities by Unit Process

Treatment Process	Capacity	~Year Capacity Expected to be Reached
Influent pumps	20 mgd [1]	After 2052
Influent screens	23.5 mgd [1]	After 2052
Grit removal	23.5 mgd [1]	After 2052
Aeration basins	Dry weather (2 basins): 2.96 mgd, 5,400 lb/d [2]	Currently at capacity
	Wet Weather (3 basins): 6.94 mgd, 8,390 lb/d [2]	After 2052
Aeration blowers	Dry weather (2 basins): 3.47 mgd, 6,890 lb/d [2]	After 2052
	Wet Weather (3 basins): 6.48 mgd, 6.810 lb/d [2]	2035
Secondary clarifiers	Dry weather (2 basins, 3 clarifiers, 30% RAS): 3.02 mgd, 5,600 lb/d [2]	2027
	Dry weather (2 basins, 3 clarifiers, 50% RAS): 3.65 mgd, 7,520 lb/d (extrapolated) [2]	After 2052
	Wet weather (3 basins, 4 clarifiers, 30% RAS): 6.66 mgd, 7,440 lb/ d [2]	2051
	Wet weather (3 basins, 4 clarifiers, 50% RAS): 7.22 mgd, 9,450 lb/d (extrapolated) [2]	After 2052
UV	22 mgd [1]	After 2052
Plant hydraulics	20 mgd [3]	After 2052
Aerobic digesters	Dry weather: > 3.5 mgd, > 8,170 lb/d [2]	After 2052
	Wet weather (digester feed TS ≤ 1.1%): 6.33 mgd, 6,300 lb/d [2]	Currently at capacity
	Wet weather (digester feed TS ≥ 1.3%): 6.67 mgd, 7,440 lb/d [2]	2052
BFP	Dry weather (2 basins): > 3.5 mgd, > 8,170 lb/d [2]	After 2052
	Wet weather (digester feed TS ≤ 1.1%): 6.33 mgd, 6,300 lb/d [2]	Currently at capacity
	Wet weather (digester feed TS ≥ 1.4%): 6.67 mgd, 7,440 lb/d [2]	2052

1. Capacity expressed as plant influent peak hour flow.

2. Capacity expressed as plant influent MMF and maximum month BOD loading.

3. Capacity expressed as peak instantaneous flow

6.3.2 Summary of Capacity Constraints by Timing

Capacity constraints at the OLWS WWTP have been divided into two phases based on the anticipated timing of each limitation. In addition, recommendations were developed to potentially address these capacity constraints or to improve performance. These are summarized below.

6.3.2.1 Near-Term (now to 2030) Capacity Constraints

Near-term capacity constraints for major elements of the treatment system are summarized below.

6.3.2.1.1 Aeration system limitations

Assuming the dissolved oxygen (DO) concentrations are maintained at the recommended level of 2 mg/L in the aerated zones, the diffuser air flow in the first aerated zone would currently be near or at the capacity limit under dry weather conditions. High diffuser air flow would result in lower oxygen transfer efficiency and high head loss across the diffusers. This limitation could be addressed by increasing the diffuser density. The current operating strategy allows DO control only in the last aerated zone due to the lack of control valves along the individual drop legs. The upstream aerated zones are aerated at constant air flows, which result in fluctuations in DO concentrations and often low DO concentrations. It is recommended that control valves and air flow meters be added to the drop legs to improve DO control.

As an alternative, the system could operate in simultaneous nitrification and denitrification (SND) mode. In a SND process, nitrification and denitrification occur concurrently in the same aerobic tank operated at consistently low DO concentrations (approximately 0.4 mg/L or less). Operating in SND mode could provide a significant reduction in aeration demand for nitrification and carbon demand for denitrification but it requires precise control of the DO concentrations in different parts of the basins and thus advanced instrumentation and controls. The biomass, and nitrifiers in particular, need to be transitioned to low DO conditions over a period of several weeks. There is also still the potential risk of proliferation of low DO filaments that can lead to poor mixed liquor settleability. To prevent that, an unaerated anoxic zone will still be included. In addition to the anoxic selector, BC has demonstrated that use of hydrocyclones on the WAS stream can also be beneficial to SND performance and maintaining good settleability.

6.3.2.1.2 Secondary clarifier limitations

The secondary clarifiers are projected to reach their solids loading limit in the next few years under dry weather conditions if one clarifier is out of service. This limitation can be addressed by operating all four clarifiers, operating more than 2 aeration basins, or operating at a higher return activated sludge (RAS) rate (higher than 30 percent). Operating at a low RAS rate and turning off the RAS pump for a few hours a day to allow the sludge to thicken in the clarifiers has the potential to result in deteriorated effluent quality if there is a bulking event, especially in the winter. Without a separate thickening process, operating at a higher RAS rate would produce a thinner digester feed, thus negatively impacting the downstream digester and dewatering operation. In addition to solids loading limitations, the original design peak clarifier surface overflow rate (SOR) is exceeded at the current projected plant peak hour flow rate. Stress testing is recommended to determine the actual peak hour SOR limit.

While not directly impacting capacity, the excessive foaming that often occur at the aeration basins may be associated with high sludge volume indices (SVIs) and cause other operational problems. Potential solutions include addition of water sprays, a classifying selector, and a foam wasting station.

6.3.2.1.3 Aerobic digestion limitations

With all four digesters in service, the digesters have sufficient capacity to meet the hydraulic retention time (HRT) requirements for Class B biosolids as long as the digester feed solids concentration is above a specific value. Without a separate thickening process, that requires thickening within the secondary clarifiers, which negatively impacts the clarifier performance and reduces their solids loading capacity as mentioned above. It is recommended that the GBT be brought into service to provide a dedicated thickening step to counteract the potential secondary clarifier limitation.

Because operating at a high solids concentration in the digesters may require increased aeration to maintain an adequate DO concentration and may also increase the risk of having the process becoming autothermal, a thickened solids concentration of no more than about 2 to 2.5% solids is recommended.

Recent digester performance and review of plant data indicate that, to consistently meet the 38% volatile solids reduction (VSR) requirement for Class B biosolids, all four digesters would be required to be in service. Having all four digesters in service also provides a higher overall HRT. However, this provides no redundancy in digester operation. An evaluation of the digester aeration system is recommended within the next 5 years to investigate the feasibility of taking one digester out of service and potentially operating at a concentration higher than the recommended 2.5% solids concentration level. Performance data after the GBT has been brought back into service should be included in the evaluation.

6.3.2.1.4 Effluent quality limitations.

While the modeling results indicate that secondary effluent concentrations would meet the current permit limits under all flows and loadings evaluated, the actual effluent quality may be reduced due to different factors including deteriorated settling characteristics, different influent wastewater characteristics, and clarifier operation. The effluent TSS concentration limit during the dry weather period (10 mg/L for the monthly average limit) has the highest risk of being exceeded, as it has occurred a couple of times since 2020. To meet the effluent limits consistently, effluent filtration is recommended.

6.3.2.2 Long-Term (after 2030) Capacity Constraints

Long-term capacity constraints for major elements of the treatment system are summarized below. The recommended improvements, upon review by OLWS staff and modified as needed, are incorporated in the WWTP alternatives analysis. All of the capacity constraints identified in the next 20 years are loading related. The WWTP has the hydraulic capacity to pass and treat a peak flow of 20 mgd, which is higher than the projected peak hour flow in 2052. If RDII reduction work is not implemented such that the RDII volume increases, thus increasing the plant flows, then hydraulic constraints at the WWTP will occur sooner.

6.3.2.2.1 Aeration system limitations

The aeration blowers are projected to reach their firm capacity limit around 2035 under wet weather conditions. The blower capacity can be increased by placing all blowers in service but that would result in no redundant blower available. Increasing the diffuser density in the first aerated zone will increase the oxygen transfer efficiency and thus reduce the air flow requirements. Conversion to a SND process will also reduce air flow requirements. Without those changes or other process changes, a new blower will be required. OLWS could choose to convert to the SND process or increase blower capacity through installing larger blowers or adding additional blowers.

6.3.2.2.2 Aerobic digestion limitations.

Based on the findings of digester aeration system evaluation recommended above, an upgrade of the digester system is likely to be needed.

6.4 Identification and Evaluation of WWTP Alternatives

In accordance with the guidance document entitled Preparing Wastewater Planning Documents and Environmental Reports for Public Utilities (DEQ, 2018), this section describes the process used to develop and consider of all viable alternatives and to implement a transparent selection process to make recommendations to meet short- and long-term needs at the OLWS WWTP.

6.4.1 Process Methodology

OLWS and BC implemented the following methodology to identify and evaluate WWTP alternatives. It includes the following steps, discussed in more details below:

- Initial conceptual analysis
- Screening of conceptual alternatives
- Analysis of shortlisted alternatives

6.4.1.1 Initial Conceptual Analysis

BC performed a conceptual analysis to identify a range of alternatives for each unit process to meet projected flow and load conditions and potential future regulatory requirements.

6.4.1.2 Workshop to Evaluate Conceptual Alternatives

BC facilitated a workshop on September 28, 2022, to present the range of alternatives and the preliminary scoring based on criteria developed with OLWS input. The minutes and presentation from the September workshop are included in Appendix J of the WWMP. Alternatives for each unit process were then shortlisted for further analysis as noted in Appendix J of the WWMP and described below.

6.4.1.3 Alternative Analysis for Shortlisted Alternatives

BC performed an alternative analysis for the shortlisted alternatives that included the following, as applicable:

- Preparation of planning level layouts
- Estimation of performance
- Analysis of hydraulic impacts
- Projection of planning level capital and operation and maintenance (O&M) costs
- Comparative evaluation of alternatives based on economic and non-economic criteria

6.4.1.4 Workshop to Complete Alternatives Evaluation

BC facilitated a second workshop on October 26, 2022, to present the preliminary results of the alternatives analysis and updates from the September presentation based on OLWS input. The minutes and presentation from the October workshop are included in Appendix J of the WWMP.

6.4.2 Evaluation Criteria and Scoring Factors

Table 6-3 lists the evaluation criteria that were used to evaluate the WWTP alternatives.

Table 6-3: Evaluation Criteria and Scoring Factors

Evaluation Criteria
Planning for future • **Footprint and future expansion** • **Potential Regulatory changes**
O&M considerations • **Operability** • **Maintainability** • **Constructability** • **Reliability**
Environmental • **Risk to environment** • **Energy efficiency**
Cost and rate impacts • **Construction** • **O&M (annual)**

The alternatives were scored in each of the categories listed in Table 6-3 on scale of 1 (least desirable) to 3 (most desirable), so that the highest scoring alternatives were preferred. Additional information and details on the evaluation criteria are provided in the workshop minutes and presentations including the September workshop.

6.4.3 Energy Considerations

Energy efficiency is a key consideration in the evaluation of alternatives. Energy considerations include selecting efficient equipment such as blowers, utilizing gravity flow rather than pumping such as in the selection of tertiary treatment technology, and using instrumentation to allow better control of treatment processes to minimize energy usage. Energy efficiency was considered as part of the environmental category and is incorporated into life cycle cost evaluations as applicable.

6.4.4 Seismic Resilience

The WWMP does not include a seismic resilience evaluation for existing facilities. Seismic resiliency requirements for new facilities should be established as part of a basis of design. Structural condition assessments, development of site-specific response spectra, Tier 1 evaluation, and a life safety structural analysis are recommended as part of a seismic resilience evaluation.

6.5 Development of Costs

Life cycle cost evaluations were performed for evaluations of shortlisted alternatives. Opinions of probable construction costs for the alternatives were developed in accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria as Class 5 estimates, unless noted otherwise. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete. Class 5 estimates are used to prepare planning level cost scopes or evaluation of alternative schemes, long range capital outlay planning, and can also form the base work for the Class 4 Planning Level or Design Technical Feasibility Estimate.

Expected accuracy for Class 5 estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimates were prepared using quantity take-offs, vendor quotes and equipment pricing furnished either by the WWMP team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor and equipment. Estimates were prepared using BC’s estimating system, which consists of Sage Construction and Real Estate 300 estimating software engine (formerly Timberline) using RS Means database, historical project data, the latest vendor and material cost information, and other costs specific to the project location.

Development of ongoing costs for life cycle costs analyses are described for each section as applicable.

6.6 WWTP Alternatives Evaluation

This section summarizes the evaluation of alternatives for each unit process.

6.6.1 Liquid Stream

Section 6.6.1 summarizes the results of the alternatives evaluation for each liquid stream unit process. OLWS made a significant investment in new liquid stream facilities as part of Phases 1A and 1B completed approximately 10 years ago. These facilities remain in good condition. This was a key consideration in developing and evaluating liquid stream alternatives.

6.6.1.1 Influent Lift Station and Headworks

The Influent Lift Station, Plant Drain Pump Station, Influent Channel, and Influent Sampler were determined to be operating generally as intended, based on input from the operating staff. As described in the WWTP Operations and WWTP Condition Assessment TM, there are concerns with debris collecting in the Influent Lift Station Wet Well as well as access to these pumps. There is also concern with the location of the influent sampler suction line. Projects to address these concerns are included in the CIP presented in Chapter 7.0 of the WWMP.

The Headworks Building houses equipment to remove and process screenings and grit. The screenings equipment includes Huber Multi-Rake screens with 1/4-inch bar spacing, screenings trough, and Huber screenings compaction equipment with grinder and auger. BC identified and evaluated alternatives for screenings and grit removal based on potential improvements in performance but considered the conveyance and processing equipment acceptable in the current configuration.

The OLWS WWTP does not include a primary treatment step in the liquid stream train. As described in the WWTP Operations TM included as Appendix C to the WWMP, debris including floating material can pass through the fine screening system and cause operational problems such as becoming trapped on mixer blades in the aeration basins. There appear to be gaps in the seal between the equipment frame and concrete channel where the screens are installed that may be the reason for the lack of capture. Alternatives for screening removal that would use the existing Headworks Building to improve performance were identified and evaluated.

Screening removal alternatives included:

1. Keep the existing Huber Multi-Rake screens but modify channel installation to provide a better seal to prevent debris from passing through gaps between channel and equipment frame.
2. Replace existing screens with new equipment that would provide even finer openings of 1/4-inch or less for better debris capture.

3. Replace existing screens with perforated plate type that would provide even finer openings for better debris capture.

Table 6-4 summarizes the evaluation of screening removal alternatives. As shown in this table, the recommended alternative is to keep the existing Huber Multi-Rake screens and adjust channel fit. This alternative has a lower cost than the other two alternatives. This is included as a project in the CIP included in Chapter 7.0.

Table 6-4: Screenings Removal Equipment Alternatives

Criteria	Keep Existing Huber Multi-Rake and Adjust Channel Fit	Replace with Even Finer Screens (</=1/4")	Replace with Perforated Plates
Planning for future	3	3	3
▪ Footprint and future expansion	3	3	3
▪ Potential regulatory changes	3	3	3
O&M considerations			
▪ Operability	3	2	2
▪ Maintainability	3	3	3
▪ Constructability	3	2	2
▪ Reliability	3	3	3
Environmental	3	3	3
Cost and rate impacts			
▪ Construction	3	1	1
▪ O&M (annual)	2	3	3
TOTAL	**26**	**23**	**23**

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

As noted above, no alternatives to the existing screening washing and compaction system were considered because this equipment is performing well.

The Headworks Building also houses equipment to remove and process grit. The grit equipment includes Hydro International HeadCell units for grit removal, recessed impeller centrifugal grit pumps, and Hydro International Slurry Cup and Snail units for grit dewatering. OLWS staff report that the stacked trays of the HeadCell are difficult to access and maintain because of the concrete cover. WWTP staff have been working with Hydro International to design modifications that will improve accessibility. An alternative to improving access to the HeadCell would be to replace the grit removal equipment with an alternative vortex system. Table 6-5 summarizes a comparison of these two alternatives. As shown in Table 6-5, the recommended alternative is to keep the existing HeadCell equipment with cover modifications that are included in the CIP.

Table 6-5: Grit-Removal Equipment Alternatives

Criteria	Keep Existing Equipment and Improve Cover Access to HeadCell	Replace HeadCell with Alternative Vortex System
Planning for future		
▪ Footprint and future expansion	3	2
▪ Potential regulatory changes	3	3
O&M considerations		
▪ Maintainability	3	2
▪ Constructability	3	1
▪ Reliability	3	3
Environmental	3	3
Cost and rate impacts		
▪ Construction	3	1
▪ O&M	2	2
TOTAL	**23**	**17**

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

Opportunities for optimization, O&M cost savings, and reducing maintenance costs associated with these facilities have been documented in the Condition Assessment section and quantified in the CIP included in Chapter 7.0. Replacement of equipment based on projected service life age is also addressed in the CIP.

6.6.1.2 Secondary Treatment

Alternatives for replacement or modification of the secondary treatment system were evaluated with considerations for future regulatory drivers, potential cost savings, and aging equipment. A range of potential alternatives were considered and screened in the September 28, 2022, workshop, including:

- Modified Ludzack-Ettinger (MLE) (current process)
- Anoxic step-feed
- Anaerobic-Anoxic-Oxic (A2O)
- Simultaneous nitrification denitrification (SND)
- Integrated fixed film activated sludge (IFAS)
- Ballasted sedimentation (BioMag®)
- Membrane bioreactor (MBR)

For all these alternatives, the existing aeration basins will remain. Except for MBR, the existing secondary clarifiers will also remain as part of the process. In a MBR system, microfiltration or ultrafiltration membranes are used in the solids separation step instead of clarifiers.

6.6.1.2.1 Alternatives Screening Analysis

The initial alternatives listed above were screened based on the evaluation criteria presented in Table 6-3. The results and shortlisted alternatives are summarized in Table 6-6.

Table 6-6: Secondary Treatment System Alternatives Screening

Criteria	MLE	Anoxic SF	A2O	SND	IFAS	BioMag	MBR
Planning for future							
▪ Footprint and future expansion	2	1	1	2	2	2	3
▪ Potential regulatory changes	1	1	3	3	2	2	3
O&M considerations							
▪ Operability	3	3	3	3	2	2	1
▪ Maintainability	3	3	3	3	2	2	1
▪ Constructability	3	3	2	2	2	2	1
▪ Reliability	3	3	3	2	2	2	3
Environmental	2	2	3	3	2	2	1
Cost and rate impacts							
▪ Construction	3	3	2	2	1	1	1
▪ O&M	2	2	2	2	2	2	1
TOTAL	**22**	**21**	**22**	**22**	**17**	**17**	**15**

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

Based on the screening analysis, the following alternatives were further evaluated:

1. MLE
2. A2O
3. SND
4. SND/A2O

The SND/A2O alternative was added as a combination of A2O and SND to provide the benefits for both alternatives.

6.6.1.2.2 Alternatives Detailed Analysis

The four shortlisted secondary treatment alternatives were evaluated based on the design criteria presented in Table 6-7.

Table 6-7: Secondary Treatment Design Criteria

Parameter	Value
Design year	2052
Startup year	2032
Ammonia limits	0.5 mg/L (dry weather)
	2 mg/L (wet weather)
Total phosphorus (TP) limit	1-2 mg/L

Table 6-1 provides additional details regarding the influent flows and loads associated with the 2052 design year. Brief descriptions of the four alternatives and their associated capital and process requirements are presented below.

6.6.1.2.3 MLE

The existing secondary process at the OLWS WWTP is shown as a process schematic in Figure 6-1.

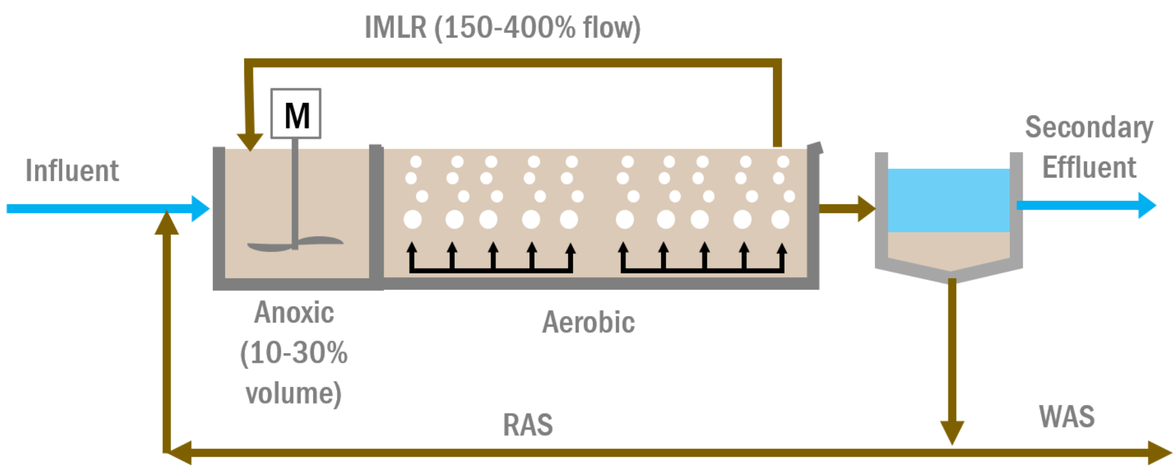


Figure 6-1: MLE Process Schematic

The internal mixed liquor recycle (IMLR) stream, which is routed from the end of the aerated zone to the anoxic zone, typically ranges from 150 to 400 percent of the influent flow. The anoxic zone allows denitrification and by incorporating the IMLR, the denitrification capability is increased. In evaluating this alternative to meet the design criteria listed in Table 6-7, new baffle walls were added to provide better separation of the anoxic and aerated zones. The existing diffuser grids would be replaced to increase aeration capacity. New dissolved oxygen (DO) sensors, air flow control valves, and air flow meters are also added to improve DO control.

As the MLE process is not designed to provide phosphorus removal, the TP limit will be met by chemical addition. This is typically achieved by adding metal salts such as alum or ferric chloride, followed by tertiary filtration. The dissolved fraction of the secondary effluent phosphorus is targeted with the metal salts and forms a precipitate that is removed in the tertiary filter along with the particulate fraction of the phosphorus. For OLWS WWTP, aluminum sulfate (alum) addition is recommended since ferric chloride can be detrimental to UV disinfection. A multi-point chemical addition scheme may also be used, with chemical dosing at the secondary clarifier splitter box and upstream of the filters. Process modeling indicated that the biological treatment process would become alkalinity limited under certain operating conditions (winter maximum month loading); therefore, caustic addition is also recommended.

6.6.1.2.4 A2O

In an A2O process, an anaerobic zone is included, followed by the anoxic zone and then the aerobic zone. This sequence allows for biological phosphorus removal, denitrification, and nitrification and BOD oxidation in those respective zones. Figure 6-2 shows a process schematic for this process.

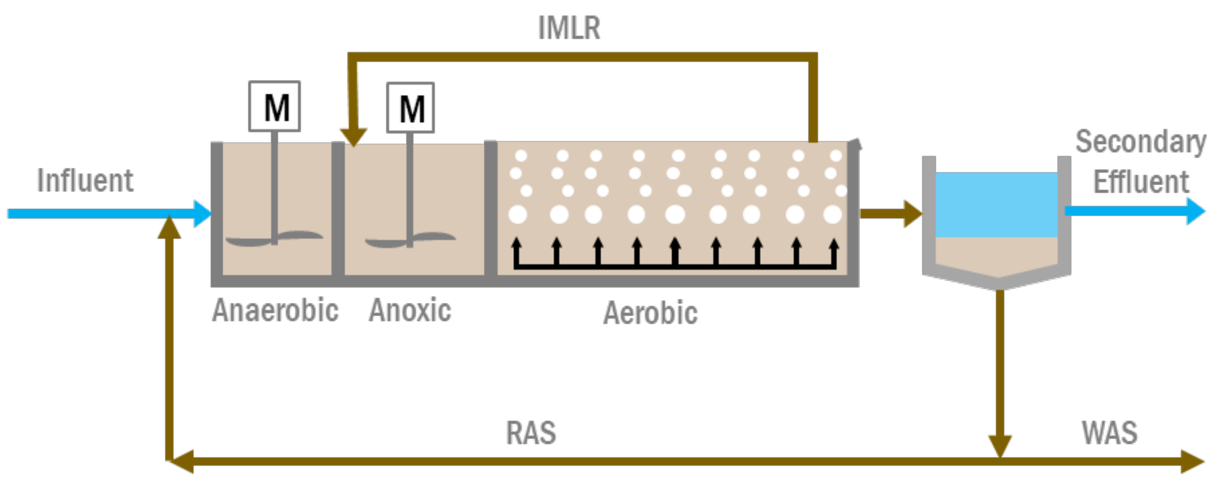


Figure 6-2: A2O Process Schematic

In addition to new baffles, diffuser grids, and instrumentation for improved DO control, this alternative would require additional mixers (for the expanded unaerated zones) and re-routing of the IMLR piping. Chemical precipitation may still be required depending on the actual effluent P limit. Process modeling indicates that alum addition would be required if the TP limit is 1 mg/L or lower, although the dosing rate will be lower than for the MLE alternative. Caustic addition is also required under the winter maximum month loading condition.

6.6.1.2.5 SND

In an SND process, nitrification and denitrification occur concurrently in the same aerobic tank operated at low DO concentrations. The main advantages of SND are reductions in oxygen demand for nitrification and carbon demand for denitrification. However, SND requires careful process control of the DO concentrations in different parts of the aeration basins. Advanced aeration controls, such as ammonia-based aeration control (ABAC), are often recommended to maximize performance and to provide process stability. An upstream anoxic zone is typically still included for filament control.

Figure 6-3 shows a process schematic for the SND process, which is similar to the MLE process. For this analysis, an ammonia sensor was assumed to be added at the mixed liquor channel upstream of the clarifier splitter box to facilitate ABAC. Other capital improvements including new baffles, diffuser grids, DO sensors, air flow control valves, and air flow meters would be required. An alum feed system would be needed for phosphorus removal. However, caustic addition is not required because the increased denitrification in the process results in increased alkalinity recovery.

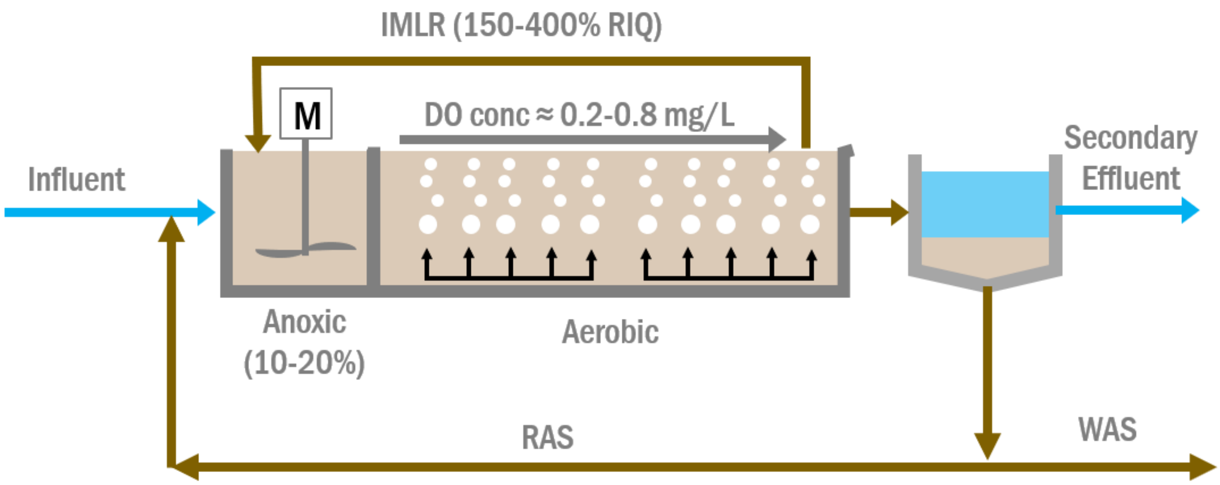


Figure 6-3: SND Process Schematic

6.6.1.2.6 SND/A2O

This alternative is a hybrid of the A2O and SND alternatives created by adding an anaerobic zone upstream of the anoxic zone. Figure 6-4 shows the process schematic. In addition to the capital improvements for SND, this alternative would require a new mixer for the expanded unaerated zone and re-routing of the IMLR piping. Chemical addition, however, would not be required for phosphorus removal and alkalinity control.

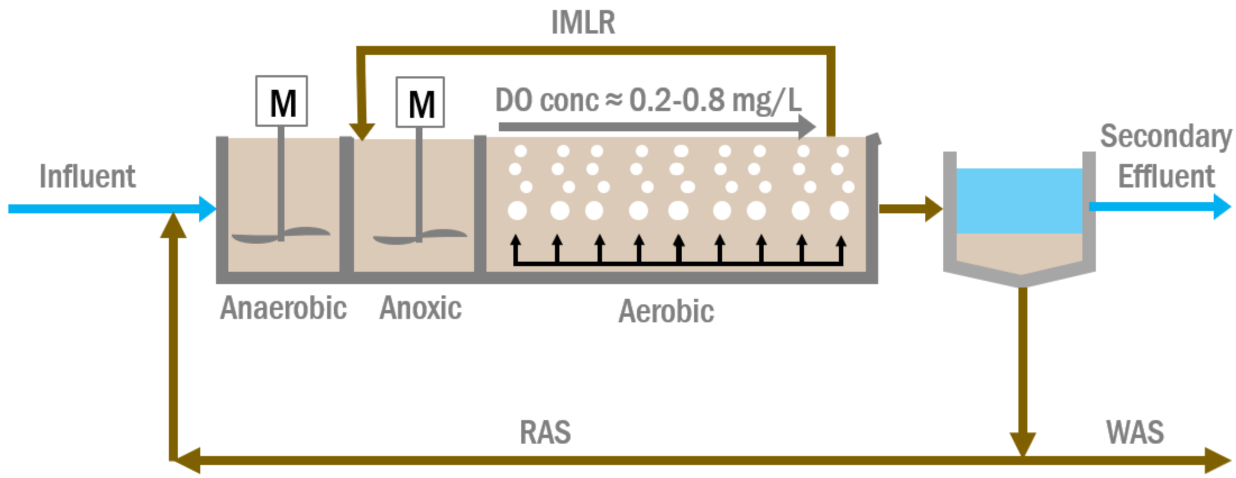


Figure 6-4: SND Process Schematic

Preliminary layouts showing the aeration basin modifications for the four alternatives are provided in the October and November 2022 workshop slides provided in Appendix J. A life cycle cost analysis was conducted for the four alternatives to account for both the capital and operating costs. Results of the cost analysis are summarized in Table 6-8. It should be noted that power costs account for aeration blower power requirements only; power costs for other equipment including mixers and pumps are considered similar among the alternatives or negligible compared to the blower power costs. Similarly, the labor costs presented are for comparison purposes only and mainly account for estimated differences in full-time equivalent (FTE) to operate and maintain the instrumentation and chemical systems.

The results show the SND/A2O alternative has the lowest net present value (NPV).

Table 6-8: Secondary System Alternatives Cost Comparison

Alternatives	MLE	A2O	SND	SND/A2O
Construction Cost[1] (2022$)	$1,116,000	$2,212,000	$1,047,000	$1,903,000
Annual Operating Costs (2022$ for 2032)[2]				
Power	$32,000	$33,000	$26,000	$27,000
Labor	$200,000	$200,000	$200,000	$133,000
Chemical	$129,000	$34,000	$120,000	--
Subtotal	$361,000	$267,000	$346,000	$160,000
NPV (2022$)[3]	**$12,097,000**	**$10,668,000**	**$11,567,000**	**$7,078,000**

[1] Class 5 estimate, with a range from -50% to +100%, un-escalated, undiscounted.

[2] Operating costs include power costs for aeration, additional labor costs, and chemical costs (caustic and alum), un-escalated, undiscounted. Unit power cost of $0.045/kWh (provided by OLWS) and labor cost of $133,133/FTE/year (derived from OLWS adopted budget 2022-23 for total treatment personnel services and FTEs) assumed.

[3]NPV assuming design and construction in 2029 to 2031, operating costs from 2032 to 2052, 5% escalation rate, and 3.4% discount rate.

6.6.1.2.7 Recommended Alternative

While the SND/A2O alternative has the lowest NPV in the life cycle analysis, it requires relatively significant retrofits to re-route the IMLR piping as well as more basins in service. It is thus recommended that SND be first implemented to provide energy savings and improve alkalinity recovery. New diffuser grids and baffles will be designed to allow subsequent conversion to the SND/A2O process, and space will be set aside for a potential future chemical feed system. The process could then be converted to SND/A2O in the future as needed when the nutrient permit limits are known. A chemical feed system would be needed only if it was decided in the future to implement chemical phosphorus removal instead of converting to A2O.

Figure 6-5 shows the layout for the SND/A2O alternative with phasing. The conversion from SND to SND/A2O would involve re-routing the IMLR piping and addition of a baffle and a mixer in Aeration Basin 3.

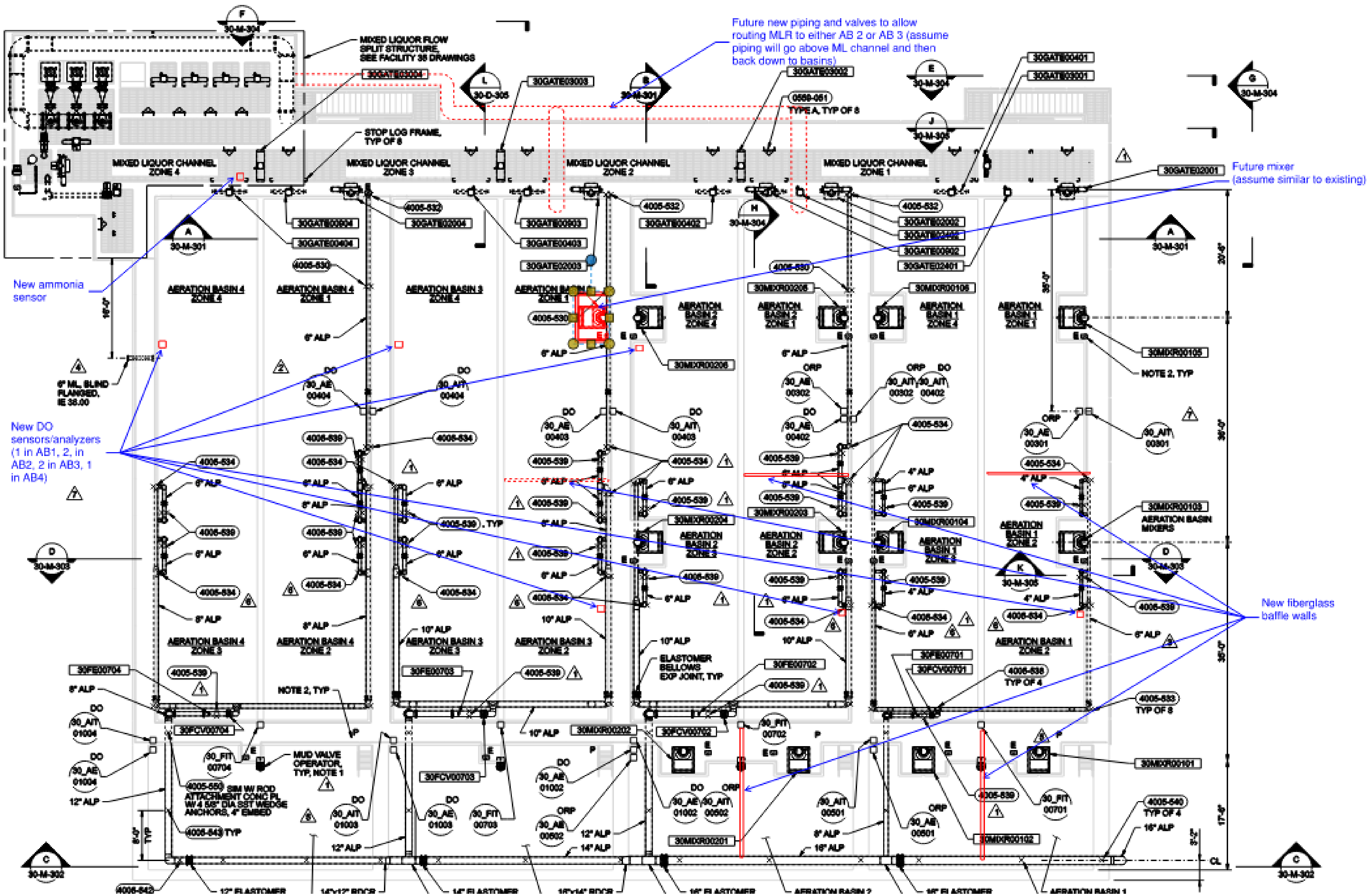


Figure 6-5: Layout of Recommended SND/A2O Alternative

6.6.1.3 UV Disinfection

A qualitative evaluation of the UV Disinfection Facility concluded the current configuration was optimal (see Table 6-9), so alternatives for replacement were not considered further in the WWMP. Opportunities for optimization, O&M cost savings, and maintenance costs associated with this facility have been documented in the Condition Assessment section and quantified in the CIP. Replacement of equipment based on projected service life age is also addressed in the CIP.

Table 6-9: Disinfection Alternatives

Criteria	Keep Existing Trojan UV System and Make Gate and Actuator Improvements	Replace with Paracetic Acid	Replace with Alternative UV System
Planning for future			
▪ Footprint and future expansion	3	2	2
▪ Potential regulatory changes	3	1	3
O&M considerations			
▪ Operability	3	2	3
▪ Maintainability	3	2	2
▪ Constructability	3	2	2
▪ Reliability	3	2	3
Environmental	3	2	3
Cost and rate impacts			
▪ Construction	3	1	1
▪ O&M	3	2	3
TOTAL	**27**	**16**	**21**

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

6.6.1.4 Tertiary Filtration

Alternatives for a new Tertiary Filtration Facility were evaluated with consideration of future regulatory drivers and cost impacts. The alternatives were evaluated based on the design criteria presented in Table 6-10.

Table 6-10: Tertiary Filtration Design Criteria

Parameter	Value
Design year	2052
Startup year	2025
Maximum Influent TSS	35 mg/L
Maximum Effluent TSS	5.0 mg/L
Design flows (mgd)	
Annual average (1 train in service)	3.5
Max month (1 train in service)	6.7
Peak hour (3 trains in service)	19.4
Filtration rate	5 gpm/sf

The following alternatives were considered for tertiary treatment and are summarized in more detail in the October 2022 workshop slides in Appendix J.

1. Disk filters
2. Downflow (granular media) filters
3. Membrane filters
4. Upflow filters
5. Iron-coated sand filters
6. Ballasted/chemical clarifiers
7. Compressible media filters

6.6.1.4.1 Alternatives Screening Analysis

Each of the alternatives were initially evaluated for shortlisting based on whether they would fit in 1) the available site footprint (see Figure 6-6), and 2) the available hydraulic profile allocated for tertiary filters in the 2012 WWTP upgrades.

Figure 6-6: Site Footprint Allocated for Future Tertiary Filters

(From OLWS June 2022 Online Community Conversation)

The hydraulic profile in the 2012 record drawings specifically stated that the design had considered disk filters in the hydraulic profile, as shown in Figure 6-7. Approximately 3.5 ft of available head loss is available in the hydraulic profile; the note is clarifying that 2 ft was assumed in the original hydraulic calculations.

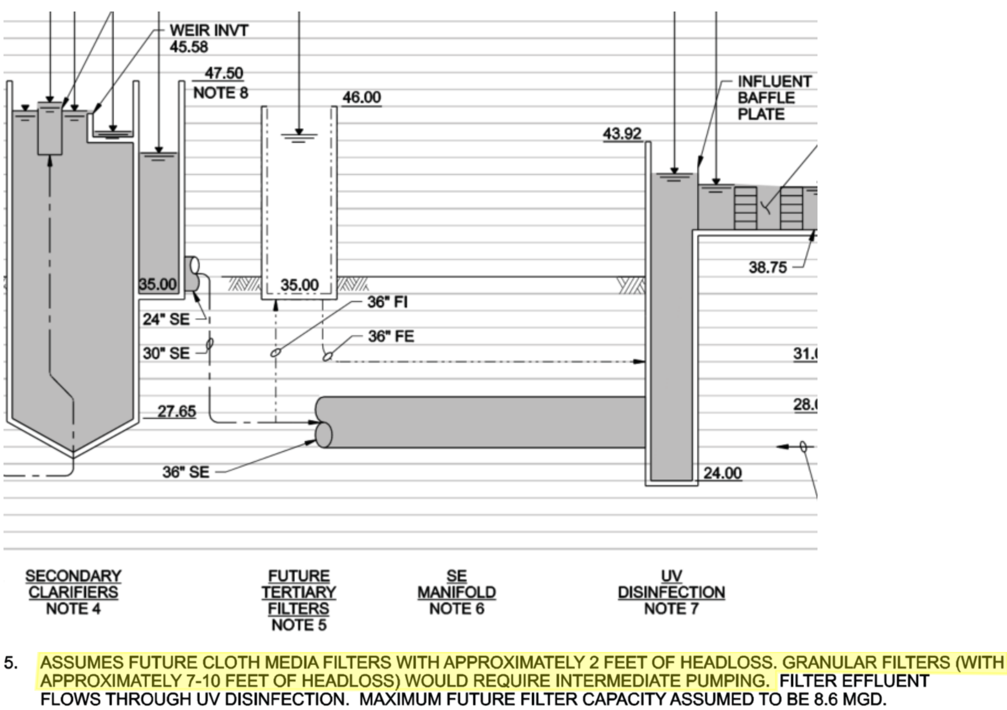


Figure 6-7: 2012 Record Drawings Showing Hydraulic Profile Assumptions for Future Tertiary Filters

A review of the alternatives considering only whether they would fit onsite and within the hydraulic profile revealed that disk filters were by far the most viable alternative, as summarized in Table 6-11.

Table 6-11: Tertiary Filter Alternatives - Site Footprint and Hydraulic Profile Evaluation

Alternatives	Will it fit onsite?	Will it fit in the hydraulic profile? (Or will additional pumping be necessary?)
Disk filters	✓	✓
Downflow (granular media) filters	?	X
Membrane filters	?	X
Upflow filters	?	X
Iron-coated sand filter (BluePro®)	X	X
Ballasted/chemical clarifiers	X	?
Compressible media filters	?	X

The accommodations required to fit the alternatives other than disk filters heavily influenced the initial scoring for shortlisting, as shown in Table 6-12. The scoring exercise resulted in disk filters being the only shortlisted alternative. Accordingly, a life cycle cost evaluation was not performed, and disk filters were selected for detailed evaluation.

Table 6-12: Tertiary Filtration Alternatives Screening

Criteria	Disk Filters	Granular Media Filters		Membrane Filters	Iron-coated sand filter (BluePro®)	Ballasted/ chemical Clarifiers	Compressible media filters
		Downflow	**Upflow**				
Planning for future							
▪ Footprint and future expansion	3	2	2	2	1	1	2
▪ Potential regulatory changes	2	3	3	3	3	1	2
O&M considerations							
▪ Operability	3	2	2	2	2	1	1
▪ Maintainability	3	2	2	1	1	2	2
▪ Constructability	3	2	2	2	1	1	2
▪ Reliability	3	2	2	1	1	1	2
Environmental	3	2	2	1	2	2	2
Cost and rate impacts							
▪ Construction	3	2	2	1	1	1	2
▪ O&M	3	2	2	1	1	2	2
TOTAL	**26**	**19**	**19**	**14**	**13**	**12**	**17**

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

6.6.1.4.2 Tertiary Filtration Recommended Alternative

The detailed evaluation of disk filters focused on equipment from the following manufacturers:

- Aqua Aerobic – cloth media (outside-in flow pattern)
- Veolia – woven fabric media (inside-out flow pattern)
- Nuove Energie – stainless steel mesh media (inside-out flow pattern)

Table 6-13 presents a summary of the proposed equipment from each manufacturer based on the OLWS design criteria.

Table 6-13: Summary of Proposed Disk Filter Equipment

Manufacturer	Aqua Aerobic	Veolia	Nuove Energie (Aggressive)	Nuove Energie (Conservative)
Equipment Cost	$1.57 M	$1.42 M	$1.13 M	$2.00 M
Pore Size	10 micron	10 micron	20 micron	
Hyd Loading Rate at ADF (gpm/sf)	3.23	2.56	5.5 [1]	
Hyd Loading Rate at PHF (gpm/sf)	5.96 [1]	4.73	10.2 [1]	4.8
# of Units	3	3	3	(DOES NOT FIT IN AVAILABLE FOOTPRINT)
Total No. of Disks	42	66	Not reported	
Total Filter Area per Unit	753	1,463	441	
Total Filter Area	2,260	4,389	1324	
Submerged Filter Area	2,260	2,847	1321	
Disk Material	Cloth	Woven fabric	316 SST mesh	
Tank Material	Painted steel	304 SST	304 SST	
Shaft Material	304 SST	304 SST	304 SST	
Max Headloss (ft)	3.06	2.18	2.20	
Height (ft)	12	8.2	7.6	
Dry Weight (lbs) per Unit	17,000	11,244	13,200	
Wet Weight (lbs) per Unit	75,000	40,785	45,100	
Drive Motor HP	2	1.5	3	
Backwash pump HP	2	20	15	
Power Consumption (kWh/d)	114	134	69	
Backwash Flow (% of INF)	1%-3%	1.6%	1.5%	

1. *Exceeds design criterion of 5 gpm/sf.*

All the disk filter equipment alternatives are modular, packaged systems with their own steel tanks and control systems for backwash and performance monitoring. Aqua Aerobic and Veolia are reputable manufacturers with multiple similar installations in the Pacific Northwest. Although Aqua Aerobic's proposal exceeds the 5 gpm/sf design criteria at peak hour flow, the offering is close enough to keep in consideration during preliminary design. Further refinement of the design criteria and equipment scope of supply during design may allow increased competition between Veolia and Aqua Aerobic, as well as other manufacturers of similar equipment.

Nuove Energie provided two proposals, but the only one that was potentially viable and competitive with Aqua Aerobic and Veolia (the "aggressive" offering shown in Table 6-13) did not meet the design criteria for hydraulic loading rate or pore size. Therefore, their equipment would be more susceptible to solids pass-through during peak flow events. In addition, there are very few similar installations of this equipment in the Pacific Northwest for operational evaluation and comparison to the other equipment alternatives. Accordingly, Nuove Energie is not likely to be considered further during preliminary design.

The Tertiary Filtration project will be selected for early implementation following completion of the WWMP due to regulatory drivers. Accordingly, additional details were developed for the project concept to provide greater refinement on anticipated cost.

A conceptual layout for the Tertiary Filtration Facility based on the Veolia disk filter proposal is presented in Figure 6-8 and Figure 6-9.

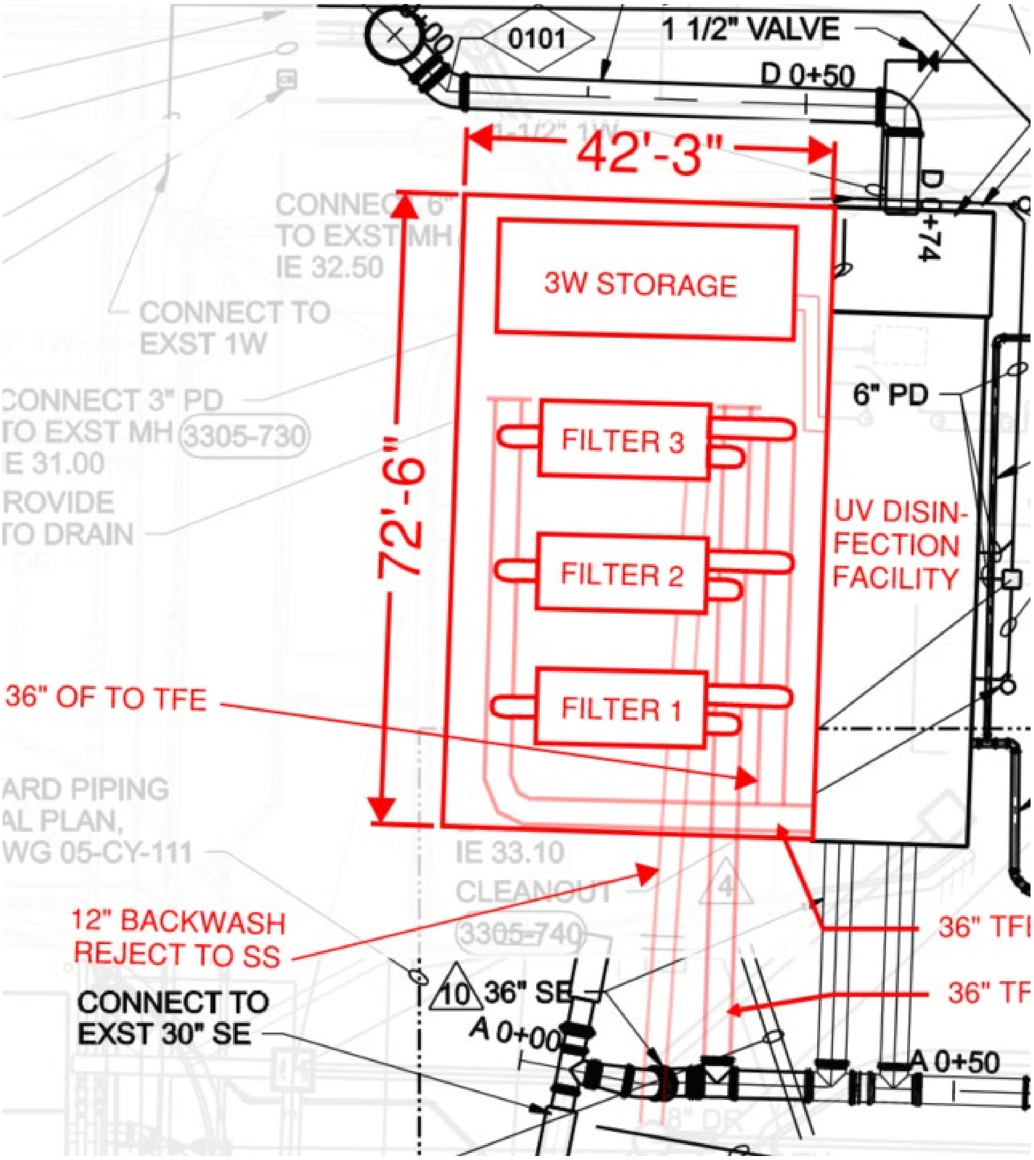


Figure 6-8: Tertiary Filtration Facility Conceptual Layout - Plan View

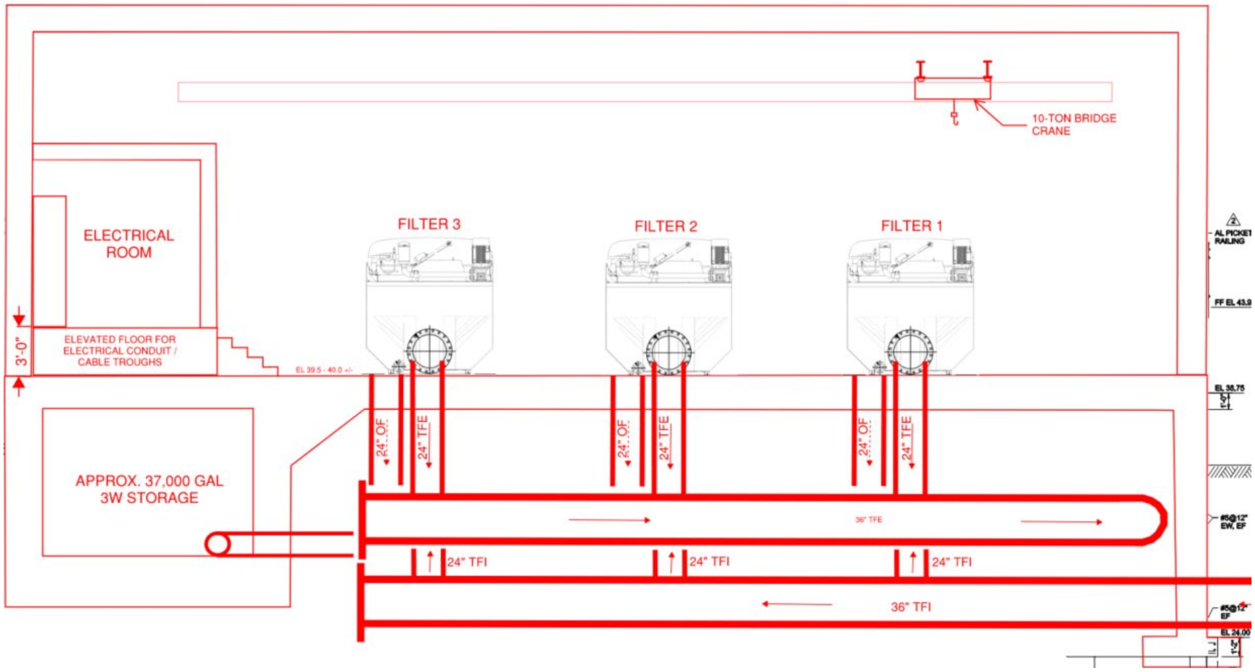


Figure 6-9: Tertiary Filtration Facility Conceptual Layout - Section View

The opinion of probable construction cost (OPCC) for the Tertiary Filtration Facility is considered to be an AACE Class 4 estimate due to the additional level of detail for this project. The accuracy range is -30% to +50%, and included the following assumptions:

- The new structure will include additional storage volume for treated effluent (3W) in a subgrade tank to resolve issues with insufficient 3W supply for WWPT uses during low flows.
- The foundation and operating floor of the building will be cast-in-place concrete.
- The superstructure will be a steel frame and masonry building.
- A 10-ton bridge crane will be provided for maintaining the filters.
- The filter room will be heated only with no air conditioning.
- An interior electrical room will be provided with air conditioning to mitigate the heat load from the electrical equipment.
- The subgrade conditions are unknown; no support piles, rock anchors, or other geotechnical features are included under the structure.
- No modifications to existing yard piping are required, other than connections to new piping.
- Costs escalated to midpoint of construction (October 2024).
- Includes 40% design level contingency.

Design for the Tertiary Filtration Facility is anticipated to begin in 2023, with construction occurring in 2024 and 2025. Table 6-14 presents the anticipated project costs.

Table 6-14: Anticipated Project Costs - Tertiary Filtration Facility

Description	Value
OPCC	$ 10.2 M
Accuracy Range	- 30% to + 50%
Estimated Design Fees	$1.0 M
Estimated Construction Management Fees	$0.5 M
TOTAL PROJECT COST	**$11.7 M**

6.6.2 Solids Stream

This section summarizes the alternatives considered for solids handling system improvements.

6.6.2.1 Current System Operation

The current solids handling system consists of four aerobic digesters and thickening and dewatering equipment. Aerobic Digesters 1 and 2 (previously interchange bioreactor (IBR) tanks associated with the Cannibal system that is no longer used at the OLWS WWTP) were constructed in 2012. Aerobic Digesters 3 and 4, which operate in series with Digesters 1 and 2, were constructed in 1995. A Solids Handling Building (SHB) was constructed in 2002 and includes a GBT, BFP, and all other appurtenant equipment. The layout of the existing solids handling system is shown in Figure 6-10.

Currently, OLWS sends WAS to Digesters 1 and/or 2 and then onto Digesters 3 and 4 to meet the time and temperature criteria and the volatile solids reduction needed to meet Class B biosolids regulatory requirements. Solids are pumped from Digester 4 to the BFP at a concentration of approximately 1.5 to 2 percent solids. Liquid polymer is used to help dewater the solids to approximately 14 to 17 percent solids. The dewatered solids are conveyed to a dump truck outside the SHB and hauled to an onsite covered storage shed as shown on Figure 6-10. A contract hauler then picks up biosolids 1 to 2 times per week and hauls them to Madison Farms in Echo, Oregon, for land application.

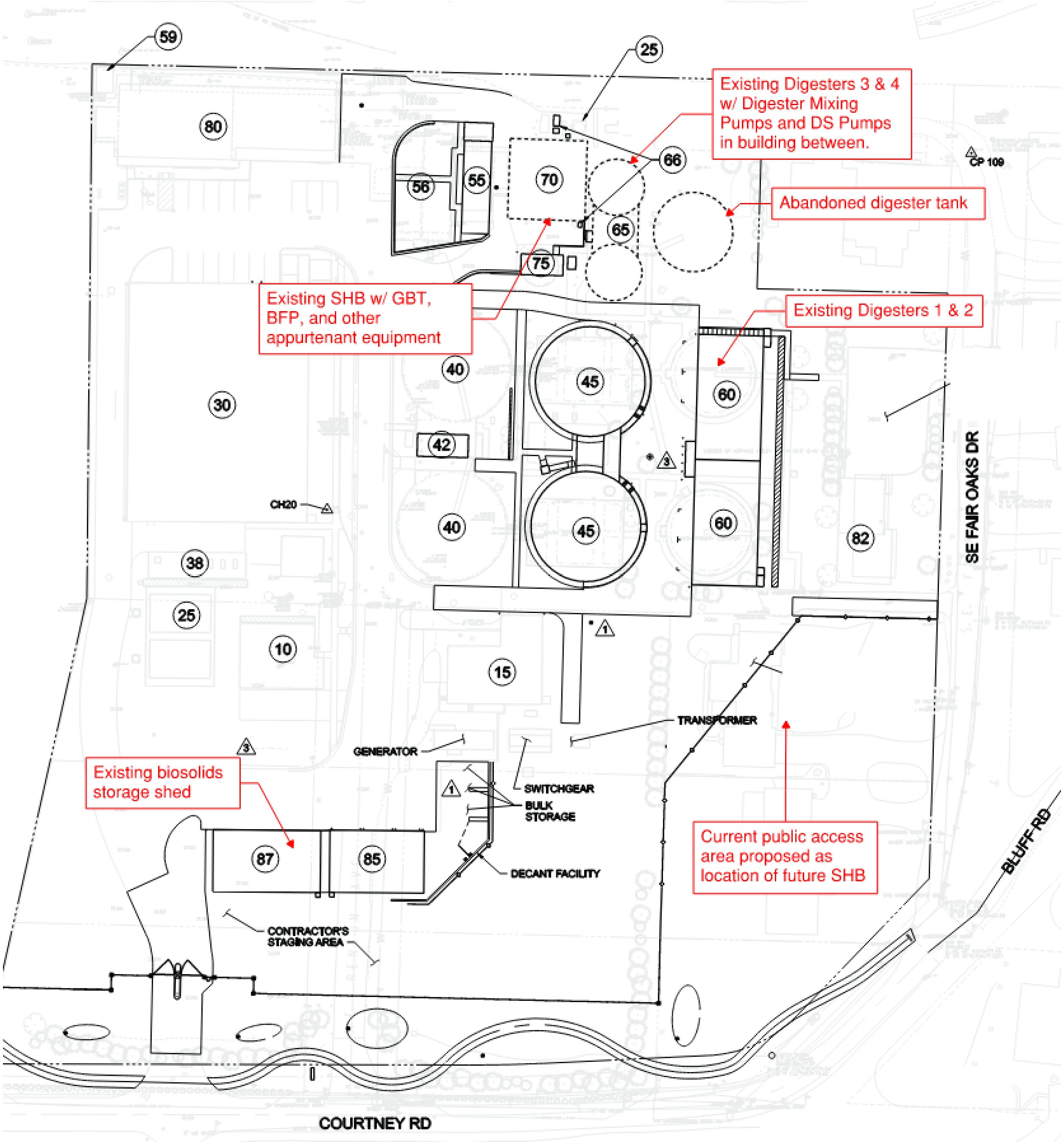


Figure 6-10: Existing Solids Handling Facilities

6.6.2.2 Biosolids Handling and End Use Alternatives

Alternatives for biosolids handling and end use were presented during the September 28, 2022, workshop. The minutes and presentation from the September workshop are included in Appendix J of the WWMP. The alternatives with their initial screening criteria are summarized in Table 6-15.

Although Alternative 1, which consists of continuing to transport and store biosolids in an existing onsite storage shed, scored slightly higher than Alternative 2, which includes a drive under storage hopper, it is the preference of OLWS to have a drive under storage hopper for ease of biosolids storage and loading for contract hauling. Therefore, all the alternatives developed for the solids handling facilities include a drive under storage hopper.

The initial screening for thermal drying to produce Class A biosolids scored low and was not incorporated in the solids handling facility alternatives, but future regulatory changes for biosolids recycling could trigger reconsideration.

6.6.2.3 Solids Handling Alternatives

Alternatives for replacement and reconfiguration of the Solids Handling system were evaluated with consideration of future regulatory drivers, potential cost savings, and aging equipment. The alternatives were evaluated based on the aerobic digestion design criteria presented in Table 6-16.

The current Biosolids Management Plan indicates OLWS gets a credit for running the digesters in series, resulting in a lower required HRT. However, for purposes of this WWMP, it was assumed the full hydraulic residence time (HRT) of 40 days at 20 degrees Celsius (°C) will need to be met as indicated in Table 6-16. It was also assumed there will be three digesters in service with one on standby for redundancy (assumes only one of Digesters 1 and 2 would be in operation) and that WAS flow combined with tertiary filter backwash flow would be thickened to at least 2% solids prior to being sent to the digesters.

Additionally, the alternatives assume there will be two new blowers dedicated to Digesters 1 and 2 and two for Digesters 3 and 4. They would be sized such that there would be one duty and one standby blower for each pair of digesters.

The digester volume and blower capacities provided in Table 6-16 are based on estimated solids production for the SND alternative for secondary treatment as described in Section 6.6.1.2.5. Solids from addition of a tertiary treatment system as described in the previous section are also taken into consideration. Future evaluation would be needed following any upgrades to the secondary treatment system to determine the actual solids loading, necessary digester volume, and aeration capacity needed.

Table 6-15: Biosolids Handling and End Use Alternatives

Criteria	Alternative 1 – Continue to produce/store Class B biosolids in onsite storage shed with contract hauling to land application	Alternative 2 – New drive under storage hopper with contract hauling of Class B biosolids to land application	Alternative 3 – Thermal drying to produce Class A biosolids
Planning for future			
▪ Footprint and future expansion	3	2	2
▪ Potential regulatory changes	3	3	2
O&M considerations			
▪ Operability	2	3	2
▪ Maintainability	3	3	1
▪ Constructability	3	2	2
▪ Reliability	3	3	2
Environmental	2	3	3
Cost and rate impacts			
▪ Construction	3	1	2
▪ O&M	2	3	1
TOTAL	24	23	17

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

Table 6-16: Aerobic Digestion Design Criteria

Parameter	Value
Design year	2052
Startup year	2037
Digesters in service	3 duty/1 Standby
HRT [1]	40 days at 20 °C
Max month WAS production[2]	
Solids load (lb/day)	4,200
Flow (gpm)	39
Tertiary filter backwash solids[3]	
Solids load (lb/day)	1,000
Solids Load (lb/day)[3]	5,210
Digester Volume (gal)	
Existing Digesters 1 & 2, ea	430,000
New Digesters 3 & 4, ea	375,000
Max. TWAS flow to digesters[4] (gpm)	20.6
Blower capacity, ea (scfm)[5]	
Digesters 1 & 2	2,500
Digesters 3 & 4	2,200

[1] HRT required to meet pathogen reduction requirements for Class B biosolids, 40 CFR Part 503 and OAR 340-050. Does not assume any credit is given for operating digesters in series.

[2] Assumes SND alternative is implemented for secondary treatment.

[3] Includes chemical sludge and TSS removed from tertiary filters.

[4] Assumes TWAS includes thickened solids from WAS and tertiary filter backwash combined and is 2% solids. This is the maximum flow that can be sent to the digesters to maintain a 40-day HRT given the digester volumes provided.

[5] Blower capacity calculations assume two blowers dedicated to each pair of digesters with one duty and one standby. Assumes additional mechanical mixing for the digesters.

The following alternatives for the overall solids handling system were considered and are summarized in more detail in the October and November 2022 workshop slides in Appendix J:

1. North Solids Handling Facility and Expansion of the Rectangular Digesters
2. South Solids Handling Facility and Expansion of the Rectangular Digesters
3. South Solids Handling Facility and New North Circular Digesters

Each of the alternatives listed above would include a new SHB with all new redundant thickening and dewatering units, thickened waste activated sludge (TWAS) and digested sludge (DS) pumps, polymer equipment, odor control equipment, an electrical room, drive under solids storage hopper, and other appurtenant equipment.

For Alternative 1, the new SHB would be located where the existing SHB and Digesters 3 and 4 are in the northeast corner of the plant. For Alternatives 2 and 3, the new SHB would be located south of existing Digesters 1 and 2 in an area that is currently not part of the plant. It is property owned by OLWS but currently outside of the fenced plant property and available for public access. The public access area is shown in Figure 6-10, and can be seen in the aerial view in Figure 2-5.

The three alternatives also include two new aerobic digesters to replace existing Digesters 3 and 4, which were constructed in 1995 and will be nearing the end of their useful life. Those new digesters would either be located east of existing Digesters 1 and 2 for Alternatives 1 and 2, or in the vicinity of the existing SHB for Alternative 3.

6.6.2.3.1 Solids Processing Equipment Alternatives

Alternatives for solids digestion were presented during the September 28, 2022, workshop and additional information is included in Appendix J. Those alternatives, with their initial screening criteria, are summarized in Table 6-17. The overall solids handling system alternatives that are described in the following section include variations of all three of the digestion alternatives presented in in Table 6-17. Alternative 1, which consists of replacing Digesters 3 and 4 in their current location, scored the highest overall mainly due to criteria related to footprint and future expansion and construction. However, it scored lowest for operability and maintainability.

Alternatives for solids thickening and dewatering equipment were also presented at the September workshop and are summarized in Table 6-18 and Table 6-19.

Based upon the criteria listed and information available at the time of evaluation, rotary drum thickeners (RDTs) and BFPs scored the highest for thickening and dewatering equipment, respectively. Future evaluation is recommended as equipment and needs of the WWTP are likely to change prior to design of a new solids handling facility.

Figure 6-11 provides a process schematic for the proposed solids handling system.

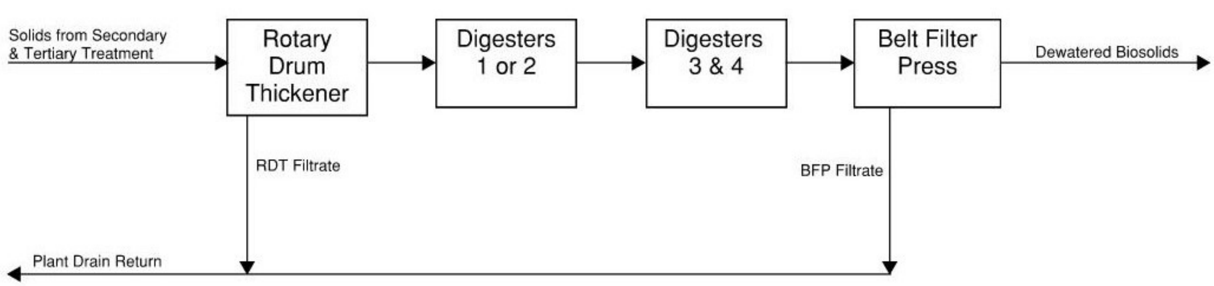


Figure 6-11: Proposed Solids Handling Process Flow Schematic

Table 6-17: Digestion Alternatives

Criteria	Alternative 1 - Replace Digesters 3 & 4 in current location and refurbish Digesters 1 & 2 and make necessary aeration and pump improvements	Alternative 2 - Construct two new digesters east of Digesters 1 & 2 and utilize Digester 3 & 4 area for new SHB	Alternative 3 - Replace Digesters 3 & 4 to the east and refurbish Digesters 1 & 2 and make necessary aeration and pump improvements
Planning for future			
▪ Footprint and future expansion	3	1	2
▪ Potential regulatory changes	3	3	3
O&M considerations			
▪ Operability	2	3	3
▪ Maintainability	2	3	3
▪ Constructability	3	1	1
▪ Reliability	3	3	3
Environmental	3	2	3
Cost and rate impacts			
▪ Construction	3	1	1
▪ O&M	2	3	3
TOTAL	**24**	**20**	**22**

Note: Numerical scores were decided relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial to OLWS.

Table 6-18: Thickening Equipment Alternatives

Criteria	Gravity Belt Thickeners	Centrifuges	Rotary Drum Thickeners
Planning for future			
▪ Footprint and future expansion	2	2	2
▪ Potential regulatory changes	3	3	3
O&M considerations			
▪ Operability	3	1	3
▪ Maintainability	3	1	2
▪ Constructability	2	2	3
▪ Reliability	3	3	3
Environmental	2	3	3
Cost and rate impacts			
▪ Construction	3	1	3
▪ O&M	2	1	3
TOTAL	**23**	**17**	**25**

Note: Numerical scores are relative to other alternatives considered, where 1 = Least beneficial to OLWS, and 3 = Most beneficial.

Table 6-19: Dewatering Equipment Alternatives

Criteria	Belt Filter Presses	Centrifuges	Screw Presses
Planning for future			
▪ Footprint and future expansion	2	2	2
▪ Potential regulatory changes	3	3	3
O&M considerations			
▪ Operability	3	2	2
▪ Maintainability	3	2	2
▪ Constructability	2	2	3
▪ Reliability	3	3	1
Environmental	3	3	2
Cost and rate impacts			
▪ Construction	3	1	3
▪ O&M	2	1	2
TOTAL	**24**	**19**	**20**

Table 6-20 provides preliminary design criteria for the thickening and dewatering equipment based on solids calculations completed at the time this WWMP was prepared, assuming the SND alternative for secondary treatment and addition of tertiary treatment.

Table 6-20: Thickening and Dewatering Equipment Design Criteria

Parameter	Value
Design year	2052
Startup year	2037
Rotary Drum Thickeners	1 duty/1 Standby
Max. Day RDT Feed[1] (lb/hr)	256
Max. Day RDT Flow[1] (gpm)	333
Belt Filter Presses	1 duty/1 Standby
Max. Month Feed[2] (lb/hr)	600
Max. Month Flow[2] (gpm)	82

[1] Assumes RDT is operated continuously, 24 hours per day, 7 days per week.
[2] Assume BFP is operated 6 hours per day, 7 days per week.

6.6.2.3.2 Solids Handling System Alternatives Analysis

Three alternatives for replacing and reconfiguring the existing solids handling system, including biosolids handling and end use, were developed and evaluated. Based upon the initial thickening and dewatering equipment screenings presented in Table 6-18 and Table 6-19, RDTs and BFPs were used in the evaluation for each of the three alternatives. As mentioned above, variations of the digester alternatives presented in Table 6-17 are used in each of the three alternatives described in further detail below.

Alternative 1 – New North Solids Handling Facility and Expansion of the Rectangular Digesters

For this alternative, the existing SHB and circular aerobic digesters located at the northeast corner of the WWTP would be demolished. Two new rectangular digesters would be constructed east of existing Digesters 1 and 2 and a new SHB would be constructed in the location of the existing SHB and circular digesters. The new SHB would be larger than the existing to house a second thickening and dewatering unit for redundancy and to house all the pumps and other appurtenant equipment needed.

A drive under storage hopper would be constructed south of the building to store dewatered solids conveyed from the BFPs. A contract hauler would drive under the hopper to load biosolids for transport for land application.

Figure 6-12 provides a conceptual layout of the layout for Alternative 1. The blue arrows indicate the proposed truck route for the contract hauler. OLWS operations staff have indicated this route would likely not be possible for the size of truck used. Construction of this alternative would require temporary dewatering and thickening facilities during the construction of the SHB after new Digesters 3 and 4 are constructed.

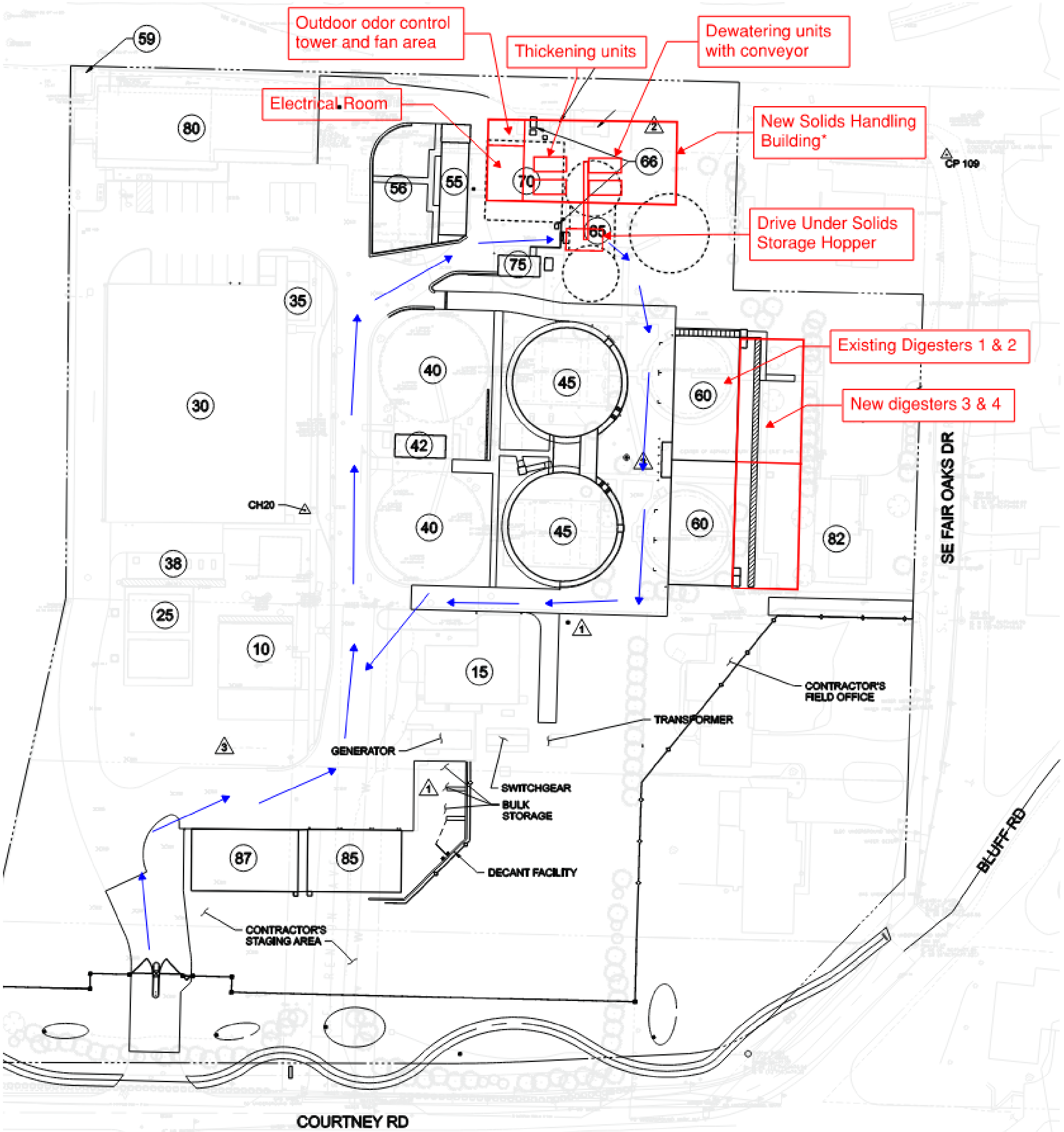


Figure 6-12: Alternative 1 - North Solids Handling Facility and Expansion of Rectangular Digesters

Alternative 2 – South Solids Handling Facility and Expansion of the Rectangular Digesters

For this alternative, the existing SHB and circular aerobic digesters located at the northeast corner of the WWTP would be demolished. Two new rectangular digesters would be constructed east of existing Digesters 1 and 2 and a new SHB would be constructed south of the digesters in an area that is owned by OLWS but currently outside of the fenced plant property and used for public access.

Similar to Alternative 1, the new SHB would be larger than the existing to house a second thickening and dewatering unit for redundancy and to house all the pumps and other appurtenant equipment needed. A drive through storage hopper and truck loading area would be constructed as part of the SHB on the north end. A new entrance road would be constructed on the east side of the WWTP connecting to SE Fair Oaks Drive to provide access for biosolids contract hauling trucks.

Figure 6-13 provides a conceptual layout of the layout for Alternative 2. The blue arrows indicate the proposed truck route. Temporary dewatering and thickening facilities would not be needed during construction of this alternative because the equipment in the existing SHB can remain operational until the new SHB is constructed and the equipment brought online.

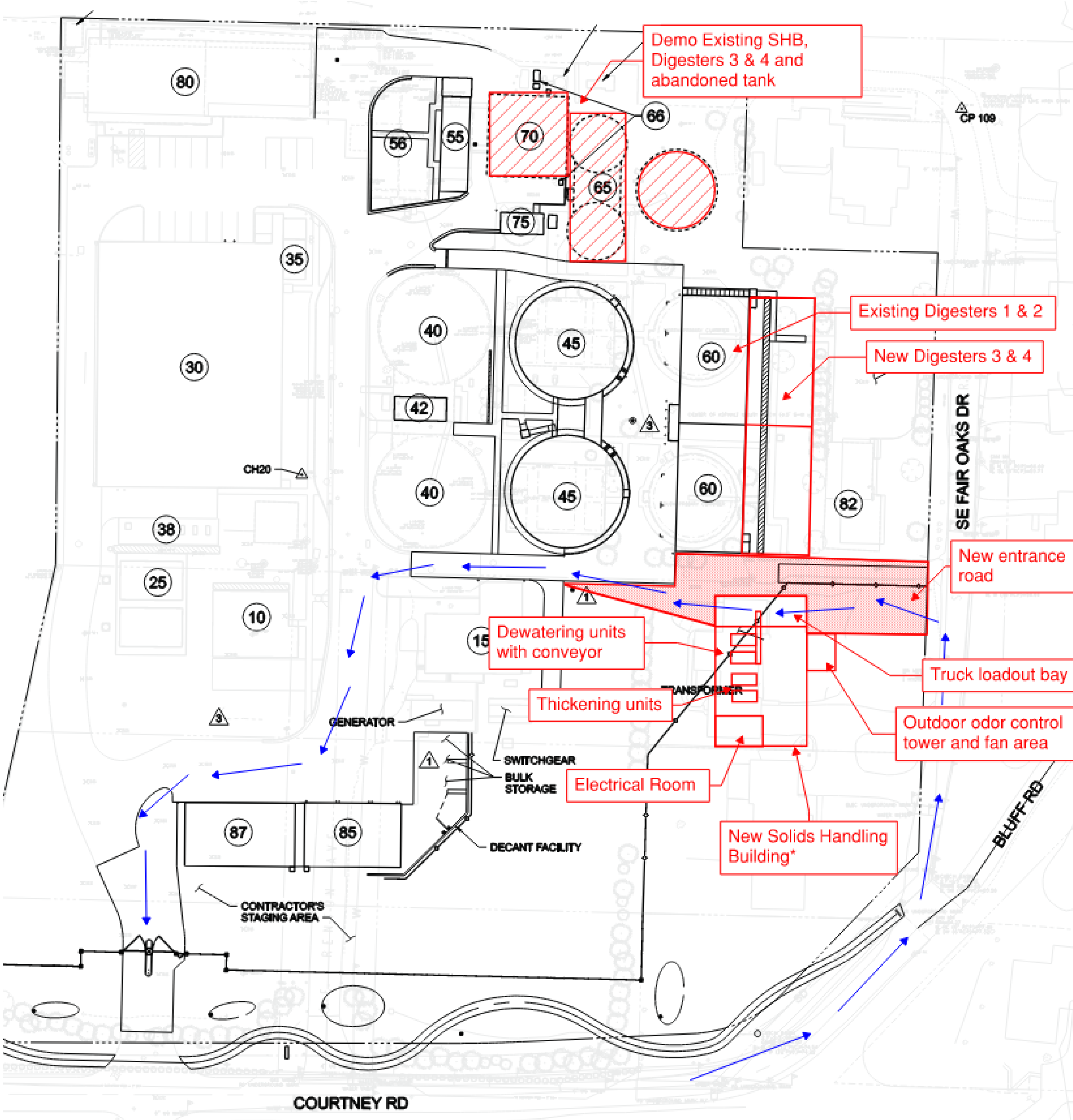


Figure 6-13: Alternative 2 - South Solids Handling Facility and Expansion of Rectangular Digesters

Alternative 3 – South Solids Handling Facility and New North Circular Digesters

For this alternative, the existing SHB and Digesters 3 and 4 located at the northeast corner of the WWTP would be demolished, and two new circular digesters with a solids mixing and pumping facility would be constructed in that location. Like Alternative 2, a new SHB would be constructed south of existing Digesters 1 and 2 in an area that is currently outside of the fenced plant property and being used for public access. The new SHB would house a second thickening and dewatering unit for redundancy and any other appurtenant equipment needed, and a drive through storage hopper and truck loading area would be constructed as part of the SHB on the north end. A new entrance road would be constructed on the east side of the WWTP connecting to SE Fair Oaks Drive to provide access for biosolids contract hauling trucks.

Figure 6-14 provides a conceptual layout of the layout for Alternative 3. The blue arrows indicate the proposed truck route. Temporary dewatering and thickening facilities may not be needed during construction of this alternative because the new SHB can be constructed and brought online prior to the existing building being demolished. For purposes of the cost estimate for this alternative, it was assumed that temporary facilities are not needed.

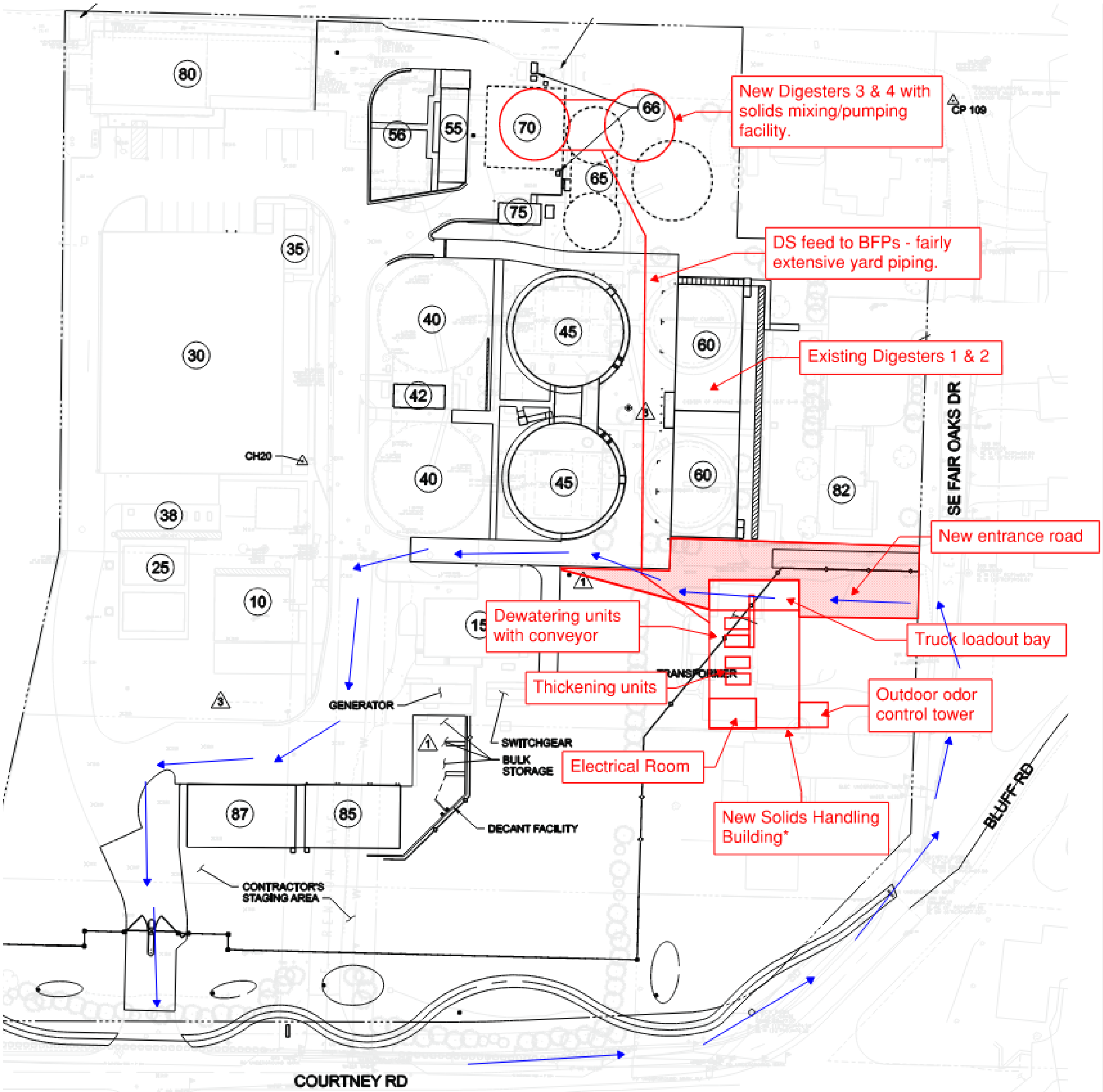


Figure 6-14: Alternative 3 - South Solids Handling Facility and North Circular Digesters

6.6.2.3.3 Solids Handling System Alternatives Cost Analysis

Class 5, conceptual level construction cost estimates were completed for the three alternatives. As described in Section 6.5, the OPCC have an accuracy level of -50 to +100 percent. As indicated in Table 6-21, the costs for all three alternatives are essentially the same; thus, cost does not really provide a differentiator between the alternatives and will not be a large factor in alternative selection. Other factors. such as truck access, ability to expand into the current public access area, constructability, and ease of operation and maintenance will have a much larger impact on alternative selection.

Table 6-21: Solids Handling System Alternative Cost Estimate

Alternative	Upper Range (+100%)	Estimated Cost	Lower Range (-50%)
1	$59,402,000	$29,701,000[1]	$14,850,500
2	$58,772,000	$29,386,000	$14,693,000
3	$58,350,000	$29,175,000	$14,587,500

[1]Costs for temporary thickening and dewatering facilities were included in Alternative 1

6.6.2.3.4 Recommended Alternative

Because the OPCC for the three alternatives are approximately equal, capital cost is not a significant factor in alternative selection. Other factors, such as truck access, constructability, ease of operation and maintenance, and the ability to be able to expand into the current public access area south of Digesters 1 and 2 have a more significant impact on alternative selection.

Table 6-22 presents a comparison of the advantages and disadvantages of each alternative taking these factors into account. As outlined in the table, Alternatives 2 and 3 would have the better truck access.

All three alternatives will have their own constructability issues and require extensive demolition and construction of new facilities; however, Alternative 1 would require temporary dewatering and thickening facilities during construction and Alternative 3 would require extensive yard piping placement through a very congested area between the Secondary Clarifiers and Digesters 1 and 2.

The initial response from OLWS during the October 26, 2022, workshop was that Alternative 2 seemed most desirable; it is the preferred alternative. This alternative will be incorporated into the CIP included in Chapter 7.0.

Table 6-22: Solids Handling System Alternatives Comparison

Alternative	Advantages	Disadvantages
1	Would make use of the existing WWTP site and not require expansion outside of the current fenced plant property.	Truck access for solids pickup could be challenging at the far north side of the WWTP. Temporary dewatering and thickening facilities would be needed for many months during demo of the existing SHB and construction of a new one.
2	Truck access to the solids loading bay as part of the new SHB would be easier and more accessible.	Expansion into the public access area south of Digesters 1 & 2 may require permitting and community acceptance.
3	Truck access to the solids loading bay as part of the new SHB would be easier and more accessible.	Expansion into the public access area south of Digesters 1 & 2 may require permitting and community acceptance Would require extensive yard piping through a likely congested area to pump digested sludge from new Digesters 3 & 4 to the new building.

6.6.3 Support Systems

Support systems at the WWTP include the 3W disinfection system, 3W pumps, odor control systems for the ILS/Plant Drain PS, Headworks Building, Aerobic Digesters 1 and 2, and the SHB, and the outfall. WWTP personnel requested additional storage volume for the 3W pumps due to capacity shortages during low influent flows, so this additional volume will be incorporated into the Tertiary Treatment Project.

The other processes were determined to be operating as intended, so alternatives for replacement were not considered in the WWMP. Opportunities for optimization, O&M cost savings, and maintenance costs associated with these facilities have been documented in the Condition Assessment section and quantified in the CIP. Replacement of equipment based on projected service life age is also addressed in the CIP.

6.6.4 Outfall

Ballard Marine Construction performed an inspection and prepared the Oak Lodge Outfall Inspection Report dated October 28, 2020. The report indicates that the secondary diffusers were all in good condition and in no need of repair. However, the report also notes that the area had an accumulation of heavy timber and debris. The inspection team also located the primary diffusers further offshore. These diffusers were found to be in good condition requiring little to no repair.

The current NPDES permit requires that an outfall inspection be performed once every permit cycle with a report documenting the findings. The permit requires that the next report be submitted by December 15, 2026, in the fourth year of the permit.

7.0 Capital Improvement Plan

This chapter summarizes the identified improvement projects that address hydraulic capacity deficiencies, condition of aging infrastructure, and improvements anticipated to meet future regulations for the wastewater system. A recommended wastewater Capital Improvement Plan (CIP) is provided summarizing anticipated projects over the thirty-year planning horizon that includes a schedule for implementation and the anticipated costs. The following sections describe the methodology for estimating project costs and prioritization, a recommended implementation plan, brief descriptions of individual projects and plans, and a recommendation for financing through customer rates and system development charges.

IN THIS SECTION

PREPARED BY:

WSC

Brown AND Caldwell

7.1 CIP Development Methodology

The following sections describe the basis and assumptions used to develop cost estimates for recommended projects, estimate system development charge (SDC) eligible costs, and the criteria used to prioritize individual projects within the CIP.

7.1.1 Cost Estimating Basics and Assumptions

An engineering opinion of probable construction costs (estimate) has been developed for each of the improvement projects identified in previous chapters. Project definitions and associated costs presented in this CIP are conceptual in nature due to the limited design information that is available at this stage of project planning. For pipeline replacement projects, OLWS GIS data was used to estimate quantities for pipeline length, depth, manholes, service laterals, and pavement restoration. The scope of work for non-pipeline projects and studies were approximated based on equipment and/or facility size and comparison with similar replacement projects. As each project progresses into design and construction, the associated costs may vary as project-specific requirements are identified.

All estimates provided in this chapter were prepared in accordance with a Class 5 Opinion of Probable Construction Costs as defined by the Association for the Advancement of Cost Engineering. A Class 5 estimate is appropriate for projects that have been developed to a conceptual level only. The purpose of a Class 5 Estimate is to provide a cost that can be used in budgetary planning. The expected range in accuracy of a Class 5 estimate is from -50 percent low and +100 percent high and is typically developed through analogy to costs from similar construction, judgment, and parametric models. These cost estimates are based on unit costs developed using a combination of data from RS Means CostWorks® and recent bids, experience with similar projects, and foreseeable regulatory requirements. Costs are tied to an Engineering News Record (ENR) Seattle Construction Cost Index (CCI) of 15202.68 for November 2022. The ENR CCI can be used to adjust projected future costs based on monthly updates to the CCI.

The Class 5 estimate for each project includes an allowance for “soft costs” and for contingency. The “soft costs” are the portion a project’s total cost required to plan, design, and manage each project through construction and are estimated at the planning level using a percentage markup applied to the estimated construction cost. The contingency allowance accounts for aspects of the work that are currently unknown and that cannot be reasonably identified at the conceptual phase. The contingency allowance is also estimated at the planning level using a percentage markup, which can be reduced as the project is better understood through detailed design.

Adjustments to each project estimate were made using the following markups:

- A 30 percent markup of the itemized construction sub-total was added to account for construction contingency and unforeseen work items
- A 30 percent markup of the total construction cost including contingency was added to account for project development services including project administration, planning, alternatives analysis, engineering design, surveying, permitting, construction administration, inspection, materials testing, etc.

Detailed cost estimates for each project are included in Appendix K.

7.1.2 System Development Charges

ORS 223.297 to 223.314 authorize OLWS to establish SDCs to recover a fair share of the cost of existing and planned facilities that provide capacity to serve future growth. The SDC is a one-time fee on new development that is paid prior to connection to the wastewater collection system.

To calculate a defensible SDC for the OLWS wastewater system, three elements of costs can be recovered improvement, reimbursement, and administrative costs. Improvement costs include those portions of future costs that will provide increased capacity that could serve new connections. Reimbursement costs include the eligible costs for existing facilities associated with the unused capacity that could benefit new connections. Administrative costs include the annual expenses associated with managing and administering the SDC program. The total eligible costs are divided by the number of EDUs of anticipated growth in the OLWS wastewater service area through 2052 to determine the cost per EDU.

An SDC study is being prepared by FCS group outside of this master plan. This study will outline the methodology for developing the SDCs and will determine the percentage of SDC eligibility for each of the projects identified within this WWMP.

7.1.3 Project Scheduling and Prioritization

In addition to developing a cost estimate for each project and determining the SDC eligible costs, the timing of each project was considered. Timing was determined using a prioritization matrix for each type of project (collection system, treatment plant, and planning). The list of projects within each type were prioritized independently of the other project types. Projects with the highest scores using the prioritization matrix were given the highest priority and included in earlier fiscal years.

The prioritization matrix scoring criteria and weighting is included in Table 7-1.

Table 7-1: Prioritization Matrix Criteria and Weights

Objective	Scoring Factor	Criteria 5	Criteria 4	Criteria 3	Criteria 2	Criteria 1	Questions
Asset Criticality and Condition	4.00	Extreme risk; Very likely failure with severe consequences	High risk; Poor condition asset with moderate to high consequences or fair condition asset with severe consequences	Moderate risk; Fair to poor condition with moderate consequences or fair condition with high consequences	Low risk; Better than fair condition and/or low consequences	New asset	• What is the risk of failure? (Risk = Likelihood x Consequences) • What is the asset condition? • Is it critical infrastructure?
Customer Criticality	2.00	Low Cost/High benefit	High Cost/High Benefit	Low Cost/Low Benefit	High Cost/Low Benefit		• Level of importance based on cost per customer benefit
Regulatory Mandates	3.00	Required by existing regulations; Severe penalty for noncompliance	Required by pending regulations; Severe penalty for noncompliance	Required by existing or pending regulations; Moderate penalty	Required by existing or pending regulations; Minor penalty	No regulatory requirement	• Is the project required to meet existing or pending regulations?
Relationship to Other Projects/ Coordination	2.00	Required for the delivery of other concurrent or subsequent projects and/or greatly improves efficiency when delivered in conjunction with other projects	Opportunity exists for efficient packaging and economies of scale when combined with other projects	Neutral effect on other projects	May hinder the efficient delivery of concurrent or future projects	Prevents execution of other projects and/or requires other projects to be completed prior to delivery	• Will this project enable coordination and economy of scale when bundled with concurrent or adjacent projects? • Do other projects depend on the completion of this project? • Does it depend on completion of others?
Leverages Outside Funding	1.00	External funding assured and Board has ability to provide any required match	External and match funding likely available	External and match funding possible	Slim chance at external funding and/or limited by ability to match external funds	No opportunity to leverage external funds	• Is external funding available for this project? • Do we have available funding resources to provide required match?
Level of Service	2.00	Significantly improves or expands existing level of service	Improves level of service and/or required to prevent noticeable drop in level of service	Preserves existing level of service	Neutral impact on level of service	Negative impact on level of service	• Will this investment preserve or increase customer service to our citizens?
OLWS Board Goals and Adopted Plans	2.50	Project specifically called for in Board Goals and master plan documents	Project specifically required by a Board Goal or planning document or measurably boosts the achievement of multiple adopted goals and objectives	Project generally aids in execution of Board Goals and master plan objectives	No impact on Board goals and plans	Negatively impacts achievement of Board goals and/or policies	• Is the project identified in Board Goals, Utility Master Plans, or other planning documents? • Does it help achieve policy aims of the Board?
Public Interest	1.00	Project will have a significant positive impact on public opinion and political environment OR prevent major negative impacts if project is not addressed in the short term	Project will have a noticeable impact on public opinion and political environment OR address issues likely to escalate in the public arena	Project has potential for significant public opinion or political impacts OR could prevent long-standing minor issues from escalating in the public arena	Project has minor impact on public opinion and political environment	Minimal public awareness or change in political environment due to project	• Is the Issue politically charged? Is there high public awareness of this issue.
Operation & Maintenance (O&M) Effectiveness/ Efficiency	2.50	Project will measurably result in least life cycle cost for assets involved	Project will result in measurable improvements in O&M efficiency	Project will marginally improve operational efficiency	Neutral impact on O&M	Negative impact on O&M	• Will this project enhance our O&M effectiveness and efficiency? • Will operations costs be minimized?

7.2 Recommended Capital Improvement Plan

Using the scheduling, prioritization and cost estimating methodology described in the previous sections, a plan was developed to project the annual capital spending required to address deficiencies within the wastewater collection system and water reclamation facility over the 30-year planning period. Project timing was adjusted to keep the annual spending projections as consistent as possible to minimize spikes in spending from year to year. A detailed spending plan is provided for the initial 10 years through fiscal year 2032. The recommended year for implementing each improvement was established using the methodology described in Section 7.1.3 above. Some projects were separated into multiple phases across two or more fiscal years to keep the annual average capital spending as consistent as possible. Projects that are lower priority or that are anticipated to occur beyond 2032 are not assigned to a specific year but are collectively allocated for spending in fiscal years 2033 through 2052. The recommended CIP plan is provided in Table 7-2, Table 7-3, Table 7-4, and Table 7-5.

A total of approximately $159.9M in capital improvements was identified. $88.4M of this was identified for the wastewater collection system, $69.2M for the WWTP, and $2.2M for planning work. It is important to note that although the collections and treatment projects are listed separately, they are not mutually exclusive. For example, if RDII reduction projects listed for the collections system are deferred or eliminated, assumptions of a constant volume of RDII through 2052 at the WWTP will no longer be valid and the sizing and timing of WWTP projects would likely be impacted.

In current dollars, the average annual capital spending would be $5.3M per year over the 30-year planning period and $8.0M per year over the first 10 years. Average annual spending exceeds the current FY23-FY28 budget, which averages $3.3M in wastewater CIP annual spending during the 6-year period.

7.3 Capital Improvement Projects

The following sections provide a brief description of each of the prioritized CIP projects including collection system projects, treatment plant projects, and planning studies. All CIP projects are also identified on a system map provided as a plate in Appendix L.

7.3.1 Collection System Projects

A total of 18 collection system projects were identified as part of this wastewater master plan. C-1 through C-11 were identified as part of the hydraulic modeling analysis and are described in Chapter 5.0. Table 5-16 provides a description of the scope for these projects. The remaining projects (C-12 through C-18) are projects previously identified by OLWS outside of the master planning process and are included in the current CIP (FY23 – FY28). Annual repair programs were extended to continue to provide services beyond FY28. The Trunk Main Capacity (River Forest SSO) project was removed from the existing CIP as the deficiencies will be addressed through Projects C-1 through C-3 and C-8. Based on conversations with OLWS, additional projects (C-19 and C-20) were added to cover additional lift station rehabilitation work at LS4 and LS6 that OLWS has planned but is not within their current 6-year CIP. A summary of the existing OLWS CIP projects is provided below in Table 7-6.

It is worth noting that the proposed collection system projects will reduce RDII in the system, which will produce energy savings over time by reducing the volume of water that must be pumped and treated. Projects included within the FY23-FY28 CIP include lift station rehabilitation projects that will include seismic resiliency and standby power elements to improve the ability to continue wastewater conveyance during and after unexpected natural hazard events, such as earthquakes or large power outages from winter storms.

Table 7-2. Collection System (C) Capital Improvement Program Implementation

Project ID	Description	Project Rank	Project Total (FY 2023 Dollars)	CIP Value in FY23 Dollars										
				FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33-52
				1	2	3	4	5	6	7	8	9	10	11-30
C-1	Lift Station 5 Basin RDII Reduction Pilot	1	$3,021,000	$383,000	$2,638,000									
C-2	Lift Station 2 Basin RDII Reduction Program	1	$4,954,000		$810,000	$4,144,000								
C-3	Lift Station 6 Basin RDII Reduction Program	1	$495,000		$75,000	$420,000								
C-4	Influent Lift Station Basin RDII Reduction Program	1	$7,167,000			$1,102,000	$3,033,000	$3,032,000						
C-5	Lift Station 4 Basin RDII Reduction Program	5	$205,000				$41,000	$164,000						
C-6	Lift Station 3 Basin RDII Reduction Program	6	$8,367,000									$733,000	$7,634,000	
C-7	Annual Condition Rehabilitation	7	$25,658,000											$25,658,000
C-8	Trunk Main A Upsizing	13	$11,852,000						$1,185,000	$5,334,000	$5,333,000			
C-9	Trunk Main B Upsizing	13	$10,364,000							$1,036,000	$4,664,000	$4,664,000		
C-10	Trunk Main 2A Upsizing	15	$1,943,000								$194,000	$1,749,000		
C-11	Trunk Main C Upsizing	16	$144,000									$14,000	$130,000	
C-12	Lift Station 5 Rebuild	8	$160,000	$160,000										
C-13	Lift Station 2 Construction	10	$1,450,000	$800,000	$650,000									
C-14	Lateral Repair Program	18	$3,050,000	$50,000	$100,000	$100,000	$100,000	$150,000	$150,000	$100,000	$100,000	$100,000	$100,000	$2,000,000
C-15	Hillside and Boardman Sewer Line Replacement	17	$1,000,000		$1,000,000									
C-16	Lift Station 3 Rehabilitation	10	$1,800,000			$200,000	$800,000	$800,000						
C-17	Manhole Repair Program	10	$2,900,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$2,000,000
C-18	Mainline Repair Program	9	$2,900,000		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$2,000,000
C-19	Lift Station 4 Rehabilitation	20	$239,000									$24,000	$108,000	$107,000
C-20	Lift Station 6 Rehabilitation	19	$769,000									$77,000	$346,000	$346,000
Collection System Project Subtotal			**$88,438,000**	**$1,393,000**	**$5,473,000**	**$6,166,000**	**$4,174,000**	**$4,346,000**	**$1,535,000**	**$6,670,000**	**$10,491,000**	**$7,561,000**	**$8,518,000**	**$32,111,000**

Note: OLWS' fiscal year runs from July 1 – June 30. The 2023 fiscal year begins on July 1, 2022. Project costs are rounded to the nearest $1,000. All costs are based on an Engineering News and Review Seattle Construction Cost Index of 15202.68 for November 2022

Table 7-3. Treatment (T) Capital Improvement Program Implementation

Project ID	Description	Project Rank	Project Total (FY 2023 Dollars)	CIP Value in FY23 Dollars										
				FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33-52
				1	2	3	4	5	6	7	8	9	10	11-30
T-1	Aeration Instrumentation & Controls [2]	10	$340,000						$40,000	$300,000				
T-2	Chemical Feed Systems [2]	21	$160,000						$20,000	$140,000				
T-3	Replace (2) aeration blowers: K-Turbo to Hybrid PD	4	$460,000		$230,000	$230,000								
T-4	Replace Aeration Basin Diffusers [2]	2	$340,000						$20,000	$150,000				$170,000
T-5	Replace Mixers [2]	18	$1,300,000						$140,000	$1,160,000				
T-6	Replace Internal Mixed Liquor Recycle Piping [2]	18	$720,000						$80,000	$320,000	$320,000			
T-7	Replace (3) Internal Mixed Liquor Recycle Pumps [2]	18	$240,000						$30,000	$210,000				
T-8	Foam Management / Wasting Facility	27	$170,000						$20,000	$150,000				
T-9	Secondary Clarifier 1 and 2 Rehab	3	$2,580,000		$280,000	$1,200,000	$1,100,000							
T-10	RAS Control Center Refurbishment	9	$1,140,000						$140,000	$1,000,000				
T-11	Aeration Basin Baffle Walls to separate anoxic / aerobic	11	$260,000				$30,000	$230,000						
T-12	Tertiary Filtration Facility and Future Media Replacement [3]	1	$12,300,000	$1,000,000	$6,000,000	$5,000,000								$300,000
T-13	Digester Blower Design and Replacement	4	$170,000	$85,000			$85,000							
T-14	UV Disinfection Rehabilitation	12	$390,000					$40,000	$350,000					
T-15	UV Disinfection Equipment Replacement	17	$2,090,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$165,000	$1,700,000
T-16	Influent Lift Station Reconstruction	25	$1,010,000				$110,000	$450,000	$450,000					
T-17	Influent Pump Replacement	28	$200,000											$200,000
T-18	3rd screen: multi-rake 1/4" bar screen (or perf plate?)	16	$500,000											$500,000
T-19	Improved seals on two existing influent screens	24	$85,000											$85,000
T-20	Grit system cover replacement	21	$170,000											$170,000
T-21	2012 Screening and Grit Equipment Replacement	21	$2,800,000											$2,800,000
T-22	Biofilter Fan Replacement	30	$120,000											$120,000
T-23	WWTP Air Piping Inspection	13	$80,000	$80,000										
T-24	GBT Refurbishment	13	$250,000				$250,000							
T-25	TWAS Pump Replacement	13	$75,000				$75,000							
T-26	Solids Handling Upgrades [4]	8	$35,000,000											$35,000,000
T-27	W3 Sodium Hypochlorite System Replacement	29	$150,000									$150,000		
T-28	Secondary Clarifier 3 and 4 Rehab Project	6	$3,700,000											$3,700,000
T-29	Ongoing Electrical Equipment Replacement and Upgrades	26	$2,315,000	$35,000	$35,000	$35,000	$35,000	$35,000	$500,000	$35,000	$35,000	$35,000	$35,000	$1,500,000
T-30	Plant Drain Pump Replacement	7	$120,000				$120,000							
Treatment Projects Subtotal			**$69,235,000**	**$1,225,000**	**$6,570,000**	**$6,490,000**	**$1,710,000**	**$780,000**	**$1,815,000**	**$3,490,000**	**$380,000**	**$210,000**	**$200,000**	**$46,245,000**

Notes:

1. OLWS' fiscal year runs from July 1 – June 30. The 2023 fiscal year begins on July 1, 2022. Project costs are rounded to the nearest $1,000. All costs are based on an Engineering News and Review Seattle Construction Cost Index of 15202.68 for November 2022
2. Secondary Treatment Upgrades (SND/A2O alternative) as described in Section 6
3. Tertiary Treatment (disk filter alternative) as described in Section 6. Includes future media replacement as recommended by disk filter manufacturers.
4. Solids Handling Upgrades (independent of a preferred alternative as costs were similar) as described in Section 6.

Table 7-4. Planning (P) Capital Improvement Program Implementation

Project ID	Description	Project Rank	Project Total (FY 2023 Dollars)	CIP Value in FY23 Dollars										
				FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33-52
				1	2	3	4	5	6	7	8	9	10	11-30
P-1	Wastewater Master Plan Update		$2,220,000					$370,000					$370,000	$1,480,000
Planning Projects Subtotal			**$2,220,000**					**$370,000**					**$370,000**	**$1,480,000**

Note: OLWS' fiscal year runs from July 1 – June 30. The 2023 fiscal year begins on July 1, 2022. Project costs are rounded to the nearest $1,000. All costs are based on an Engineering News and Review Seattle Construction Cost Index of 15202.68 for November 2022

Table 7-5. Capital Improvement Program Implementation Summary

Project Type	Project Total (FY 2023 Dollars)	CIP Value in FY23 Dollars										
		FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33-52
		1	2	3	4	5	6	7	8	9	10	11-30
Collection System Project Subtotal	$88,438,000	$1,393,000	$5,473,000	$6,166,000	$4,174,000	$4,346,000	$1,535,000	$6,670,000	$10,491,000	$7,561,000	$8,518,000	$32,111,000
Treatment Projects Subtotal	$69,235,000	$1,225,000	$6,570,000	$6,490,000	$1,710,000	$780,000	$1,815,000	$3,490,000	$380,000	$210,000	$200,000	$46,245,000
Planning Projects Subtotal	$2,220,000					$370,000					$370,000	$1,480,000
Total	**$159,893,000**	**$2,618,000**	**$12,043,000**	**$12,656,000**	**$6,004,000**	**$5,496,000**	**$3,350,000**	**$10,160,000**	**$10,871,000**	**$7,670,000**	**$8,634,000**	**$79,383,000**

Note: OLWS' fiscal year runs from July 1 – June 30. The 2023 fiscal year begins on July 1, 2022. Project costs are rounded to the nearest $1,000. All costs are based on an Engineering News and Review Seattle Construction Cost Index of 15202.68 for November 2022

Table 7-6: Projects from Existing Collections CIP

Project ID	Capital Project Description
C-12	**LS5 Rebuild:** Refurbish the existing concrete structure with an anti-corrosive epoxy lining and replace pumps with submersible non-clog designs.
C-13	**LS2 Construction:** Reconstruct the dry well area to a larger wet well with submersible non-clog pumps and increase the wet well size. Replace the backup generator and improve sound attenuation at the site.
C-14	**Lateral Repair Program:** Repair and replace the public portion of wastewater laterals within the right-of-way. Priority will be given to laterals allowing inflow and infiltration through breaks and which cause the greatest impact to operating budget.
C-15	**Hillside and Boardman Wastewater Main Replacement:** Replace 638 LF of 12-inch diameter pipe that has settled. This settlement causes sediment, grease, and fats to accumulate in the line which causes field staff to maintain this line more often than desired.
C-16	**LS3 Rehabilitation:** Reconstruct the dry well area to a larger wet well with submersible non-clog pumps and increase the wet well size. Replace the backup generator and improve sound attenuation at the site.
C-17	**Manhole Repair Program:** Rehabilitate manholes identified as having poor structural integrity. Projects are identified based on routine system monitoring and/or maintenance done by the Field Crews.
C-18	**Mainline Repair Program:** Perform spot repairs where structural or inadequate flow conditions exist. Projects are identified based on routine system monitoring and/or maintenance done by the Field Crews.
C-19	**LS4 Rehabilitation:** Provide an access driveway to provide vehicle access to the wet well and driveway, a new electrical and control kiosk, and new electrical and control equipment.
C-20	**LS6 Rehabilitation:** Modify the wet well/dry well configuration to allow for liquid storage in both portions. Install submersible non-clog pumps and a new valve vault. Upgrade electrical and control kiosk.

7.3.2 Treatment Plant Projects

A total of 30 treatment system projects were identified as part of this wastewater master plan. Some of the recommended projects overlapped with current projects that are in the 2023-2028 OLWS 6-year CIP and have been modified accordingly. Although each project was assigned a unique prioritization score, the schedule for implementation for some projects can be grouped together to reduce costs and improve the ability to design and construct holistically. The highest priority project is T-12 which will provide a new tertiary treatment facility to improve reliability in meeting new waste discharge permit limits, particularly for TSS. A summary of the existing projects is provided below in Table 7-7.

Table 7-7: Projects from Existing Treatment CIP

Project ID	Capital Project Description
T-1,2,4,5, 6, 7, 8 & 11	**Secondary Treatment Upgrades for SND/A2O:** Adding diffusers to increase density and improving controls to the existing aeration system, modifying the mixed liquor return system, and other improvements will allow the WWTP to address capacity constraints and provide the ability to meet potential future nutrient discharge limits.
T-3	**Replace Aeration Blowers:** Current aeration blower replacement is needed to provide reliable operations. This project is in the current OLWS CIP.
T-9,10	**Rehab Secondary Clarifiers 1 & 2 and RAS Control Center:** Recent condition assessment conducted by OLWS identified the need to rehab the secondary clarifiers.
T-12	**Tertiary Filtration Facility:** A new treatment process will improve reliability to meet new waste discharge permit limits.
T-13	**Digester Blower Replacement:** Current digester blower replacement is needed to provide reliable operations. This project is in the current OLWS CIP.
T-14,15	**UV Disinfection Upgrades:** Ongoing replacement of UV bulbs and upgrades to the flow control gates are necessary.
T-16,17	**ILS Rehab:** Pump replacement and other improvements are necessary to provide reliable operations. This project is in the current OLWS CIP.
T-18,19,20 21,22	**Headworks Improvements:** Upgrades to screen seals in channel, access to HeadCell, providing a third mechanical screen, and other improvements at the headworks will improve operations.
T-23	**WWTP Air Piping Inspection:** Inspection and identification of necessary repairs to the air piping is needed for reliable operations. This project is in the current OLWS CIP.
T-24,25	**GBT and TWAS Refurbishment:** A refurbishment of the existing GBT unit and replacement of TWAS pumps are necessary to provide reliable operations.
T-26	**Solids Handling Upgrades:** A new solids handling building south of existing Digesters 3 & 4 and the replacement of Digesters 1 & 2 will provide improved reliability and operations for solids handling.
T-27	**W3 Sodium Hypochlorite Replace:** Replacement of the system is needed for reliable operations.
T-28	**Secondary Clarifier 3&4 Rehab:** Rehabilitation of mechanical elements are needed for reliable operations.
T-29	**Ongoing Electrical Upgrades:** Plant staff typically replace sensitive electrical equipment, such as variable frequency drives, to provide reliable operations.
T-30	**Plant Drain Lift Station Rehab:** Pump replacement and other improvements are necessary to provide reliable operations. This project is in the current OLWS CIP.

7.3.3 Planning Projects

WSC recommends an update to the WWMP on an approximate 5-year basis to keep the CIP plan refreshed to improve the utility of the wastewater master plan. As time passes from the completion of each WWMP update, new regulations may be implemented, system conditions gradually deteriorate, and priorities for OLWS can shift. Updating the master plan every 5 years also requires less effort than developing a completely new master plan document. Project P-1 allocates budget every 5 years to provide an update to this wastewater master plan to facilitate future CIP development and reflect improvements made within the wastewater system. In particular, the next update to the WWMP will be important for assessing the results of the proposed RDII reduction projects so that the resulting post-rehab PWWF can be estimated. The post-rehab PWWF could change the extents, costs, and timing of trunk capacity upsizing and WWTP improvement projects.

7.4 Staffing Considerations

Developing the WWMP has shown a need to conduct a detailed staffing analysis to determine OLWS' appropriate level of staff for current and future operations. A description of impacts to staffing, particularly operations and maintenance, for both the collections and treatment systems are described in the following sections.

7.4.1 Collections System

Operations and maintenance staff for the collections system are also responsible for addressing the storm water infrastructure in the OLWS service area, and sometimes also support the drinking water operations team. As described in Section 2.4 of this WWMP, collections system operations staff conduct preventative maintenance and routine inspections of the wastewater manholes and mains. Currently, OLWS relies on outside contractors to complete repairs to the collection system.

The recommended CIP projects and associated estimates of implementation costs assume that OLWS will use contractors to complete smoke testing, flow monitoring, all repairs to wastewater manholes, mains, and laterals, and all upgrades to existing lift stations. As projected growth within the service area is anticipated to come from infill development, expansion of the collections system infrastructure is not anticipated.

7.4.2 Treatment System

According to the OLWS adopted budget for FY22-23, there are 8.30 full-time equivalent (FTE) positions in the Wastewater Treatment Division (Division 21). The major funding source for the positions are wastewater service charges billed to OLWS customers. The WWTP Superintendent directly oversees treatment staff operations and maintenance that includes five operators, two mechanics, and the asset resource specialist position. The Asset Resource Specialist is allocated at 0.3 FTE to the Treatment and Collection Divisions.

Additional FTEs should be evaluated for operations and maintenance of new equipment including:

- Operation of tertiary filters described in Section 6.6.1.4.2
- Operation of the SND process described in Section 6.6.1.27 for process control and maintenance of new instrumentation and process controllers
- Solids handling processes described in Section 6.6.2.3.4

During design of the above improvements, staffing requirements should be considered in more detail. Many decisions during the design process can impact personnel demands, and each project should be balanced appropriately between ongoing O&M budgets and capital expenditures.

7.4.3 Technical Services and Engineering

Currently OLWS has two full-time engineers that function as project managers for CIP projects. In discussions with the District Engineer, each position can typically manage between 2 to 5 projects per year depending on the size and complexity. The proposed CIP represents a significant increase in the anticipated dollar value of CIP to be delivered each year. The engineering team also have the responsibility for project management time of water and stormwater system CIP projects that are outside of the scope of this WWMP. Additional technical services and engineering staff are anticipated to be necessary and would likely include one additional full-time project manager and one engineering technician that could provide inspection services. The costs for project staffing are included within each individual CIP project as part of the project development costs described in Section 7.1.1.

7.5 Funding and Financing

OLWS has several options to fund the CIP including user fees, bonds, grants from outside agencies, and SDCs. The following sections will describe the potential for funding the recommended capital improvements through user fees and SDCs, bonds, or grants from outside agencies.

7.5.1 Rates and SDCs

With relatively low levels of projected growth in the OLWS service area, SDCs are not likely to contribute significantly to fund the recommended CIPs. The recommended increase in annual capital improvement spending will likely require increases in rates to fund the improvements. An estimate of potential rate increases is beyond the scope of this WWMP, however a rate study is recommended to estimate the magnitude and timing of rate increases necessary.

7.5.2 Bonds

Debt financing of capital improvements through issuance of revenue bonds is common practice, but typically will incur a higher interest rate than low-interest government loans. The adopted FY22-23 OLWS budget indicates that the wastewater fund currently budgets for $3,434,144 in debt service as part of the Wastewater Revenue Bond Debt Service fund. Issuance of public debt could be considered to help fund the implementation of the CIP in addition to rate increases.

7.5.3 Grants and Loans

As an alternative to bond financing, there are several state and federal programs that offer low-interest financing. Projects meeting certain criteria may also qualify for loan forgiveness or grant funding. Several potential programs are listed below and could be considered for funding specific capital improvements:

- **Clean Water State Revolving Fund (CWSRF):** The CWSRF is managed through the Oregon DEQ and provides loans with below market rates. Loans can be used for wastewater system improvements, including designing and planning costs, with no limit on total project cost. Projects approved for funding must begin within two years of receiving the funding agreement.
- **Water/Wastewater Financing Program:** The water/wastewater financing program is managed through Business Oregon Infrastructure Finance Authority and provides low interest loans and occasionally grants to municipalities for compliance with the Safe Drinking Water Act and Clean Water Act. Loans can be used for wastewater system improvements, including design and planning costs, up to $10,000,000 per project.
- **Federal Emergency Management Agency Pre-Disaster Mitigation Loans:** Projects for mitigating seismic risk can be eligible for this program but must be consistent with the goals and objectives identified within the County's Natural Hazard Mitigation Plan.
- **Sewer Overflow and Stormwater Reuse Municipal Grants (OSG) Program**: The OSG program through the EPA provides funding to plan, design, or construct projects that correct combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), stormwater needs, or subsurface drainage needs. The program is administered through the State. For fiscal year 2022, funding is prioritized for financially distressed communities, communities implementing long-term control plans for CSOs or SSOs, those requesting funding for a project on the State's Intended Use Plan for the CWSRF, and those in an Alaskan native village.

7.6 CIP Summary

The recommended CIP identifies approximately $156.2M in projects, with roughly 50% of the work to be completed within the next 10 years. An implementation schedule that provides for an average capital improvement budget of $7.9M per year for the next 10 years appears feasible but will likely require rate increases or additional funding mechanisms. Prioritization of projects is based upon the currently known deficiencies within the system but as continued inspections and assessments of wastewater mains, manholes, lift stations, and wastewater treatment plant facilities provide new information, there may be a need to adjust the prioritization and timing of the CIP.

References

A Toolbox for Sanitary Sewer Overflow Analysis and Planning (SSOAP) and Applications. **Fu-hsiung Lai, Srinivas Vallabhaneni, Carl Chan, Edward H. Burgess, Richard Field.** s.l. : U.S. Environmental Protection Agency.

Brown and Caldwell. 2013. *Inflow and Infiltration Update Report.* Sweet Home, OR : s.n., 2013.

CH2M Hill. 2007. *Sanitary Sewer Master Plan.* 2007.

Environmental Protection Agency. April 2015. *Condition Assessment of Underground Pipes.* April 2015.

Gettring More From Flow Monitoring - Interpreting Sewer Flow Data to Yield the Maximum Benefit. **Paul S. Mitchell, P.E. and Patrick L. Stevens, P.E. 2005.** Huntington Beach, CA : Water Environment Federation, 2005, Vols. Collection Systems 2005 - Sustaining Aging Infrastructure: System, Workforce, and Funding.

J.F. Miller, R.H. Frederick, and R.J. Tracey. 1973. *Atlas 2: Precipitation-Frequency Atlas of the Western United States.* s.l. : NOAA, 1973.

Portland State University. 2020. *2019 Population Estimates.* 2020.

State of Oregon. Oregon Administrative Rule, Chapter 660, Division 11. *Public Facilitites Planning.*

Weather-US. 2021. Weather-US. *Monthly Weather Forecast and Climate Oak Grove, OR.* [Online] 2021. [Cited: August 18, 2021.] https://www.weather-us.com/en/oregon-usa/oak-grove-climate#rainfall.