Appendix A WWTP Description and Condition Assessment of Unit Processes

A

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Technical Memorandum

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Limitations:

This document was prepared solely for Oak Lodge Water Services (OLWS) and Water Systems Consulting, Inc. (WSC) in accordance with professional standards at the time the services were performed and in accordance with the contract between WSC and Brown and Caldwell dated May 18, 2021. This document is governed by the specific scope of work authorized by OLWS and WSC; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by OLWS and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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List of Abbreviations

3W	3-water
AB	aeration basin
B&Bs	aeration basins and blowers
BC	Brown and Caldwell
BFP	belt filter press
BMP	Biosolids Management Plan
BOD_5	five-day biochemical oxygen demand
CIP	capital improvement program
CMMS	computerized maintenance management system
DEQ	Oregon Department of Environmental Quality
DO	dissolved oxygen
DPS	Drain Pump Station
ft	feet/foot
GBT	gravity belt thickener
gpm	gallons per minute
IPS	Influent Pump Station
IBRs	interchange bioreactors
IR	interchange return
hp	horsepower
MCC	motor control center
mgd	million gallons per day
mg/L	milligrams per Liter
MLE	modified Ludzack-Ettinger
MLR	mixed liquor recycle
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
OLWS	Oak Lodge Water Services
O&M	operation and maintenance
ppd	pounds per day
psi	pounds per square inch
psig	pounds per square inch gage
RAS	return activated sludge
scfm	standard cubic feet per minute
SRT	solids retention time
SVI	sludge volume index
TDH	total design head
TM	technical memorandum
TSS	total suspended solids
TWAS	thickened waste activated sludge
WAS	waste activated sludge
wc	water column
WWMP	Wastewater Master Plan
WWTP	wastewater treatment plant
WSC	Water Systems Consulting, Inc.
µm	micromho
UV	ultraviolet

Section 1: Introduction

This technical memorandum (TM) provides background and history of development of the Oak Lodge Water Services (OLWS) Water Reclamation Facility (WWTP). This TM also provides a description of the WWTP including design data and an evaluation of the present condition and service life of the equipment and facilities.

Separate TMs are being prepared to describe and provide additional performance evaluations of the WWTP as listed below:

1. Existing WWTP Operations
2. Historical Performance
3. Capacity Assessment

Figure 1 shows a process flow schematic of the existing liquid and solid stream treatment systems.

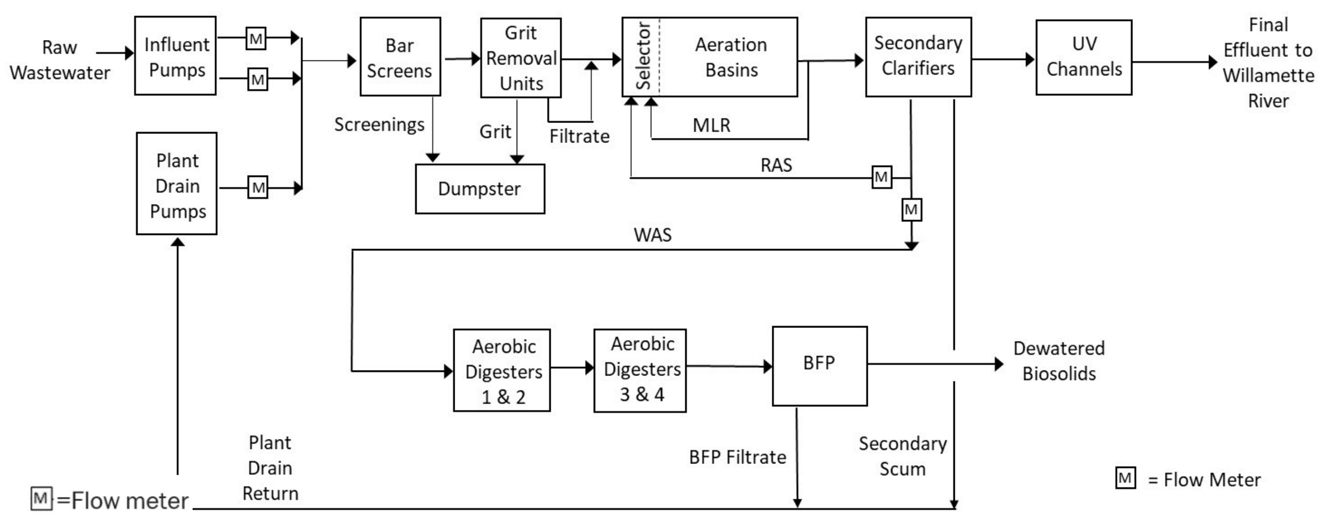

Figure 1. WWTP process schematic

(Note: Existing gravity belt thickener [not shown in the schematic] could be used in the future to thicken WAS prior to digestion)

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

This TM is intended to meet the Oregon Department of Environmental Quality's (DEQ) guidelines for preparing a wastewater facility planning document and includes the following information:

- WWTP expansion history
- Approach used to assess the facility
- Description of the existing conditions/expected service life of the equipment
- Condition assessment findings
- Summary of results and recommendations for equipment

Figure 2. Aerial view of WWTP with major facilities labeled

Section 2: Background

This section provides background and history for the OLWS WWTP located at 13750 SE Renton Avenue in Oak Grove, Oregon. Treated effluent is discharged to the Willamette River at river mile 20.1. The facility uses conventional activated sludge treatment. The National Pollutant Discharge Elimination System (NPDES) permit for the WWTP was renewed in 2022 by DEQ. The previous permit was issued on December 30, 2004. Table 1 summarizes the waste discharge limitations for key parameters in the 2004 permit.

Table 1. Previous NPDES Permit Waste Discharge Limits

Parameter	Average Effluent Concentrations		Monthly Average, ppd	Weekly Average, ppd	Daily Maximum, pounds
	Monthly	Weekly			
May 1–October 31					
$CBOD_5$ [a]	15 mg/L	25 mg/L	500	750	1,000
TSS	20 mg/L	30 mg/L	670	1,000	1,300
November 1–April 30					
BOD_5 [a]	30 mg/L	45 mg/L	1,500	2,250	3,000
TSS	30 mg/L	45 mg/L	1,500	2,250	3,000

Source: Adapted from NPDES permit issued in December 2004.

a. The $CBOD_5$ concentration limits are considered equivalent to the minimum design criteria for BOD_5 specified in Oregon Administrative Rules (OAR) 340-01. These limits and $CBOD_5$ mass limits may be adjusted (up or down) by permit action if more accurate information regarding $CBOD_5/BOD_5$ becomes available.

Abbreviations:

$CBOD_5$ = 5-day carbonaceous biochemical oxygen demand
mg/L = milligrams per Liter
ppd = pounds per day
TSS = Total suspended solids

The current permit was issued on April 7, 2022, and has been effective since May 1, 2022. WWTP Waste discharge limits for the permit renewal, as listed in the new permit, are summarized in Table 2. Two of the most significant changes are the lower concentration limits during dry weather and changes in the mass loading limits. The latter in the current permit are based on the maximum month dry weather design flow of 5.9 mgd for the dry weather monthly average and weekly average limits and the maximum month wet weather design flow of 10.5 mgd for the wet weather monthly average and weekly average limits. The daily maximum limits are set to be twice the monthly average limits.

Table 2. Current NPDES Permit Waste Discharge Limits

Parameter	Average Effluent Concentrations		Monthly Average, ppd	Weekly Average, ppd	Daily Maximum, pounds
	Monthly	Weekly			
May 1–October 31					
$CBOD_5$	10 mg/L	15 mg/L	490	740	980
TSS	10 mg/L	15 mg/L	490	740	980
November 1–April 30					
BOD_5	30 mg/L	45 mg/L	2,600	3.900	5,200
TSS	30 mg/L	45 mg/L	2,600	3,900	5,200

Source: Adapted from NPDES permit effective May 1, 2022.

2.1 History

OLWS provides sanitary sewer service and surface water management to portions of the cities of Gladstone and Milwaukie and unincorporated areas of Clackamas County. The OLWS WWTP began operating in 1960 and treats mostly domestic sewage. Original WWTP processes included primary and secondary treatment (activated sludge) with anaerobic digestion of solids. Various improvements have been made over the past 60 years, as summarized in Table 3. Note that some earlier documentation refers to the WWTP as the Water Reclamation Facility (WRF). OLWS standardized on the term WWTP in 2022.

Table 3. OLWS WWTP Improvements

Year	Improvement(s)
1960	Original construction with 1.5 mgd capacity including primary anaerobic digester
1970	Increased capacity to 2.0 mgd
1973	Increased capacity to 4.0 mgd including two secondary anerobic digesters
1981	Added influent screening and rock trap
1986	Converted to fine bubble diffusion in the aeration basins
1995/1996	Replaced secondary clarifiers and installed new return and waste activated sludge pumping facilities
1999	Constructed new outfall with diffusers
2002	Constructed new solids handling facility with gravity belt thickening and belt filter press (BFP) dewatering
2005	Replaced aeration blowers
2008	Replaced influent screens
2012	Constructed major plan improvements including new influent and drain pump stations, headworks, aeration basins and blowers (AB&Bs), additional secondary clarifiers, ultraviolet (UV) disinfection, Plant water facilities, interchange bioreactors, increased aerobic digestion and secondary treatment capacity, and foul air treatment systems
2020	Upgraded BFP dewatering
2020	Upgraded solids piping

The major improvements completed in 2012 were implemented in two phases and were based on a Master Plan completed in 2007 (CH2M 2007), a Project Definition Report completed in 2008 (CH2M 2008), and a Schematic Design Report completed in 2009 (CH2M 2009). These documents projected a 20-year design basis to meet anticipated growth and future regulatory requirements. The improvements increased the WWTP's capacity to a maximum month flow of 10.5 mgd with a peak wet weather capacity of 18 mgd. .

Prior to 2010, biosolids generated at the WWTP have been seasonally applied at local land application sites in rural Clackamas County. From 2010 through 2014, anaerobically treated biosolids were transported to Madison Farms in Echo, Oregon, and beneficially re-used. Following the decommissioning of the anaerobic digestion system as part of the Phase 1B improvements, the production of aerobic biosolids has been increasing. These solids have been transported to Heard Farms in Roseburg, Oregon, and to the landfill for disposal. In late 2016, OLWS received approval from DEQ to apply aerobic solids at Madison Farms. Since then, Madison Farms has been the sole receiver of biosolids from OLWS. OLWS meets 40 CFR Part 503 requirements and continues to land apply Class B biosolids on approved sites in accordance with its BMP.

2.2 Wastewater Master Plan

OLWS has contracted with Water Systems Consulting, Inc. (WSC) to prepare their Wastewater Master Plan (WWMP). The WWMP will evaluate the adequacy of the wastewater collection and treatment systems to provide safe and reliable service to customers and recommend capital improvements necessary to maintain that level of service into the future. The analysis will be based on estimated wastewater demand projections and a set of evaluation criteria designed to meet regulatory requirements, accepted engineering practices, and OLWS preferences. This TM is designed to work in concert with the WWMP document and will be included as an attachment.

Section 3: Approach

OLWS staff provided relevant background information, including record documents from previous WWTP improvements projects, and other documentation including manufacturer's operation and maintenance (O&M) manuals, to facilitate the condition assessment. Brown and Caldwell (BC), as a subconsultant to WSC, reviewed the documentation provided as part of the condition assessment activities.

3.1 Documentation from Prior Projects

The following documents from previous WWTP improvements projects were reviewed:

- Wastewater Treatment Plant Solids Thickening, Dewatering and Reuse Project Contract Documents, Oak Lodge Sanitary District (Brown and Caldwell, January 2000)
- WWTP Improvements, Phases 1A, Record Drawings, Oak Lodge Sanitary District (CH2MHill, March 2012)
- WWTP Improvements, Phases 1B, Record Drawings, Oak Lodge Sanitary District (CH2MHill, December 2012)
- OLWS BFP Installation, Contract Documents (Brown and Caldwell, April 2020)
- OLWS Solids Piping Project, Drawings (Murraysmith, August 2020)
- OLWS Aeration Blower and Baffle Project, Drawings (Murraysmith, July 2021)

3.2 Review of Previous Reports and Documents

A variety of historical data and previous reports and documents were reviewed in order to prepare the description of the WWTP and prepare for the condition assessment. One of these reports included the Aeration Basin Evaluation prepared by Murraysmith in 2019 to evaluate components in the aeration system (basins, blowers, and aerobic digesters). The purpose of the evaluation was to identify alternatives and make recommendations to improve operations of these systems for current and future flows and loads. Design of the recommended improvements was completed early in 2021 and construction is planned for 2022. Some of the findings from this evaluation are incorporated into the discussion of existing WWTP facilities and proposed modifications. The following documents, prepared in 2021 as part of OLWS's ongoing coordination effort with DEQ to renew the WWTP's NPDES permit, were also reviewed.

- Updated Fact Sheet Facility Description
  - DEQ and OLWS worked together to prepare an updated Fact Sheet Facility Description to be incorporated into a new NPDES permit for the WWTP. Information from this updated Fact Sheet Facility Description is reflected in this evaluation of current WWTP operations.
- Biosolids Management Plan
  - OLWS staff coordinated with DEQ to prepare an updated BMP that was included in the public notice for the NPDES permit renewal. Information from this updated BMP is incorporated into this evaluation of existing WWTP operations.

3.3 Condition Assessment Site Visit

BC performed a site visit and visual inspection on October 20, 2021. The objective of the condition assessment was to assess the physical condition, functional integrity, and operability of the equipment at the WWTP. The information and data collected during the assessment was based primarily on visual observations and interviews with OLWS staff. The observations and input, along with other documentation, were used to evaluate the extent and severity of any deterioration and to identify and locate specific areas of wear or damage.

Based on the time available, BC performed a rapid visual assessment of major equipment assets at the WWTP. More focus was given to those assets identified through staff interviews and document review as worthy of special attention. The condition assessment database, or asset registry, described in this section includes the major equipment assets that were selected from records in OLWS's computerized maintenance management system (CMMS). Some of the assets, such as submersible pumps and slide gates, were submerged and not visible on the day of the inspection. In other cases, the assets observed were considered typical of similar units. Table 43 in Section 5 summarizes the assets that were visually assessed and documented with photos during the October 20, 2021, site visit. The plant asset registry is also provided in Attachment A.

3.4 Data Collection and Management

The asset registry is the basis of the condition assessment and data collection efforts for this evaluation. The asset registry is a database containing records for assets to be evaluated by BC. Prior to field assessments, BC built the asset registry using information provided by OLWS. The registry was pre-populated with asset records and identifying information necessary for BC to locate those assets in the field. The primary sources of information used to pre-populate the asset registry was an export from the OLWS Maximo asset database supplemented by the record drawings and submittal documentation.

On the day of the site visit, BC had the Fulcrum app pre-loaded onto their mobile devices. Using Fulcrum allowed them to effectively document their respective observations, including any photos or videos they captured on individual WWTP assets, and access and update the asset registry while in the field. As a result, BC was able to create a single repository of inspection findings using a consistent methodology for collecting and managing the condition assessment data.

3.4.1 Data Fields

Table 4 lists the data fields used in the asset database. Much of the information was obtained from the OLWS CMMS database. Additional information including drawing references for equipment, field observations, ratings, recommendations, and photos were added by members of BC. The Asset Registry that includes a selection of key data fields from the condition assessment database is provided in Attachment A.

Table 4. Data Fields in Asset Database

Data Fields	Condition Assessment Fields
Asset Number	Asset number assigned by OLWS
Equipment Number	Equipment number assigned by OLWS
Description	Description from OLWS CMMS database or added
Company	Company from OLWS CMMS database or added
Serial Number	Description from OLWS CMMS database
Installation Date	Installation date from CMMS database
Model Number	Model number from OLWS CMMS database

Table 4. Data Fields in Asset Database	
Instrumentation Drawing Number	Added if applicable
Piping &Instrumentation Diagram Sheet Number	Added if applicable
Other Drawing Number	Added if applicable
Mechanical Sheet Number	Added if applicable
Condition Score	Added
Performance Score	Added
Photos	Links to photos added

3.4.2 Enterprise Asset Management Software

OLWS uses the Maximo enterprise asset management software as part of its CMMS. OLWS staff exported a list of assets and associated data that were imported into the Fulcrum database to preserve asset IDs, equipment names and numbers, and other relevant information and maintain consistency between records. Use of asset IDs and equipment numbers will facilitate identification of assets during field assessments and follow-up evaluation.

3.4.3 Field Observations

Field observations were limited to equipment that was in service at the time of the October 20, 2021, site visit (equipment operation was not rotated during the site visit). In most cases, the observed condition of at least one example of each asset was documented with at least one date- and time-stamped photo taken of the asset being assessed when visible. In some cases, multiple examples were documented with photos. Additional photos were taken to document observations, as needed. These digital image files were associated with the asset through links in the database. Some assets, such as diffusers and some instruments, were not directly observable. However, two of the aeration basins (ABs) were empty, or partially empty, during the site visit, and some photos were taken. Field observations and input from OLWS staff were applied to general categories of equipment based on the site visit, as reflected in the evaluation of individual assets in the condition assessment database.

3.4.4 Condition and Performance Ratings

BC assigned a condition and a performance rating to each asset or asset category based on review of documentation, input from OLWS, and visual assessment. BC used the International Infrastructure Management Manual to the extent possible and applicable, as modified for the equipment being evaluated for this project. BC established a set of standardized condition, performance, and recommendation ratings to ensure consistent documentation of asset conditions.

BC used the condition ratings listed in Table 5 and the performance or operational ratings in Table 6 to make the recommendations presented in Section 5.

Table 5. Physical Condition Ratings

Rating	Description
1	New or near new condition.
2	Minor cosmetic surface abrasion or coating deterioration.
3	Good condition and average surface or structural wear and tear based on the asset age.
4	Fair to poor condition based on observations or other indication.
5	Higher risk of failure due to condition and should be examined more closely.

Note: *The same condition ratings were used for all disciplines. There were some differences in the performance ratings for the disciplines due to obsolescence of equipment that is more typical of electrical and instrumentation and control components.*

Table 6. Operational Performance Score

Rating	Description
1	Runs like new.
2	Minor performance impacts typical of asset age.
3	Performs as anticipated for asset age.
4	Operates but does not meet performance or operational expectations
5	Does not meet industry standards.

Note: *The same condition ratings were used for all disciplines. There were some differences in the performance ratings for the disciplines due to obsolescence of equipment that is more typical of electrical and instrumentation and control components.*

Performance ratings were based on observation of operational equipment, along with input from OLWS staff and written documentation, such as maintenance records and test reports. Performance scores also consider the typical service life for that type of equipment. Similar to the condition scores, performance ratings were applied to general categories of assets unless specific information warranted a different value. Based on the results of the field assessment, a recommendation for further actions for categories of equipment were made using the options listed in Table 7.

Table 7. Recommendations

Options	Recommended Action
1	No immediate action, continue to perform preventive maintenance.
2	Plan more frequent preventive maintenance.
3	Monitor performance on a more frequent basis in anticipation of inspection and/or repair in the next 3 to 5 years.
4	Monitor performance more frequently and plan for rehabilitation or replacement in the next 5 to 10 years due to performance or obsolescence.
5	Incorporate project into Capital Improvement Program.

3.5 Factors that Affect Asset Condition

Several key factors likely to impact equipment condition at a wastewater treatment facility are summarized below.

- **Age and Frequency of Operation.** Equipment has a useful or expected life. As run-time hours increase, the condition of the equipment naturally degrades. This criterion also includes operational history, such as frequency of starting and stopping and frequency of use, as factors that can impact equipment condition.
  - Some of the liquid stream equipment dates back to 1995 when Secondary Clarifiers 1 and 2 were replaced and the RAS/WAS Pump Station was installed. The tanks associated with the circular aerobic digesters were constructed as anaerobic digesters in 1962, while new equipment for aerobic digestion treatment was installed as part of Phase 1B improvements completed in 2012. The solids handling facilities date back to 2002. Most of the remaining equipment dates back to 2012 when major Plant upgrades included the influent and plant drain pump stations, headworks, AB, and interchange bioreactors. Equipment associated with conversion of the two anaerobic digesters to aerobic digestion, addition of secondary clarifiers 3 and 4, and UV disinfection was also added in 2013.
  - A second BFP purchased by the OLWS was also installed in 2020 to be used as a backup to the BFP installed in the Solids Handling Building. The unit was temporarily installed while the main BFP was being rebuilt and then removed. It is stored by the interchange bioreactor tanks (Aerobic Digesters 1 and 2). The portable BFP can be installed outside the Solids Handling Building as needed.
- **Maintenance History.** Predictive maintenance activities enable equipment to achieve or go beyond the predicted service life or lifespan. Predictive maintenance can also reduce downtime caused by system failure. On the other hand, corrective maintenance can increase maintenance costs by reducing labor productivity and increasing costs of obtaining spare parts.

  The consequences of not performing predictive maintenance can be far greater than the additional cost of individual equipment items. Equipment failure can lead to more damaging and costly system failures.
- **Environment.** Environmental factors that can impact service life and condition include corrosion, heat, and dust, and whether equipment is located indoors or outdoors. Corrosion can be caused by contaminants such as hydrogen sulfide and its associated contaminants. Hydrogen sulfide results from anaerobic conditions and presence of sulfites and sulfates in wastewater collection systems and in wastewater treatment Plant systems. Hydrogen sulfide can be converted into sulfuric acid that can attack concrete and steel as well as other metals in the presence of oxygen. Moist air is also more corrosive than dry air. High temperatures can reduce service life of electrical and other equipment due to material degradation including insulation.
- **Power Quality.** The quality of electrical power supplied by the electrical utility affects the life of electric motors. Power quality is a measure of voltage and current quality based on several criteria including magnitude, frequency, wavelength, and symmetry. Harmonics and voltage interruptions, imbalance or frequency fluctuation represent deviations that affect power quality and can cause overloading of the electrical system and reduce equipment life.

Section 4: WWTP Description and Condition Assessment

This section presents the findings of the October 20, 2021, condition assessment. It also summarizes information gathered during discussions with OLWS staff during an on-site workshop and subsequent facility inspection. Relevant equipment design criteria, and the findings from a review of prior WWTP projects, reports, and documents, are also provided. The section is organized by process treatment units installed at the WWTP including liquid stream, solids stream, and support facilities.

On September 1, 2021, members of BC and OLWS staff participated in a workshop at the WWTP to discuss current Plant operations and to collect information needed for an operations evaluation of existing facilities. The workshop also gave BC an opportunity to gather preliminary information related to equipment and facility conditions. The findings of the workshop are documented in the Existing Water Reclamation Facility Operations TM (BC 2023). On October 20, BC performed a visual inspection of WWTP facilities. During this visit, BC observed the operation and condition of major assets and discussed equipment performance with OLWS staff.

4.1 Liquid Stream

The OLWS WWTP is a secondary treatment system that uses conventional activated sludge without primary treatment. Table 8 provides the liquid stream flow and load design criteria used as the basis for the Phase 1A and 1B WWTP Improvements.

Table 8. Liquid Stream Influent Flows and Loads

Parameter	Design Value	Parameter	Design Value
Flows, mgd		**TSS loadings, lbs/day**	
Average annual	4.3	Average annual	7,450
Average dry weather	3.5	Maximum month wet weather	8,390
Average wet weather	5.2	Maximum week wet weather	10,010
Maximum month wet weather	10.5	Maximum day wet weather	13,290
Maximum week wet weather	13.5	Maximum month dry weather	8,960
Maximum day wet weather	17.3	Maximum week dry weather	10,070
Maximum day dry weather	8.6	Maximum day dry weather	12,970
Peak hour	18 [a]		
BOD loadings, lbs/day		**Total Kjeldahl Nitrogen loadings, lbs/day**	
Average annual	6,680	Average annual	994
Maximum month wet weather	7,440	Maximum month wet weather	1,244
Maximum week wet weather	8,910	Maximum month dry weather	1,354
Maximum day wet weather	11,090		
Maximum month dry weather	7,250	**Ammonia loadings, lbs/day**	
Maximum week dry weather	8,790	Average annual	775
Maximum day dry weather	10,900	Maximum month wet weather	970
Average annual	994	Maximum month dry weather	1,055
Maximum month wet weather	1,244		
Maximum month dry weather	1,354		

a. *Hydraulic carrying capacity of all facilities is designed to pass a peak instantaneous flow (PIF) of 20 mgd to avoid overtopping of walls, flooding of weirs, etc.*

Table 9 summarizes the liquid stream effluent requirements for dry weather and wet weather conditions to achieve waste discharge requirements listed in Table 1 for the current NPDES permit.

Table 9. Liquid Stream Effluent Requirements

Parameter	Value
Dry weather	
BOD mg/L, 7-day average	15
TSS mg/L, 7-day average	15
BOD mg/L, 30-day average	10
TSS mg/L, 30-day average	10
Wet weather	
BOD mg/L, 7-day average	45
TSS mg/L, 7-day average	45
BOD mg/L, 30-day average	30
TSS mg/L, 30-day average	30

The Headworks Building receives pumped flow from the Influent Pump Station (IPS) and Plant Drain Pump Station (DPS). The wastewater is screened and degritted at the Headworks Building then continues to flow by gravity to the activated sludge secondary treatment system. The AB train includes an anoxic zone that is used to promote denitrification, with nitrification occurring in the aerobic zones. The activated sludge system is configurated with the ability to operate in different modes based on operational and effluent permit goals. The secondary process was previously operated as a Cannibal process resulting from the Phase 1A expansion completed in 2012 but the Cannibal process has since been abandoned.

AB effluent flows by gravity to secondary clarifiers where settled solids can be returned to the ABs as return activated sludge (RAS) or pumped as waste activated sludge (WAS) to the solids treatment system. UV disinfection is used to treat the effluent before discharge to the Willamette River. Treated effluent is also reused as 3-water (3W) as described under Section 4.3.1.

The following sections provide a description and condition assessment of individual process and pump systems associated with the OLWS WWTP liquid stream.

4.1.1 Influent Pump Station

All flow into the OLWS WWTP is conveyed to the IPS constructed as part of the Phase 1A expansion. The IPS was designed to meet the 2030 raw sewage design flow of 20 mgd with one of the larger pumps out of service. The IPS is a below grade structure that houses five submersible solids handling pumps. The wet well is partitioned into two sections with a manually operated gate separating the two sumps. Three pumps are placed in one wet well and the other two pumps are in the second wet well. The original KSB submersible pumps were replaced with Flygt submersible pumps in 2019. Discharge check valves and isolation valves for the influent pumps are located in a valve vault. The DPS was built adjacent to the IPS with a common wall separating the two facilities.

Table 10 presents the design criteria for the IPS.

Table 10. Influent Pump Station	
Parameter	**Value**
Pump type	Solids handling, submersible
Number of units	5
Capacity/unit, mgd	4 @ 5.5, 1 @ 3.5
Discharge pressure (ft)	63
Motor, ea, horsepower (hp)	4 @ 100, 1 @ 60
Drive type	Adjustable speed

Figure 3 and Figure 4 show the IPS and Plant DPS at grade.

Figure 3. IPS and Plant DPS, at grade

Figure 4. IPS and Plant DPS controls at grade

The original submersible pumps experienced frequent plugging with rags and other debris. The replacement Flygt submersible pumps are more effective at passing rags to the screening channel at the Headworks Building. To maintain the minimum pumping capacity required by DEQ, the manually operated gate is typically kept open so that the wet well functions as a single sump. At lower dry weather flows, the wet well is oversized, and debris can collect in the corners of the rectangular wet well. As discussed at the September workshop, rounding the corners of the wet well, retrofitting the Flygt pumps with the Flygt Flush Valve, and adding an automatic actuator to the wet well separation gate may improve operability of the influent pumping system. These will be considered as projects for future upgrades as they are developed.

The lack of a built-in lifting system at the IPS makes maintenance of the pumps more difficult. Currently, staff must bring in a mobile crane to lift the submersible pumps out of the wet well. Structural support for a lifting device such as a bridge crane and providing additional electric power to new equipment at the IPS have been identified as challenges to implementing these improvements. These upgrades will be evaluated as part of alternatives development.

The Meltric plugs at the IPS are uncovered and can become wet; the addition of covers would provide protection from moisture. OLWS has included budget in its capital improvement program (CIP) for reconstruction of the IPS in a future year.

4.1.2 Plant Drain Pump Station

The two Plant drain pumps are also the submersible solids handling type located in a shallower wet well located to the east of the IPS wet well. The original KSB pumps installed in 2012 are still used and are equipped with adjustable speed drives but operated in a constant speed, fill-and-draw mode. Solids have a tendency to settle out in the wet well when pumps are not operating. A system to stir the contents of the wet well such as the Flygt Flush Valve may help to minimize collection of solids and other debris in the Plant drain pump wet well.

Table 11 presents the design criteria for the DPS.

Table 11. Plant Drain Pump Station

Parameter	Value
Type	Solids handling, submersible
Number of units	2
Capacity/unit, mgd	1.75
Discharge pressure (ft)	50
Motor, ea, hp	25
Drive type	Adjustable speed

The Plant drain wet well is connected to the Plant drain inlet box. The Plant drain inlet box receives flow from the Plant drain manhole and drainage from the ABs. Discharge check valves and isolation valves for the Plant drain pumps are in a valve vault.

Figure 5 shows the DPS wet well taken from an open hatch at grade.

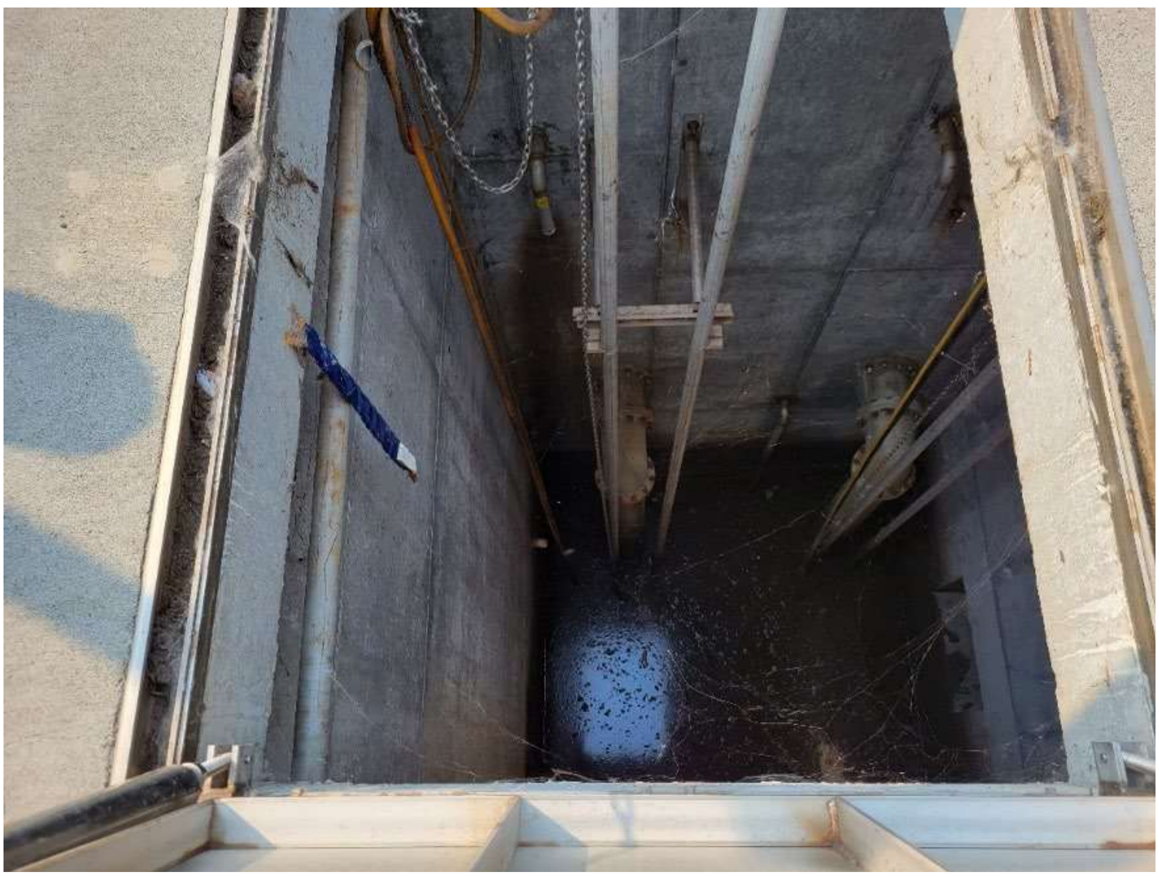

Figure 5. Drain pump station wet well

4.1.3 Influent Channel and Sampler

Equipment associated with preliminary treatment at the OLWS WWTP is located at the Headworks Building. Figure 6 shows the Headworks Building.

Figure 6. Headworks Building

Raw sewage and Plant drainage are pumped to the Headworks Building through force mains routed through the lower level of the Headworks Building, as shown in Figure 7. Each force main is equipped with a magnetic flow meter to measure the raw wastewater and Plant drainage. The raw sewage flow meters measure influent flow for NPDES permit reporting. The two raw sewage force mains combine into a single pipe before discharge at the Headworks Building. The influent pump force main discharges at one end of the raw sewage influent channel, and the Plant drain pump force main discharges near the mid-point of that channel.

As shown in Figure 6, the upper level of the Headworks Building is not enclosed. The raw sewage influent channel, the screens, and grit basins are covered and air is withdrawn for foul air treatment. Figure 8 shows a view of the raw sewage influent channel where the combined influent pump force main discharges into the end of the influent channel.

Figure 7. Influent Pump and Plant Drain Pump force mains

Figure 8. Raw sewage discharge into end of influent channel

The influent sampler collects a composite sample from this channel near the discharge point of the influent pump force main and upstream of the discharge of the Plant drain pump force main (except when the manual screen is in service). The sampler is located as shown in Figure 9.

Figure 9. Influent composite sampler

As described in the *Existing WWTP Operations TM*, debris tends to accumulate at the end of the influent channel, and the strainer on the suction tubing for the influent sampler also occasionally plugs with debris, as shown by the rags in Figure 10. This photo was taken on August 11, 2021, which was the first day of the wastewater characterization sampling program implemented to help calibrate the process models. Moving the influent sampler downstream of the screens is not an option, as the screened sewage includes the plant drainage, and the samples would then not be representative of plant influent.

Figure 10. Debris accumulation on influent sampler suction strainer

4.1.4 Influent Mechanical Screens and Influent Bypass Bar Screen

At the Headworks Building, wastewater passes through multi-rake bar screens with 1/4-inch spacing. Typically, one screen is in service and the other serves as a standby. There is also a third bypass channel fitted with a manual bar screen having 1/2-inch bar spacing.

Table 12 presents the design criteria for the Plant's influent mechanical screens.

Table 12. Influent Mechanical Screens

Parameter	Value
Units	2
Type	Multi-Rake Bar Screen
Size (width), in.	42
Capacity/unit, mgd	11.75
Opening size, in.	1/4
Motor, ea, hp	1
Drive type	Constant speed-Reverse
Influent Bypass Bar Screen	
Units	1
Type	Static
Size (width), in.	42
Capacity, mgd	11.75
Opening size, in.	1/2

As noted in Section 4.1.1, installation of the Flygt submersible pumps has resulted in greater passage of rags and other debris to the influent screenings channel. This has reduced maintenance requirements of the influent pumps, but there is now a greater tendency for the rags to accumulate in the channel, and to even pass downstream of the screens and into the ABs where they can accumulate on the anoxic zone mixer blades and other locations. Rags reach downstream of the screens by passing through the bars and/or through gaps between the screen frame and channel. There is a rubber seal at the channel and frame opening, but it does not always provide an effective seal. OLWS has considered replacing the screens with equipment having finer spaced bars or perforated plates to minimize passage of rags.

Figure 11 shows the Huber multi-rake screens and Figure 12 shows the screens with the channel influent and effluent gates.

Figure 11. Multi-rake influent screens

Figure 12. Influent screens with influent and effluent gates

4.1.5 Screenings Conveyance

A sluice trough that uses 3W conveys screenings to the washer compactor. There is approximately a 30-foot drop from the screens to the washer/compactors as shown in Figure 13.

Table 13 presents the design criteria for the Plant's screening conveyance system.

Table 13. Screening Conveyance System	
Parameter	**Value**
Units	1
Type	Sluice through
Flow, gpm	80

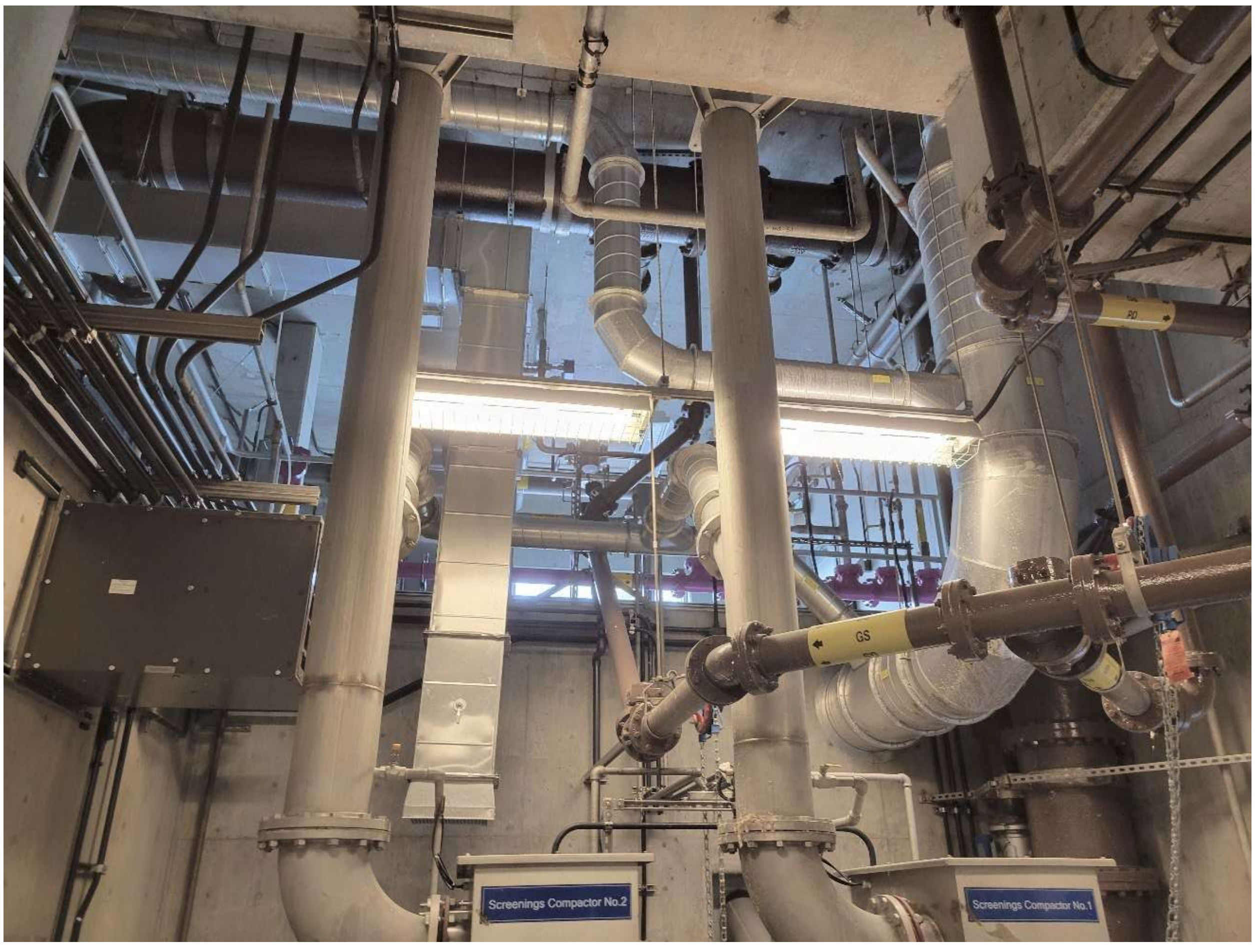

Figure 13. Screenings sluice system

When the 3W system is taken out of service for pump or other equipment maintenance, the sluice system must also be taken off-line. After an outage, there can be a slug load of debris to the compactors. Previously, the compactor door would occasionally open when there was a slug load of screenings. However, WWTP staff have made modifications to address this issue as discussed in the next section.

4.1.6 Screenings Washer/Compactor

The screenings sluice discharges into the washer/compactors in the lower level of the Headworks Building shown in Figure 14. WWTP staff added a baffle to prevent the door from opening when a slug load of screenings is received after an outage. Compacted screenings are transported off-site for disposal.

Table 14 presents the design criteria for the Plant's screening washer/compactors.

Table 14. Screening Washer/Compactors

Parameter	Value
Units	2
Type	Grinder/auger
Capacity, cubic feet per hour	150
Motor, hp	10 /3
Drive type	Cs-R/Cs-R

Figure 14. Screenings washer/compactors

Figure 15 shows the screenings washer/compactors from the side.

Figure 15. Screenings washer/compactor side view

4.1.7 Mixed Liquor Screen and Screenings Compactor

The mixed liquor screen and screenings compactor were installed as part of the Cannibal process. The mixed liquor screen is a rotary drum located on the upper level of the Headworks Building, and the mixed liquor screenings compactor is a screw press located on the lower level. A chute from the screen conveys the screenings to the press. Tables 15 and 16, respectively, list design criteria for the Plant's mixed liquor screens and screenings compactor and provide details on the current facilities.

Table 15. Mixed Liquor Screens

Parameter	Value
Units	1
Type	Rotary drum
Opening size, µm	250
Capacity/unit, (clean water/mixed liquor, gallons per minute (gpm)	2,100/1,800
Motor (each), hp	2
Drive type	Constant speed

Table 16. Mixed Liquor Screenings Compactor

Parameter	Value
Units	2
Type	Screw Wash Press
Motor (each), hp	3

Although the Cannibal process was abandoned a few years ago, the mixed liquor screen and screenings compactor were used into 2020. WWTP staff found that the equipment was effective at removing depleted cellulose from mixed liquor. However, there had been stress fractures due to wear on the polyurethane guides at the compactor. Due to the difficulty of obtaining spare parts for the equipment, this system is no longer being used.

The City of Albany, Oregon, previously used a mixed liquor screening and compaction system for its Cannibal system which is also no longer in use. The compactor at Albany has a gear reducer while the unit at OLWS does not. The OLWS unit tends to trip out on high amperage draw, as well. There were some attempts to obtain the unit from Albany to replace the one at OLWS, but those negotiations were unsuccessful.

Figure 16 shows the mixed liquor screen at the upper level.

Figure 16. Mixed liquor rotary drum screen

4.1.8 Grit Removal

Screened influent flows by gravity to the Eutek Headcell grit removal system that uses stacked trays. The equipment is located in the lower level of the Headworks Building and is difficult to access and maintain because of its cover. WWTP staff have been working with the manufacturer to design modifications that will improve accessibility. Because the tanks are hidden behind concrete, no photos are provided for this feature.

Table 17 presents design criteria for the Plant’s grit removal system.

Table 17. Grit Removal

Parameter	Value
Units	2
Type	Eutek Head Cell
Capacity/unit, mgd	11.75

4.1.9 Grit Pumps

Wemco recessed impeller pumps, also located on the lower level of the Headworks Building, are used to transfer grit to a grit washing and dewatering system. No issues with the grit pumping system were identified.

Table 18 presents the design criteria for the Plant’s grit pumps.

Table 18.Grit Pumps

Parameter	Value
Units	3 (2 duty/1 standby)
Type	Recessed impeller centrifugal
Motor (each), hp	20
Drive type	Adjustable

Figure 17 shows Grit Pump 1 and Figure 18 shows Grit Pump 2.

Figure 17. Grit Pump 1

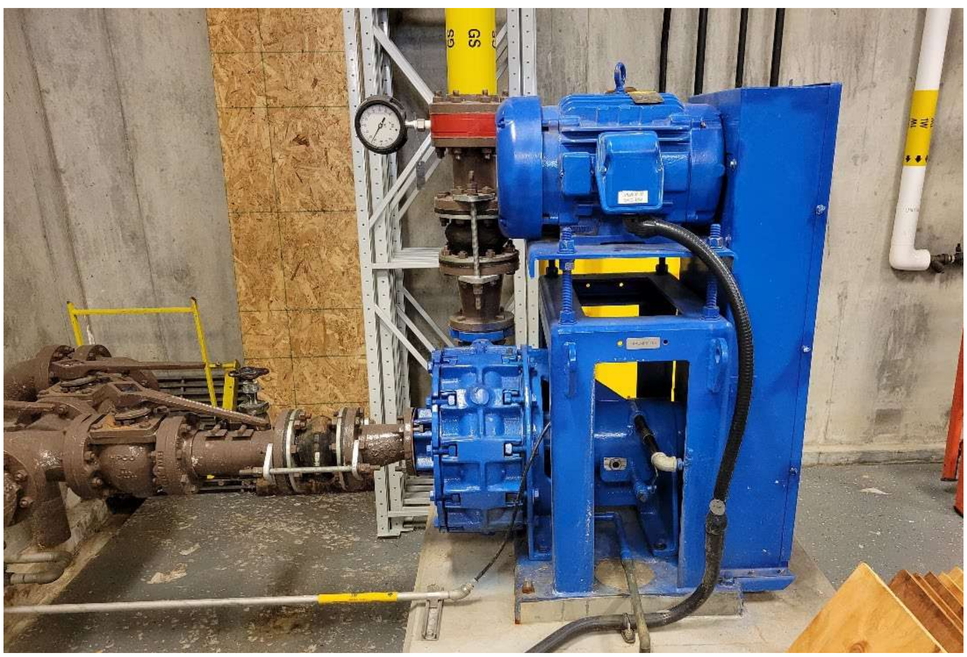

Figure 18. Grit Pump 2

4.1.10 Grit Washing/Dewatering

A Eutek Slurry Cup and Snail located on the upper level of the Headworks Building provide grit washing and dewatering. The Cannibal system was based on maximizing transfer of BOD to the ABs, so this system was designed to return finer solids to the liquid stream. Therefore, some grit passes through this equipment and is returned to the secondary treatment system where it collects in the ABs. Dewatered grit is transported off-site for disposal.

Table 19 presents the design criteria for the Plant's grit washing/dewatering system.

Table 19. Grit Washing/Dewatering System

Parameter	Value
Units	1
Type	Eutek slurry cup and snail
Motor (each), hp	1/3
Drive type	Adjustable

Figure 19 shows the grit washing/dewatering equipment.

Figure 19. Grit washing and dewatering equipment

4.1.11 Aeration Basins

There are four ABs designed for use with the Cannibal system at a mixed liquor concentration of 15,000 to 20,000 mg/L. Currently, the aeration system is operated as a modified Ludzack-Ettinger (MLE) process that assumes 17 to 25 percent of the basin is in an anoxic mode and the remaining 75 to 83 percent is aerobic. Two ABs are used during the dry weather and two or three are used during the wet weather, depending on flows and loads. Tanks 1, 2, and 3 or 2, 3, and 4 can be used in combination.

Table 20 presents the design criteria for the Plant's ABs.

Table 20. Aeration Basins

Parameter	Value
Units	4
Volume, ea, gallons	571,000
Length x width (each), ft	109 x 35
Sidewater depth, ft	20
Anoxic volume, gallons	571,000
Aerobic volume, gallons	1,713,000
Design Solids Retention Time (SRT), days	10

Figure 20 provides a panoramic view of the aeration basin structure.

Figure 20. Aeration basin structure

4.1.12 Anoxic Zone Mixers

There are six vertical turbine-type anoxic zone mixers manufactured by Lightnin in each of the first two ABs. Mixers are taken off-line once a year to collect oil samples. There have been stress fractures on some of the mixers.

Table 21 presents the design criteria for the Plant's anoxic zone mixers.

Table 21. Anoxic Zone Mixers

Parameter	Value
Type	Vertical turbine
Number of units, Basin 1	6
Number of units, Basin 2	6
Capacity, hp	1.5

Figure 21 shows Aeration Basin 1 that was out of service on the date of the site visit. Rags that have passed through preliminary treatment are visible on the mixer blades.

Figure 21. Aeration basin 1 with mixers and fine bubble diffusers visible

4.1.13 Aeration Basin Diffusers

The fine bubble diffusers in the ABs are visible in Figure 21. These are Sanitaire 9-inch-disc type diffusers. The diffusers are from the original installation in 2012. OLWS has purchased enough new diffuser membranes for one basin and will be scheduling replacement for some of this equipment. The OLWS may only do second half of basins 1 and 2 (as the first half would typically operate as the anoxic zone), so there would be enough diffusers for both basins.

Table 22 presents the design criteria for the Plant's aeration basin diffusers based on the 2012 record drawings. The actual number of diffusers in the basins should be verified by reviewing the shop drawing submittal for the diffusers and any installation drawings available.

Table 22. Aeration Basin Diffusers

Parameter	Value
Type	Fine bubble (9" disc diffusers)
Number of units	
Basin 1	296
Basin 2	1,145
Basin 3	1,145
Basin 4	810

When two ABs are in use, the first basin is operated with the first half without air (but with the mixers on) and the second half with constant air flow, and the second basin operated with dissolved oxygen (DO) control based on measurements by a DO probe at the U bend. When three ABs are in use, the first basin is half without air (and with mixing) and half constant air flow, the second basin has constant air flow, and the third basin uses DO control based on measurements by the probe at the U bend. The DO probes in the first half of each basin are not reliable. Air cannot be balanced within each basin because there are no air flow meters and control valves on the drop legs.

As noted above, the system was designed for Cannibal process, which is no longer being used. Currently, both mixers and diffusers are used in the second half of basin 2 because the diffuser air (at a constant flow rate) alone may not provide sufficient mixing. There is risk of solids settling without adequate air.

OLWS had Michael Richards examine foam and crust that occurred on the ABs approximately 6 years ago. Multiple microorganisms including *Nocardia* were identified.

Figure 22 shows an aeration basin with some foam evident at the surface. The ABs do not have a built-in spray system. However, as shown in Figure 22, spray hoses are used to help promote movement of the foam. Foaming is less severe in the winter when higher flows help move foam downstream.

Figure 22. Aeration basin showing use of hoses for spray water

4.1.14 Weir Gates and Hydraulics

Murraysmith prepared an aeration basin evaluation report in 2019 (Murraysmith 2019) to evaluate alternatives and make recommendations for process improvements. The report noted that there are no internal baffles or weirs within the basins, which limits operational flexibility. The report adds that because of foaming and hydraulic challenges, WWTP staff have created a hydraulic drop across each train by adjusting level of the effluent weir gates.

Figure 23 shows the hydraulic constriction at the horseshoe turn at the end of an aeration basin.

OLWS staff have added temporary baffles made of 2 x 4s to Aeration Basin 1. The temporary baffles have worked well. In 2022, the OLWS completed the Aeration Blower and Baffle project that was partially funded by the Energy Trust. The project originally included replacement of one of the aeration blowers and baffle wall in basin 1. However, during construction, the addition of this permanent baffle wall was removed from the project.

Figure 23. Hydraulic restriction trapping foam at aeration basin horseshoe turn

A classifying selector might also help with removal of foam and could be considered as part of a future project. Consideration will need to be made where foam would be routed to (e.g., impact on aerobic digesters). Sludge volume index (SVI), which is a measure of sludge settleability, typically fluctuates between approximately 100 and 250 milliliters per gram. They operate at about 8-day SRT during the winter months and 11–12 days during the summer.

4.1.15 Aeration Blowers

There were originally three K-Turbo centrifugal blowers that serve the ABs. Each turbo blower with air-foil bearings has a 100 hp motor. One of the blowers was not functioning properly and was out of service for several years. As part of the Aeration Blower and Baffle project recently implemented at the WWTP, a new screw hybrid blower was added, replacing the out-of-service high-speed blower. The minimum practical turndown for the K-Turbo blowers is 1,100 to 1,200 scfm, so that when the OLWS tried to provide an air flow of 1,000 standard cubic feet per minute (scfm) or less to the basins using one of the K-Turbo blowers, the blower was operating in an unstable area of its curve. As the screw hybrid blower has a higher turndown capability, its addition allows the OLWS to achieve greater operational control and energy efficiency.

The blowers are located in a three-sided shed adjacent to the ABs as shown in Figure 24. Along with the 3 original blowers that serve the ABs, there is also a fourth blower (also K-Turbo blower) in the shed that serves Digesters 1 and 2. That blower also recently failed, and one of the other blowers has been used for digester aeration. OLWS plans to replace the remaining K-Turbo blowers with screw hybrid blowers.

In addition to the K-Turbo blowers having issues stemming from operating in an unstable area on their curve, there are also issues due to the blowers being located in an open environment. There have been several surge events, overpressure events, premature filter clogging, core meltdowns, and corrosion in the inverter cabinet. It is becoming harder to find spare parts for the K-Turbo blowers. In an attempt to prevent as many operator and maintenance issues as possible, the operators limit starts and stops of the blowers as much as practicable.

Table 23 presents the design criteria for the aeration blowers serving the aeration basins and Digesters 1 and 2.

Table 23. Aeration Blowers

Parameter	Value
High speed turbo blower	
Units	3 [a]
Design capacity, scfm @ psig	1,824 @ 9.7
Screw hybrid blower	
Units	1
Design capacity, scfm @ psig	1,800 @ 9.5

a. One of the high speed turbo blowers has failed, to be replaced by another screw hybrid blower.

Blower control is currently cascade control with a DO set point of 2.0 mg/L in one basin, with the control valve for that basin adjusted and then the blower speed adjusted to maintain air header pressure. The DO set point is applied in the last aeration basin whether there are two or three ABs in service.

Figure 24. Aeration blowers

4.1.16 Mixed Liquor Recycle Pumps

Three vertical turbine, axial flow pumps convey recycled mixed liquor to the mixed liquor recycle (MLR)/RAS/ interchange return (IR) conduit and then to the first aeration basin in service. These pumps are shown in Figure 25. WWTP personnel noted that each of these pumps has been rebuilt multiple times since original installation. When these pumps are replaced in the future, a different type of pump should be considered.

Table 24 presents the design criteria for the Plant's mixed liquor recycle pumps.

Table 24. Mixed Liquor Recycle Pumps

Parameter	Value
Type	Vertical turbine, axial flow
Number of units	3
Capacity (each), gpm @ ft Total Design Head (TDH)	4,400 @ 11 ft
Power (each), hp	30
Drive type	Adjustable speed

Figure 25. Internal mixed liquor recycle pumps

4.1.17 Screened Mixed Liquor Pumps

The two screened mixed liquor submersible pumps are not currently used because the mixed liquor screen and compactor are off-line. This equipment was not able to be photographed.

Table 25 presents the design criteria for the Plant's screened mixed liquor pumps.

Table 25. Screened Mixed Liquor Pumps

Parameter	Value
Type	Submersible
Number of units	2
Capacity (each), gpm @ ft TDH	900 @ 35 ft
Drive type	Constant speed

4.1.18 Waste Activated Sludge/Scum Pumps

The RAS/WAS Pump Station houses WAS/scum pumps, as well as interchange bioreactor (IBR) feed pumps. Figure 26 shows one of the two WAS/scum pumps in the RAS/WAS Pump Station. The IBR feed pumps, shown in Figure 27, are used to pump WAS from the RAS header of Secondary Clarifiers 1 and 2 to Aerobic Digesters 1 and 2.

Figure 28 shows a third WAS pump that was recently added as part of the Solids Piping Project to convey WAS to the gravity belt thickeners (GBTs). Once the programming for this new pump is completed, it will be operational and the OLWS will be able to thicken WAS prior to sending it to the aerobic digesters. The new WAS pump will pull off the header from all four clarifiers rather than the RAS header that services only Clarifiers 1 and 2. At that point, the IBR feed pumps will be decommissioned.

Table 26 presents the design criteria for the Plant's WAS/scum pumps.

Table 26. WAS/Scum Pumps

Parameter	Value
Type	Submersible
Number of units	2
Capacity (each), gpm @ ft TDH	115 @ 15 ft
Power (each), hp	5
Drive type	Constant speed

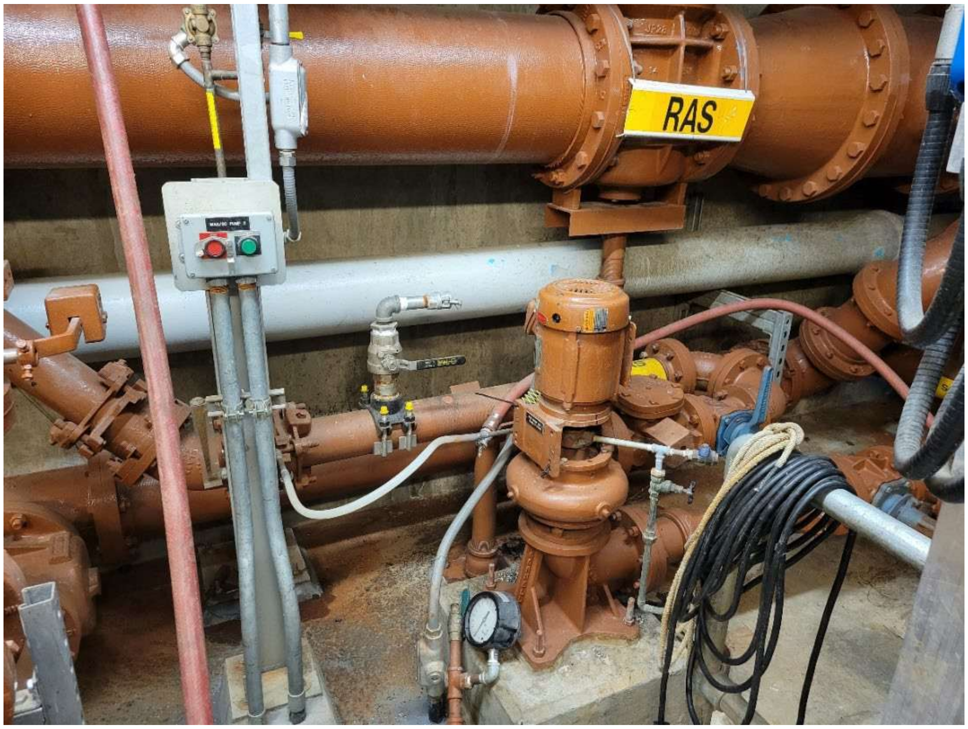

Figure 26. WAS/scum pump

Table 27 presents the design criteria for the Plant's IBR feed pumps.

Table 27. IBR Feed Pumps

Parameter	Value
Type	Non-clog centrifugal
Number of units	2
Capacity (each), gpm @ ft TDH	950 @ 18 ft
Power (each), hp	7.5 hp
Drive type	Constant speed

Figure 27. IBR feed pumps in RAS/WAS pump station

Table 28 presents the design criteria for the new WAS pump that feeds the GBTs.

Table 28. WAS Pump 3

Parameter	Value
Type	Rotary lobe
Number of units	1
Capacity (each), gpm @ ft TDH	200 @ 12 ft
Power (each), hp	5 hp
Drive type	Variable speed

Figure 28. WAS Pump 3 in RAS/WAS pump station

4.1.19 Secondary Clarifiers

There are four secondary clarifiers currently operating at the WWTP. Secondary Clarifiers 1 and 2 were constructed in 1995 and Secondary Clarifiers 3 and 4 were built as part of the major upgrade in 2012. OLWS will be implementing a project to rebuild Secondary Clarifiers 1 and 2, currently scheduled for 2024 or later. The mechanisms and rotating catwalks will be replaced.

Figure 29 shows one of the secondary clarifiers built in 1995. Figure 30 shows one of the newer clarifiers.

Table 29 presents the design criteria for the Plant's four secondary clarifiers.

Table 29. Secondary Clarifiers

Parameter	Value
Secondary Clarifiers 1 and 2	
Number	2
Type	Circular
Diameter (each), ft	70
Sidewater depth , ft	18
Peak hour surface overflow rate, gpd/sf	1,186
Max month solids loading rate, ppd/sf	38
Secondary Clarifiers 3 and 4	
Number	2
Type	Circular
Diameter (each), ft	70
Sidewater depth , ft	18
Peak hour surface overflow rate, gpd/sf	1,186
Max month solids loading rate, ppd/sf	38

Figure 29. Original secondary clarifier

Figure 30. Newer secondary clarifier

4.1.20 RAS Pumps

There are four RAS pumps that serve Secondary Clarifiers 1 and 2 located in the RAS/WAS pump station. These are referred to as the West RAS pumps. Each secondary clarifier has two dedicated RAS pumps. Two of the West RAS pumps are shown in Figure 31. Three additional RAS pumps, referred to as the East RAS pumps, serve Secondary Clarifiers 3 and 4. They are submersible pumps located in a structure between the clarifiers. Each clarifier has a single dedicated RAS pump, while the third pump can operate as a standby pump for either clarifier. Figure 32 shows the control panels and access hatches for the East RAS pumps. The discharge for the pumps is shown in Figure 33.

Table 30 presents the design criteria for the RAS pumps.

Table 30. RAS Pumps

Parameter	Value
West RAS Pumps	
Type	Non-clog centrifugal
Number of units	4
Capacity (each), gpm @ ft TDH	700 @ 36 ft
Power (each), hp	10
Drive type	Adjustable speed
East RAS Pumps	
Type	Non-clog submersible
Number of units	3
Capacity (each), gpm @ ft TDH	1,400 @ 12 ft
Power (each), hp	7.5
Drive type	Adjustable speed

Figure 31. West RAS pumps in RAS/WAS pump station

Figure 32. East RAS pumps

Figure 33. East RAS pump discharge

4.1.21 UV Disinfection

Secondary effluent flows to a Trojan UV3000 low-pressure, high-intensity UV disinfection system. There are four banks with a total of 224 bulbs placed in two channels. The system was designed for a UV transmittance of 65 percent.

Table 31 presents the design criteria for the Plant's UV disinfection system.

Table 31. UV Disinfection System

Parameter	Value
Type	Low pressure, high intensity
Number of channels	2
Capacity, mgd	22
Channel width (each), in.	28
Number of lamps	224
Number of banks	4
Number of lamps/banks	56
Power (each channel), kilowatt	28
UV dosage	35,000 mW-s/cm^2
UV transmittance	65%

WWTP staff note that there are issues with both the upstream and downstream gates associated with the UV channels. The upstream gate gearboxes are located at the bottom of the channel but were apparently not designed for submerged service because they have Zerk fittings. This equipment has failed, so the gates are kept open all the time. The upstream gates are expected to be replaced during the Tertiary Filtration Project.

The downstream gates do not effectively control flow through the UV system, and OLWS has been unable to modify the proprietary programming for the UV equipment. OLWS has budgeted gate modifications in its CIP for 2028. OLWS has used an aftermarket supplier for replacement bulbs, and they have a satisfactory service life. In 2022, the plant has reverted back to using genuine OEM bulbs. Figure 34 shows the UV channels and equipment.

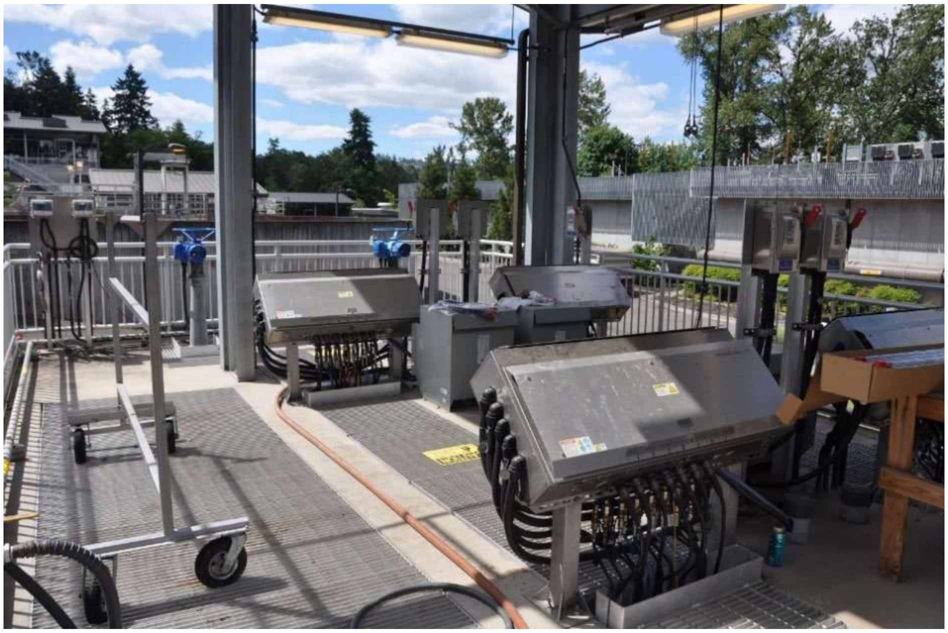

Figure 34. UV channels and equipment

4.1.22 Effluent Flow Measurement and Sampling

Two Doppler type Accusonic flow meters measure effluent flow in the UV channels. These flow meters are no longer supported by the manufacturer and will be replaced as part of the UV rehabilitation project. A composite sampler at this facility also collects effluent for NPDES reporting. Figure 35 shows the flow meter panels and the composite sampler.

Figure 35. Effluent flow meter panels and composite sampler

4.2 Solids Stream

The OLWS solids treatment train consists of four aerobic digesters and thickening and dewatering equipment. Aerobic digesters 1 and 2 are the recently converted rectangular IBR tanks, and they operate in series with the two circular aerobic digesters (3 and 4) constructed in 1995. Together, the aerobic digestion system produces a Class B biosolids that meets time and temperature criteria and volatile solids reduction requirements of 40 CFR Part 503.

OLWS is implementing the Solids Piping Project, which will provide the ability to pump WAS to the GBT for thickening prior to sending to the digesters 1 and 2 for aerobic digestion. Currently solids into Digester 4 are around 1.7 percent solids, but with the piping modifications, feed to Digester 4 is expected to be around 2.3 to 2.4 percent solids.

Digested sludge is pumped from digesters 3 and 4 to a BFP that produces a cake having a concentration of 12 to 15 percent solids. Solids are conveyed by an auger into a dump truck and OLWS staff then move the dewatered solids to a storage shed near the Plant entrance for temporary storage. A contract hauler then comes once or twice a week to load up the solids for transport to land application sites.

4.2.1 Aerobic Digesters, Mixing Systems, and Blowers

The rectangular Aerobic Digesters 1 and 2 (converted from IBRs) have a combined volume of about 862,000 gallons. Figure 36 and Figure 37, respectively, show the two aerobic digesters from the top and from below. Figure 38 shows a close-up view of one of the vertical turbine mixer motors.

In the current operation, both digesters are typically in service. These digesters are fed by the IBR feed pumps and have two vertical turbine mixers per tank as well as aeration diffusers. Sludge from these two digesters is manually transferred to Digester 3. Originally, one K-Turbo blower with a 100 hp motor (Blower #4), shown in Figure 24, provided air to the diffusers. A valve was added to the air piping as part of the Aeration Blower and Baffle Project so that a second blower can also be used to provide air to the diffusers for redundancy. As mentioned in Section 4.1.15, Blower #4 recently failed, and Blower #3 has been used for digester aeration. OLWS plans to replace the remaining K-Turbo blowers with screw hybrid blowers.

The addition of WAS Pump 3, along with piping improvements in the Solids Piping Project, will provide the ability to use the thickening equipment and then transfer thickened sludge to the aerobic digesters.

Table 32 presents the design criteria for the Aerobic Digesters 1 and 2.

Table 32. Aerobic Digesters 1 and 2

Parameter	Value
Units	2
Interior length x width (each), ft	40 X 80
Sidewater depth, ft	18
Number of diffusers (each)	120
Mixers, number (each)	2
Mixers, type	Vertical turbine
Mixer power (each), hp	1
Floating decanter, number (each)	1

Figure 36. Top of Aerobic Digesters 1 and 2

Figure 37. Aerobic Digesters 1 and 2 from below

Figure 38. Aerobic Digesters 1 and 2 vertical turbine mixer motor

Aerobic Digesters 3 and 4 are 35 feet in diameter and have an operating depth of about 25 feet. The combined volume of these two digesters is about 370,000 gallons. These were converted from anaerobic digesters in 2012. Figure 39 shows one of the circular aerobic digesters.

Table 33 presents the design criteria for Aerobic Digesters 3 and 4.

Table 33. Aerobic Digesters 3 and 4	
Parameter	Value
Units	2
Diameter (each), ft	35
Sidewater depth, ft	1 @ 25.8, 1 @ 26.3
Volume (each), gallons	1 @ 185,400, 1 @ 189,000

Figure 39. Circular aerobic digester

Aerobic Digesters 3 and 4 have radial jet pod, non-clog centrifugal mixing systems. Figure 40 shows the mixing pump at Aerobic Digester 4.

Table 34 presents the design criteria for the Plant's jet mix digester mixing system.

Table 34. Jet Mix Digester Mixing System	
Parameter	Value
Units	2
Type	Radial jet pod
Pump type	Non-clog centrifugal
Capacity (each), gpm @ ft TDH	1,075 @ 21
Power (each), hp	15

Figure 40. Digester mixing pump

Aerobic Digesters 3 and 4 are served by two Neuros turbo blowers with 30 hp motors. These blowers are housed in 50 hp enclosures. Figure 41 shows the digester blowers, which are located in a shed between Secondary Clarifiers 1 and 2. The blower in position 2 recently failed, and OLWS has recently replaced it with a screw hybrid blower.

Table 35 presents the design criteria for the two original process blowers for Aerobic Digesters 3 and 4.

Table 35. Process Blowers (Aerobic Digesters)

Parameter	Value
Units	2
Type	High speed direct drive turbo blowers
Capacity (each), cfm @ ft TDH	280 @ 11.2, 420 @ 7.8, 150 @ 6.5
Power (each), hp	30
Drive type	Adjustable speed

The aeration basin evaluation project completed by Murraysmith in 2019 also considered solids treatment modifications including impact of resuming operation of the GBT on aerobic digestion. The report notes that aerobic digester mixing, and aeration requirements may be impacted by this process change.

Figure 41. Digester blowers

4.2.2 Digested Sludge Pumps

Two rotary lobe pumps with 10 hp motors and adjustable speed drives serve as digested sludge pumps to convey the digested sludge to the BFP. Figure 42 shows one of the digested sludge pumps.

Table 36 presents the design criteria for the Plant's digested sludge pumps.

Table 36. Digested Sludge Pumps

Parameter	Value
Units	2
Pump type	Rotary lobe
Capacity (each), gpm @ psi TDH	150 @ 10
Power (each), hp	10
Drive type	Adjustable speed

Figure 42. Digested sludge pump

4.2.3 Thickening

A GBT located in the Solids Handling Building has not been used since the 2012 Plant upgrade. With implementation of the recent Solids Piping Project, however, OLWS staff will soon be able to pump WAS to the GBT and thicken prior to pumping to digesters 1 and 2. This will increase the percent total solids in digester 4 from 1.7 to approximately 2.3 percent solids and will ultimately increase the percent solids of the dewatered cake from the BFP. Figure 43 shows the GBT in the Solids Handling Building.

OLWS installed a new WAS pump that can be used to pump WAS to the GBT and thickened waste activated sludge (TWAS) pumps will pump the TWAS to digesters 1 and 2. The concentration of the WAS being pumped to the GBT will range from approximately 0.5 to 1.5 percent total solids, and the TWAS is expected to be an average of 2 to 2.5 percent total solids. Figure 44 shows one of the TWAS pumps.

Table 37 presents the design criteria for thickening system.

Table 37. Thickening

Parameter	Value
GBT	
Units	1
Type	GBT
Width (meter)	2.2
TWAS Pumps	
Units	2
Type	Rotary lobe
Capacity (each), gpm @ psi TDH	160 @ 25
Power (each), hp	7.5
Drive type	Constant speed

Figure 43. Gravity belt thickener

Figure 44. Thickened waste activated sludge pump

4.2.4 Dewatering

Digested sludge is pumped to BFP1. Until the beginning of 2022, dry polymer was used in the process and the dewatered cake had a concentration of approximately 12 to 15 percent total solids. In the beginning of 2022, a liquid polymer system was installed, and the dewatered cake concentration has increased to an average of approximately 16.5 percent total solids. Figure 45 shows BFP1 located in the Solids Handling Building.

The dewatered cake coming off BFP1 is loaded into a dump truck using an auger/conveyor system. Figure 46 shows the truck loadout facility outside of the Solids Handing Building. Biosolids are temporarily stored in a shed building located near the Plant entrance before being picked up by a contract hauler and transported to Madison Farms in Echo, Oregon, for land application.

In addition to BFP1, a second BFP (BFP2) was temporarily installed as part of the BFP Installation Project in 2020 to provide redundancy for the dewatering system. The OLWS had purchased a used BFP that was temporarily installed in the area between the Solids Handling Building and Electrical Building #75 to be used when BFP1 had to be taken out of service or to provide additional dewatering if needed. A dedicated local control panel was installed for it outside the building, as well as an air compressor for the pneumatic belt tensioning and tracking system. As part of the project, a new main PLC panel was also installed inside the building to replace the obsolete PLC; it controlled all the existing equipment in the building and was integrated with BFP2. After initial installation of BFP2, BFP1 was taken out of service and refurbished. Once BFP1 was put back online, BFP2 was uninstalled and is currently being stored by Aerobic Digesters 1 and 2. Figure 47 shows a photo of BFP2 when it was installed.

Table 38 presents the design criteria for the Plant's dewatering system.

Table 38. Dewatering

Parameter	Value
BFP1	
Units	1
Width (meter)	2.0
Cake solids, percent dry weight	15
Solids capture, percent	90
BFP2	
Units	1
Width (meter)	1.5
Cake solids, percent dry weight	15
Solids capture, percent	90

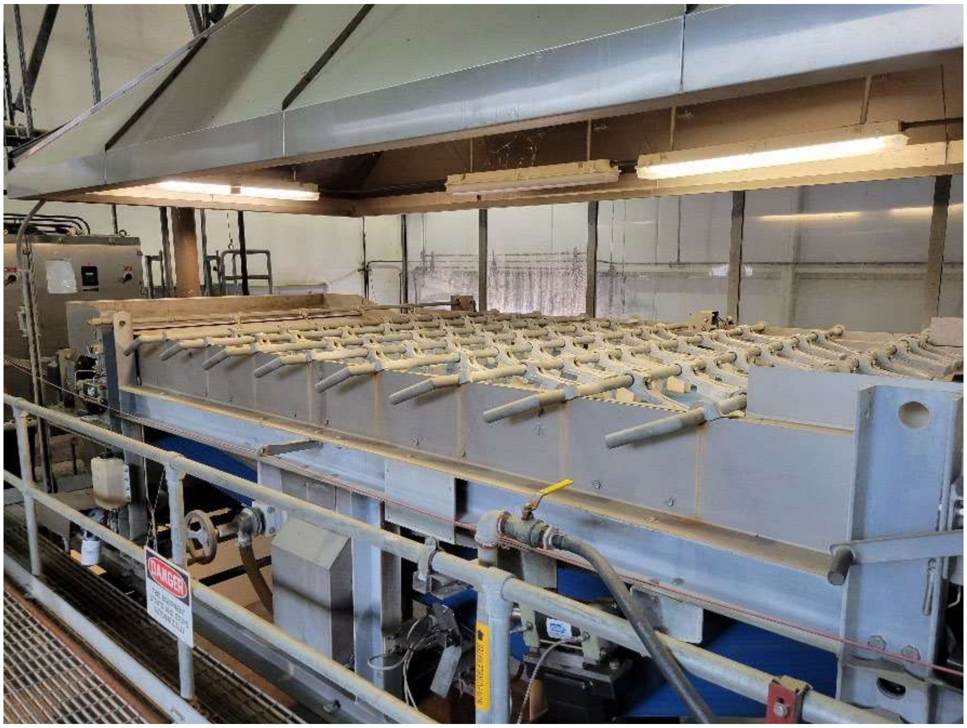

Figure 45. BFP1

Figure 46. Truck loadout at Solids Handling Building

Figure 47. BFP2 Installation

4.3 Support Systems

Support systems at the WWTP include the 3W disinfection system, 3W pumps, and odor control systems for the IPS/Plant Drain PS, Headworks Building, Aerobic Digesters 1 and 2, and the Solids Handling Building. The outfall is also described in this section.

4.3.1 3W Disinfection and Pumps

Utility (3W) is disinfected with sodium hypochlorite before Plant distribution and use. Two positive displacement metering pumps are used to dose the sodium hypochlorite. No issues with the 3W disinfection system were reported. Figure 48 shows the sodium hypochlorite metering pumps while Figure 49 shows the storage tank.

Table 39 presents the design criteria for the Plant's 3W sodium hypochlorite system.

Table 39. 3W Sodium Hypochlorite System

Parameter	Value
Concentration, percent	12.5
Metering pumps, number	2
Pump type	Positive displacement diaphragm
Capacity (each), gph @ psi	4.3 @ 150 psi
Power (each) hp	1/2

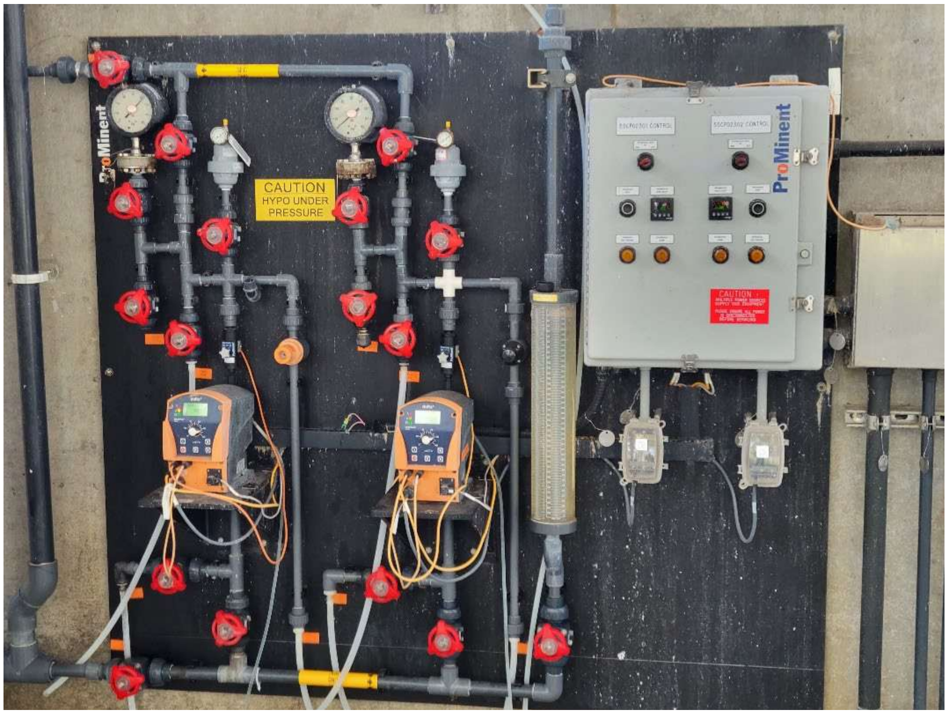

Figure 48. Sodium hypochlorite metering system

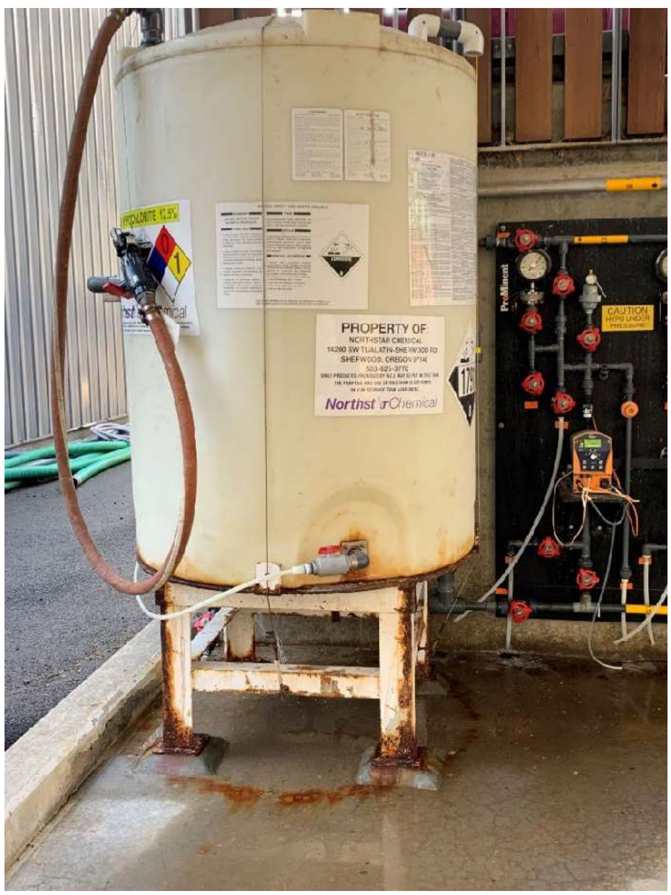

Figure 49. Sodium hypochlorite storage tank

There are three vertical turbine pumps that supply 3W for Plant use. Two of the pumps have 100 hp motors and the third has a 50 hp motor. Figure 50 shows the 3W pumps.

Table 40 presents the design criteria for the Plant's 3W pumps.

Table 40. 3W Pumps

Parameter	Value
Type	Vertical turbine
Number of units	3
Pump 1 & 2 power Capacity (each), gpm @ ft TDH	800 @ 300 ft
Pump 1 & 2 power (each), hp	100
Drive type	Adjustable speed
Pump 3 capacity, gpm @ ft TDH	450 @ 300 ft
Pump 3 power, hp	50
Drive type	Adjustable speed

Figure 50. 3W pumps located at disinfection facility

There are two strainers associated with the 3W system; one is motorized and the other is a manual strainer on a bypass line. Access to the equipment for maintenance is limited. The equipment could be shifted away from the wall but there is a road that limits its movement. Figure 51 shows the strainers.

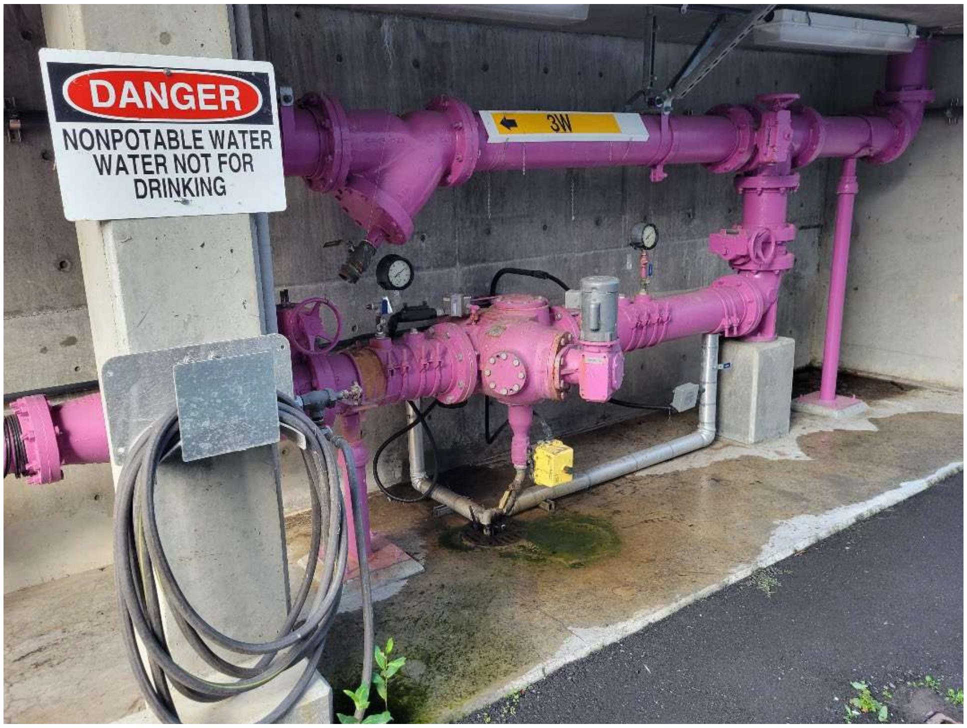

Figure 51. 3W strainers

4.3.2 IPS/Plant Drain PS and Headworks Foul Air Treatment

Foul air withdrawn at the IPS/Plant Drain PS and the Headworks Building is treated with a two-bed biofilter containing a 5-foot depth organic media. Two FRP centrifugal fans with 7.5 hp motors are used to exhaust air and supply the biofilter. Figure 52 shows the building housing the biofilter beds and some of the foul air piping.

Table 41 presents the design criteria for the Plant's headworks foul air treatment system.

Table 41. Headworks Foul Air Treatment

Parameter	Value
Headworks Biofilter	
Type	Organic media
Number of beds	2
Number of treatment stages	1
Capacity, cfm	5,000
Media depth, ft	5
Size (each), square feet	1,000
Odorous Air Exhaust Fans	
Units	2
Fan type	FRP centrifugal
Capacity (each), cfm	2,500
Static pressure, in. water column (wc)	7
Power (each) , hp	7.5

Figure 52. Biofilter building and foul air piping

4.3.3 Aerobic Digester 1 and 2 and Solids Handling Building Foul Air Treatment

Foul air withdrawn at Aerobic Digesters 1 and 2 and from the GBT and BFP in the Solids Handling Building is treated with a chemical scrubber system originally installed with construction of the Solids Handling Building in 2002. The system consists of a packed bed vertical absorption tower, a chemical solution recirculation pump, two chemical solution dosing pumps, and a foul air fan. Figure 53 shows chemical scrubber tower and foul air fan located north of the Solids Handling Building. The chemical recirculation and dosing pumps are located inside the building. Figure 54 shows the chemical recirculation pump. Foul air piping from Aerobic Digesters 1 and 2 was tied into the existing foul air piping from the Solids Handling Building as part of the 2012 Plant upgrade.

Table 42 presents the design criteria for the chemical scrubber foul air treatment system.

Table 42. Chemical Scrubber System	
Parameter	**Value**
Chemical Scrubber Tower	
Type	Packed bed vertical absorption
Number of units	1
Capacity, cfm	11,500
Vessel diameter, ft	7
Packed bed depth, ft	10
Chemical Recirculation Pump	
Number of units	1
Pump type	Horizonal, end suction centrifugal
Capacity (each), gpm @ psi TDH	230 @ 27
Power (each), hp	5
Chemical Metering Pumps	
Number of units	2
Pump type	Positive displacement diaphragm
Capacity (each), gph @ psi	1.5 @ 150 (NaOH) 2.5 @ 150 (NaOCl)
Sodium Hypochlorite	2.5 @ 150
Foul Air Fan	
Number of units	1
Fan type	Centrifugal
Capacity, cfm	11,500
Static pressure, inch wc	6
Power (each) , hp	20

Figure 53. Chemical scrubber tower and foul air fan

Figure 54. Chemical recirculation pump

4.3.4 Outfall

The outfall for the OLWS WWTP is located east of the Plant in the Willamette River approximately 165 feet east of the riverbank. Figure 55 shows the location of the outfall as provided in the Oak Lodge Outfall Inspection Report (Ballard Marine Construction, October 2020). There is a primary and secondary discharge outfall. The primary outfall is 426 feet in length with 19, 6-inch duckbill diffuser ports at 5-foot intervals. The secondary outfall is 234 feet in length with 4, 48-inch ports at 5-foot intervals. Both outfalls are constructed of 48-inch HDPE pipe.

There was an outfall inspection done in October 2020 by Ballard Marine Construction, and it was reported that all the diffusers were in good working order and none were in need of repair. The report did indicate that there was heavy buildup of timber and debris along the outfall that should be monitored and maintained. Primary diffusers 1-6 also had some sediment buildup that that should be monitored and removed as needed to avoid impeding the flow.

Figure 55. Outfall location

Source: Outfall Inspection Report, Ballard Marine Construction

Section 5: Summary of Results

The previous section provides a description of OLWS WWTP facilities and observations related to condition based on the October 20, 2021, site visit, the September 1, 2021, operations workshop, and additional communications with OLWS staff. This section summarizes the results, conclusions, and recommendations from those discussions and evaluations.

Table 43 provides a summary of the ratings, conclusions, and recommendations for the equipment assessed during the October 20, 2021, site visit.

A majority of the equipment was installed as part of the 2012 plant upgrade. Most of that equipment received condition and performance ratings of 3, which indicates that the equipment condition and performance are both as expected for the asset age. In rare instances, scores of 4 or 5 were given for equipment that has reached the end of its useful life or does not function for some reason.

In general, most of the equipment is performing satisfactorily. There are a few areas that are recommended for further evaluation and possible upgrade in the near future. As appropriate, projects have been incorporated into the CIP for equipment replacement and facility upgrades.

Table 43. Ratings, Conclusions, and Recommendations for OLWS WWTP Equipment

Equipment Name	Quantity	Approximate Install Date	Condition Ratings [a]		Recommended Action [b]	Conclusions and Recommendations	Design Considerations [c]
			Condition	Performance			
Influent Pumps	5	2019	2	2	5	• Pumps not visible during inspection. • They are Flygt pumps that effectively pass rags and don't have issues with plugging, but the rags must be dealt with downstream in the Headworks and ABs, however. • There is currently no permanent lifting system and a mobile crane needs to be brought in to lift a pump. • There is also no weather cover over Meltric plug stations.	While the equipment is generally in good condition, there is a current CIP project scheduled to make some of the possible improvements listed below. • Consider adding flushing valve to pumps to help with stirring up and flushing out contents of the wet well. (This needs to be fully evaluated because the flushing valves were originally designed for constant speed pumps and may be difficult for use with VFDs. They are also known to have issues with closing fully.) • Consider adding a permanent lifting system for the pumps. • Consider adding a cover over the Meltric plug stations.
Influent Splitter Box Gates	2	2012	3	3	5	• Gates not visible during inspection. • Gates are manual and always kept fully open.	May want to consider adding electric actuators to allow for automatic/remote control.
Influent Wet Well Gate	1	2012	3	4	5	• Gate not visible during inspection. • Gate is manual and always kept fully open, so both sides of the wet well act as one large wet well. During periods of low flow, the wet well is oversized and solids collect in the corners.	• May want to consider adding electric actuators to allow for automatic/remote control. • Could also consider rounding the corners of the wet well and/or adding the flushing valve on the influent pumps.
Plant Drain Pumps	2	2012	3	3	5	• Pumps not visible during inspection. • Solids settle out in the wet well.	• Consider replacing KSB pumps with Flygt pumps. • Consider adding flushing valve to the pumps to help with stirring up and flushing out contents of wet well. (See comment concerning flushing valves under Influent Pumps above.) • Consider modifying wet well to add concrete fill in bottom corners to prevent build-up of grit and solids there.
Plant Drain Inlet Box Gate	1	2012	3	3	1	Gate not visible during inspection.	
Plant Drain Bypass Gate	1	2012	3	3	1	Gate not visible during inspection.	
Screen Channel Influent Gates	2	2012	3	3	1	Was able to see one gate that was lifted. Normal appearance for age.	
Bypass Channel Influent Gate	1	2012	3	3	1	Gate not visible during inspection.	

Table 43. Ratings, Conclusions, and Recommendations for OLWS WWTP Equipment

Equipment Name	Quantity	Approximate Install Date	Condition Ratings [a]		Recommended Action [b]	Conclusions and Recommendations	Design Considerations [c]
			Condition	Performance			
Influent Sampler	1	2012	3	4	3	• Strainer on the suction tubing occasionally plugs with debris due to rags and debris accumulating at end of the influent channel. • Cannot move downstream of Influent Screens due to plant drainage being introduced and influent sample needs to be collected upstream of that.	Plant staff considering enclosing sample tube in an enclosure to protect it from debris.
Influent Screens	2	2012	3	3	5	• Some rags are able to pass through the bars or through gaps between the screen frame and the channel. • Rubber seal between the channel and frame opening does not always provide an effective seal.	• Consider improving the seal between channel and frame. • Consider replacing screens with finer spaced bars or perforated plates. • Add 3rd multi-rake bar screen to replace manually-cleaned screen during future Headworks Upgrades.
Screen Channel Effluent Gates	2	2012	3	3	1	Gates not visible during inspection.	
Bypass Channel Effluent Gate	1	2012	3	3	1	Gate not visible during inspection.	
Screenings Washer/ Compactor	2	2012	3	3	5	• When the 3W system is taken offline, the screenings sluice system must also be taken offline. • A large slug load of debris can go to compactors after an outage.	WWTP staff installed a baffle to prevent slug load from opening compactor door.
Screenings Diverter Gates	2	2012	3	3	1	Minor rust and corrosion on gates and operators	
Grit Basin Influent Gates	2	2012	3	3	1	Gates not visible during inspection.	
Grit Basins	2	2012	3	3	4	• Unable to view grit basins. • Basins are difficult to access and maintain due to cover.	OLWS working with manufacturer on design modifications to improve accessibility.
Grit Pumps	2	2012	3	3	5	No known issues.	
Grit Classifier	1	2012	3	4	5	The vortex separator was designed to return finer solids to stream to maximize BOD to ABs for Cannibal system. This allows grit to collect in the aeration basins.	Consider modification or replacement during future Headworks Upgrades to improve fine grit removal efficiency.
Mixed Liquor Screen	1	2012	3	3	N/A	Operates but no longer in use due to abandonment of Cannibal system.	

Table 43. Ratings, Conclusions, and Recommendations for OLWS WWTP Equipment

Equipment Name	Quantity	Approximate Install Date	Condition Ratings [a]		Recommended Action [b]	Conclusions and Recommendations	Design Considerations [c]
			Condition	Performance			
Mixed Liquor Screenings Compactor	1	2012	5	5	N/A	• No longer in use due to abandonment of Cannibal system. • Stress fractures on the polyurethane guides and cannot obtain new parts.	May consider trying to obtain spare parts or equipment from another agency to be able to put this system back into use.
Aeration Blower 1	1	2012	5	5	5	Not functional and has been unused for several years.	Has been replaced with new Aeration Blower 5 in the AB&B Project but not yet commissioned as of this TM.
Aeration Blowers 2-4	3	2012	3	4	5	• Functional but cannot achieve desired turndown and blowers operate in unstable area on curve. • AB 4 operates full speed, full time providing air to Aerobic Digesters 1 and 2. • Blowers are located in a 3-side open shed, which has led to many operational issues. Operators limit starts and stops as much as possible.	• New blower being added to replace AB1 will be smaller and provide greater operational control and efficiency. • The AB&B Project will modify the air header to allow AB3 to serve as a backup to AB4. • Replace turbo blowers with another type, such as a screw centrifugal blower.
AB Influent Gates	4	2012	3	3	5	No known issues.	Incorporated into future secondary treatment upgrades.
AB Scum Gate	1	2012	3	3	5	No known issues.	Incorporated into future secondary treatment upgrades.
Anoxic Zone Mixers	12	2012	4	3	5	• Stress fractures found on some of the mixers. • Rags that pass through IPS and Headworks get caught up on mixer blades.	Improvements to the influent screening would help reduce number of rags in the ABs.
Mixed Liquor Recycle Pumps	3	2012	3	3	5	Pumps have been rebuilt multiple times each at $40,000 apiece.	Incorporated into future secondary treatment upgrades. Consider different pump type when pumps are replaced.
Screened Mixed Liquor Pumps	2	2012	3	3	N/A	Pumps are functional but not in use due to the mixed liquor screen and compactor being offline.	
Secondary Clarifiers 1 and 2	2	1996	4	4	5	• Mechanisms are near the end of their useful life. • Clarifiers are not currently in operation.	Mechanisms and rotating catwalks will be replaced in 2023/2024 or later.
Secondary Clarifiers 3 and 4	2	2012	3	3	5	No known issues.	
West RAS Pumps 1-3	3	2017	2	2	5	• Pumps serve clarifiers 1 and 2. • Original pumps replaced with Flygt pumps. • No known issues.	No known issues with pumps, but the RAS MCC was not updated with the 2012 plant upgrade and is out of date and not up to code. Current CIP includes replacement of RAS MCC.
West RAS Pump 4	1	2019	2	2	5	• Pump serves clarifiers 1 and 2. • Original pump replaced with Flygt pump. • No known issues.	No known issues with pumps, but the RAS MCC was not updated with the 2012 plant upgrade and is out of date and not up to code. Current CIP includes replacement of RAS MCC.

Table 43. Ratings, Conclusions, and Recommendations for OLWS WWTP Equipment

Equipment Name	Quantity	Approximate Install Date	Condition Ratings [a]		Recommended Action [b]	Conclusions and Recommendations	Design Considerations [c]
			Condition	Performance			
East RAS Pumps	3	2012	3	3	5	• Pumps serve clarifiers 3 and 4. • No known issues.	
West WAS Pumps 1 and 2	2	2012	3	3	5	No known issues.	No known issues with pumps, but the RAS MCC was not updated with the 2012 plant upgrade and is out of date and not up to code. Current CIP includes replacement of RAS MCC. Pumps to be decommissioned once WAS Pump 3 comes on-line.
West WAS Pump 3	1	2021	1	1	5	Once programming is complete, this pump will draw off header of all 4 clarifiers and be able to pump WAS to the GBT in the Solids Handling Building.	No known issues with pump, but the RAS MCC was not updated with the 2012 plant upgrade and is out of date and not up to code. Current CIP includes replacement of RAS MCC.
Aerobic Digester 1 and 2 (formerly IBR) Feed Pumps	2	2012	3	3	5	No known issues.	Incorporated into future solids handling upgrades.
Aerobic Digester 1 and 2 Mixers	4	2012	3	3	5	No known issues.	Incorporated into future solids handling upgrades.
Process Blowers	2	2012	3	3	5	Since the condition assessment was performed, one of the process blowers has failed.	• OLWS plans to replace the failed blower with another type, such as a screw centrifugal blower, similar to new Aeration Blower 5. • Eventually, plans to replace the operational process blower as well.
Aerobic Digester 3 and 4 Mixing Pumps	2	2012	3	3	1	No known issues.	
UV Channel Influent Flow Valves	2	2012	4	4	5	• Gearboxes were not designed for submerged service and have failed. • Valves are kept full open all the time.	• Modification of valves budgeted in current CIP. • Recommend replacing valves during Tertiary Filtration Project.
UV Hydraulic System	1	2012	3	3	5	No known issues.	
UV Lamp Banks	2	2012	3	3	5	Staff had used aftermarket supplier for replacement bulbs and have satisfactory service life. Staff has reverted back to using OEM bulbs starting FY2022.	

Table 43. Ratings, Conclusions, and Recommendations for OLWS WWTP Equipment

Equipment Name	Quantity	Approximate Install Date	Condition Ratings [a]		Recommended Action [b]	Conclusions and Recommendations	Design Considerations [c]
			Condition	Performance			
UV Channel Effluent Gates	2	2012	3	4	5	• Gates modulate too little or too much and do not effectively control flow through the channels. • Cannot access programming in Trojan PLC to adjust control.	• Modification of gates budgeted for 2022/2023. • Plan is to replace complicated level control program with passive level control system.
Plant 3W Pump 1	1	2012	4	3	2	Significant rust and corrosion visible.	
Plant 3W Pumps 2 and 3	2	2012	3	3	2	Some rust and corrosion visible.	
3W Motorized Strainer	1	2012	3	4	4	Strainer located too close to the wall; difficult to access for maintenance.	Replace/modify piping for easier and safe access for maintenance.
3W Sodium Hypochlorite Pumps	2	2012	3	3	1	No known issues.	
Effluent Sampler	1	2012	3	3	1	No known issues.	
Effluent Flow Meters	2	2012	3	3	4	No longer supported by manufacturer	Replace when UV system is upgraded.
Digested Sludge Pumps	2	2000	3	3	5	No known issues.	Incorporated into future solids handling upgrades.
Gravity Belt Thickener	1	2000	3	3	5	• GBT reaching end of useful life; hasn't been operated since 2012. • New solids piping Project will allow WAS to be pumped to the GBT for thickening prior to sending to the digesters. • Need to evaluate performance upon restarting.	Solids Handling Facility to be replaced in future CIP project.
TWAS Pumps	2	2000	4	3	4	• Equipment reaching end of useful life; hasn't been operated since 2012. • Need to evaluate performance upon restarting.	May need to replace depending on how they operate once restarted.
Sludge Grinder	1	2000	4	3	4	• Reaching end of useful life. • No known issues.	Incorporated into future solids handling upgrades.
Belt Filter Press 1	1	2000	3	3	4	• BFP was refurbished in 2021. • New liquid polymer system increased cake solids by 2-3% TS.	Incorporated into future solids handling upgrades.
Solids Conveyor	1	2000	4	3	4	• Reaching end of useful life. • No known issues.	Incorporated into future solids handling upgrades.
Belt Filter Press 2	1	-	3	3	2	Used BFP that can be temporarily installed to provide redundant dewatering.	Incorporated into future solids handling upgrades.

Table 43. Ratings, Conclusions, and Recommendations for OLWS WWTP Equipment

Equipment Name	Quantity	Approximate Install Date	Condition Ratings [a]		Recommended Action [b]	Conclusions and Recommendations	Design Considerations [c]
			Condition	Performance			
GBT Polymer System	1	2000	4	3	4	Equipment reaching end of useful life; hasn't been operated since 2012.	Incorporated into future solids handling upgrades.
BFP Polymer System	1	2000	4	4	1	• Reaching end of useful life. • Staff looking at options to replace.	Shortly following the condition assessment, the OLWS replaced the dry polymer system with a liquid polymer system to improve dewaterability.
Solids Handling Building Foul Air Fan	1	2000	4	3	4	• Equipment reaching end of useful life. • New motorized dampers were installed in ductwork in 2012 upgrade.	Incorporated into future solids handling upgrades.
Odor Reduction Tower	1	2000	4	3	4	• No known issues. • Caustic metering pump was replaced in 2012 upgrades. Sodium hypochlorite metering pump was left in place.	Incorporated into future solids handling upgrades.
ORT Recirculation Pump	1	2000	4	3	4	Equipment reaching end of useful life.	Incorporated into future solids handling upgrades.
Biofilters	2	2012	3	3	1	No known issues.	
Odor Control Fans	2	2012	3	3	5	No known issues, but will require periodic replacement.	
Humidifiers	2	2012	3	3	1	No known issues.	

a. Descriptions of the condition and performance scores are provided in Tables 5 and 6, respectively.

b. Descriptions of the recommended action are provided in Table 7.

c. Any design considerations listed are preliminary suggestions and need to be fully evaluated prior to any implementation.

Section 6: References

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Murraysmith, Oak Lodge Water Services, Aeration Blower and Baffle Project, July 2021.

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Attachment A: Plant Asset Registry

System or Location	Equipment Number	Equipment Name	Install Date	Condition Score	Performance Score	Recommended Action
Influent Pumping System	10GATE00203.gate	Influent Wet Well Gate	12/30/2012	3	4	5
Influent Pumping System	10PUMP00101.pump	Influent Pump 1	12/4/2019	2	2	5
Influent Pumping System	10PUMP00102.pump	Influent Pump 2	12/4/2019	2	2	5
Influent Pumping System	10PUMP00103.pump	Influent Pump 3	12/4/2019	2	2	5
Influent Pumping System	10PUMP00104.pump	Influent Pump 4	9/3/2019	2	2	5
Influent Pumping System	10PUMP00106.pump	Influent Pump 6	9/3/2019	2	2	5
Influent Pumping System	10GATE00201.gate	Influent Splitter Box Gate 1	12/30/2012	3	3	5
Influent Pumping System	10GATE00202.gate	Influent Splitter Box Gate 2	12/30/2012	3	3	5
Plant Drain Pumping System	10PUMP10001.pump	Plant Drain Pump 1	12/30/2012	3	3	5
Plant Drain Pumping System	10PUMP10002.pump	Plant Drain Pump 2	12/30/2012	3	3	5
Plant Drain Pumping System	10GATE10201.gate	Plant Drain Inlet Box Gate	12/30/2012	3	3	1
Plant Drain Pumping System	10GATE10202.gate	Plant Drain Bypass Gate	12/30/2012	3	3	1
Influent Screening System	15GATE00901.gate	Screen Channel 1 Influent Gate	12/30/2012	3	3	1
Influent Screening System	15GATE00901.mtr	Screen Channel 1 Influent Gate Actuator	12/30/2012	3	3	1
Influent Screening System	15GATE00902.gate	Screen Channel 2 Influent Gate	12/30/2012	3	3	1
Influent Screening System	15GATE00902.mtr	Screen Channel 2 Influent Gate Actuator	12/30/2012	3	3	1
Influent Screening System	15GATE00903.gate	Bypass Channel Influent Gate	12/30/2012	3	3	1
Influent Screening System	15GATE00903.mtr	Bypass Channel Influent Gate Actuator	12/30/2012	3	3	1
Influent Screening System	15SCRN01101.scrn	Influent Screen 1	12/30/2012	3	3	3
Influent Screening System	15SCRN01102.scrn	Influent Screen 2	12/30/2012	3	3	3
Influent Screening System	15GATE01201.gate	Screen Channel 1 Effluent Gate	12/30/2012	3	3	1
Influent Screening System	15GATE01201.mtr	Screen Channel 1 Effluent Gate Actuator	12/30/2012	3	3	1
Influent Screening System	15GATE01202.gate	Screen Channel 2 Effluent Gate	12/30/2012	3	3	1
Influent Screening System	15GATE01202.mtr	Screen Channel 2 Effluent Gate Actuator	12/30/2012	3	3	1
Influent Screening System	15GATE01203.gate	Bypass Channel Effluent Gate	12/30/2012	3	3	1
Influent Screening System	15GATE01203.mtr	Bypass Channel Effluent Gate Actuator	12/30/2012	3	3	1
Influent Screening System	15COMP04401.comp	Screenings Compactor 1	12/30/2012	3	3	1
Influent Screening System	15COMP04402.comp	Screenings Compactor 2	12/30/2012	3	3	1
Grit Removal & Handling System	15GATE05001.gate	Diverter Gate 1	12/30/2012	3	3	1
Grit Removal & Handling System	15GATE05002.gate	Diverter Gate 2	12/30/2012	3	3	1
Grit Removal & Handling System	15GATE01501.gate	Grit Basin 1 Influent Gate	12/30/2012	3	3	1
Grit Removal & Handling System	15GATE01502.gate	Grit Basin 2 Influent Gate	12/30/2012	3	3	1
Grit Removal & Handling System	15BASIN03001	Grit Basin 1	12/30/2012	3	3	3
Grit Removal & Handling System	15BASIN03002	Grit Basin 2	12/30/2012	3	3	3
Grit Removal & Handling System	15PUMP02101.pump	Grit Pump 1	12/30/2012	3	3	1
Grit Removal & Handling System	15PUMP02101.mtr	Grit Pump 1 Motor	12/30/2012	3	3	1
Grit Removal & Handling System	15PUMP02102.pump	Grit Pump 2	12/30/2012	3	3	1
Grit Removal & Handling System	15PUMP02102.mtr	Grit Pump 2 Motor	12/30/2012	3	3	1
Grit Removal & Handling System	15CLAS03201.clas	Grit Classifier	12/30/2012	3	3	1
Mixed Liquor Screening System	15DSCN03501.scrn	Mixed Liquor Screen	12/30/2012	3	3	N/A
Mixed Liquor Screening System	15SCRW03701.scrw	Screw Press	12/30/2012	5	5	N/A
Grit Removal & Handling System	15VSEP03101.vsep	Vortex Seperator	12/30/2012	3	3	1
Secondary Clarifier 1 System	24-SC-001-COLLECTOR	Secondary Clarifier 1 Collector/Sweep	6/30/1996	4	4	5
Secondary Clarifier 2 System	24-SC-002-COLLECTOR	Secondary Clarifier 2 Collector/Sweep	6/30/1996	4	4	5

System or Location	Equipment Number	Equipment Name	Install Date	Condition Score	Performance Score	Recommended Action
Influent Odor Control System	25OFAN00401.hvac	Odor Control Fan 1	12/30/2012	3	3	1
Influent Odor Control System	25OFAN00402.hvac	Odor Control Fan 2	12/30/2012	3	3	1
Influent Odor Control System	25HMDF00701.hmdf	Humidifier 1	12/30/2012	3	3	1
Influent Odor Control System	25HMDF00702.hmdf	Humidifier 2	12/30/2012	3	3	1
Influent Odor Control System	30BIOF00201	Biofilter Cell 1	12/30/2012	3	3	1
Influent Odor Control System	30BIOF00202	Biofilter Cell 2	12/30/2012	3	3	1
Aeration Basin 1 System	30MIXR00101.mixr	Aerarion Mixers Basin 1 Mixer 1	12/30/2012	4	3	2
Aeration Basin 1 System	30MIXR00102.mixr	Aerarion Mixers Basin 1 Mixer 2	12/30/2012	4	3	2
Aeration Basin 1 System	30MIXR00103.mixr	Aerarion Mixers Basin 1 Mixer 3	12/30/2012	4	3	2
Aeration Basin 1 System	30MIXR00104.mixr	Aerarion Mixers Basin 1 Mixer 4	12/30/2012	4	3	2
Aeration Basin 1 System	30MIXR00105.mixr	Aerarion Mixers Basin 1 Mixer 5	12/30/2012	4	3	2
Aeration Basin 1 System	30MIXR00106.mixr	Aerarion Mixers Basin 1 Mixer 6	12/30/2012	4	3	2
Aeration Basin 2 System	30MIXR00201.mixr	Aerarion Mixers Basin 2 Mixer 1	12/30/2012	4	3	2
Aeration Basin 2 System	30MIXR00202.mixr	Aerarion Mixers Basin 2 Mixer 2	12/30/2012	4	3	2
Aeration Basin 2 System	30MIXR00203.mixr	Aerarion Mixers Basin 2 Mixer 3	12/30/2012	4	3	2
Aeration Basin 2 System	30MIXR00204.mixr	Aerarion Mixers Basin 2 Mixer 4	12/30/2012	4	3	2
Aeration Basin 2 System	30MIXR00205.mixr	Aerarion Mixers Basin 2 Mixer 5	12/30/2012	4	3	2
Aeration Basin 2 System	30MIXR00206.mixr	Aerarion Mixers Basin 2 Mixer 6	12/30/2012	4	3	2
MLR Pumping System	35PUMP00201.pump	MLR Pump 1	12/30/2012	3	3	1
MLR Pumping System	35PUMP00202.pump	MLR Pump 2	12/30/2012	3	3	1
MLR Pumping System	35PUMP00203.pump	MLR Pump 3	12/30/2012	3	3	1
Aeration Air System	38BLWR00101.blwr	Aeration Blower 1	12/30/2012	5	5	N/A
Aeration Air System	38BLWR00102.blwr	Aeration Blower 2	12/30/2012	3	4	2
Aeration Air System	38BLWR00103.blwr	Aeration Blower 3	12/30/2012	3	4	2
Aeration Air System	38BLWR00104.blwr	Aeration Blower 4	12/30/2012	3	4	2
West RAS Pumping System	42PUMP10001.pump	West RAS Pump 1	12/1/2017	2	2	1
West RAS Pumping System	42PUMP10001.pump	West RAS Pump 1 VFD	12/30/2012	3	3	1
West RAS Pumping System	42PUMP10002.pump	West RAS Pump 2	12/1/2017	2	2	1
West RAS Pumping System	42PUMP10002.pump	West RAS Pump 2 VFD	4/15/2020	2	2	1
West RAS Pumping System	42PUMP10003.pump	West RAS Pump 3	4/15/2020	2	2	1
West RAS Pumping System	42PUMP10003.pump	West RAS Pump 3 VFD	4/15/2020	2	2	1
West RAS Pumping System	42PUMP10004.pump	West RAS Pump 4	9/27/2019	3	3	1
West RAS Pumping System	42PUMP10003.pump	West RAS Pump 4 VFD	4/15/2020	2	2	1
West RAS Pumping System	42PUMP40001.pmp	West WAS Pump 1	4/15/2020	3	3	1
West RAS Pumping System	42PUMP40002.pmp	West WAS Pump 2	4/15/2020	3	3	1
West RAS Pumping System	42PUMP40002.pmp	West WAS Pump 3	2022	1	1	1
Digester Aeration	42BLWR02001.blwr	Process Blower 1	12/30/2012	3	3	1
Digester Aeration	42BLWR02002.blwr	Process Blower 2	12/30/2012	3	3	1
IBR Pumping System	42PUMP01001.pmp	Interchange Feed Pump 1	12/30/2012	3	3	1
IBR Pumping System	42PUMP01002.pmp	Interchange Feed Pump 2	12/30/2012	3	3	1
Secondary Clarifier 3 System	45CLAR00103.clar	Secondary Clarifier 3 Drive Mechanism	12/30/2012	3	3	1
Secondary Clarifier 3 System	45CLAR00103.mtr	Secondary Clarifier 3 Drive Motor	12/30/2012	3	3	1
Secondary Clarifier 4 System	45CLAR00104.clar	Secondary Clarifier 4 Drive Mechanism	12/30/2012	3	3	1
Secondary Clarifier 4 System	45CLAR00104.mtr	Secondary Clarifier 4 Drive Motor	12/30/2012	3	3	1

System or Location	Equipment Number	Equipment Name	Install Date	Condition Score	Performance Score	Recommended Action
East RAS Pumping System	45PUMP00701.pmp	East RAS Pump 1	5/19/2020	2	2	1
East RAS Pumping System	45PUMP00702.pmp	East RAS Pump 2	12/30/2012	3	3	1
East RAS Pumping System	45PUMP00703.pmp	East RAS Pump 3	12/11/2019	3	3	1
Disinfection System	55__FV00501.vlv	UV Channel 1 Influent Flow Valve, Motorized	12/30/2012	4	4	5
Disinfection System	55__FV00502.vlv	UV Channel 2 Influent Flow Valve, Motorized	12/30/2012	4	4	5
Disinfection System	55_HSC001.pmp	UV Hydraulic System	12/30/2012	3	3	1
Disinfection System	55_BANK1A	UV Lamp Bank 1A	12/30/2012	3	3	1
Disinfection System	55_BANK1B	UV Lamp Bank 1B	12/30/2012	3	3	1
Disinfection System	55_BANK2A	UV Lamp Bank 2A	12/30/2012	3	3	1
Disinfection System	55_BANK2B	UV Lamp Bank 2B	12/30/2012	3	3	1
Disinfection System	55GATE00601.gate	UV Channel 1 Motorized Outlet Gate	12/30/2012	3	4	5
Disinfection System	55GATE00602.gate	UV Channel 2 Motorized Outlet Gate	12/30/2012	3	4	5
3W Pumping System	55PUMP00101.pump	3W Pump 1	12/30/2012	4	3	2
3W Pumping System	55PUMP00101.mtr	3W Pump 1 Motor	12/30/2012	3	3	2
3W Pumping System	55PUMP00102.pump	3W Pump 2	12/30/2012	3	3	2
3W Pumping System	55PUMP01003.pmp	3W Pump 3	12/30/2012	3	3	2
3W Pumping System	55PUMP01003.mtr	3W Pump 3 Motor	12/30/2012	3	3	2
3W Pumping System	55STRN01701.strn	Motorized Strainer	12/30/2012	3	4	1
3W Pumping System	55_LCP01701.Inst	3W Automatic Strainer	12/30/2012	3	4	1
Interchange Reactor System	60MIXR00101.mxr	Interchange Bioreactor 1 Mixer 1	12/30/2012	3	3	1
Interchange Reactor System	60MIXR00102.mxr	Interchange Bioreactor 1 Mixer 2	12/30/2012	3	3	1
Interchange Reactor System	60MIXR00201.mxr	Interchange Bioreactor 2 Mixer 1	12/30/2012	3	3	1
Interchange Reactor System	60MIXR00202.mxr	Interchange Bioreactor 2 Mixer 2	12/30/2012	3	3	1
Gravity Belt Thickening	60-GBT-001-GBT	Gravity Belt Thickener	12/30/2012	3	3	4
Gravity Belt Thickening	60-GBT-001-BPM	GRAVITY BELT THICKENER BOOSTER PUMP	12/30/2012	3	3	4
Thickened WAS Pumping	60-TWAS-001-PMP	Thickened Waste Activated Sludge Pump 1 (east)	11/1/2000	4	3	4
Thickened WAS Pumping	60-TWAS-002-PMP	Thickened Waste Activated Sludge Pump 2 (west)	11/1/2000	4	3	4
Gravity Thickener Pumping	60-BFP-001-GDR	MUFFIN MONSTER	11/1/2000	4	3	4
Solids Odor Control	60-ORT-001-TWR	Solids Handling Bldg Odor Reduction Tower	12/30/2012	4	3	4
Belt Filter Press System	60-BFP-001-BFP	Belt Filter Press	11/1/2000	3	3	4
Belt Filter Press System	60-BFP-001-CON	Shaftless Screw Conveyor	11/1/2000	4	3	4
Polymer System	60-GBT-001-PU	GBT POLYMER UNIT	12/30/2012	4	3	3
Solids Odor Control	60-ORT-001-FAN	Odor Reduction Foul Air Fan	12/30/2012	4	3	4
Polymer System	60-BFP-001-PU	BFP POLYMER UNIT	11/1/2000	4	4	1
Solids Odor Control	60-ORT-003-PMP	Solids Handling Bldg Odor Control Recirc Pump	12/30/2012	4	3	4
Digester Sludge Pumping	65-DSP-001-PMP	Digester Sludge Pump 1	12/30/2012	3	3	4
Digester Sludge Pumping	65-DSP-002-PMP	Digester Sludge Pump 2	12/30/2012	3	3	4
Digester Pumping	65PUMP00101.pmp	Digester Mix Pump 1	12/30/2012	3	3	4
Digester Pumping	65PUMP00102.pmp	Digester Mix Pump 1	12/30/2012	3	3	4

Appendix B WWTP Historical Performance

B

Brown AND Caldwell

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Technical Memorandum

Prepared for: Oak Lodge Water Services

Project Title: Wastewater Master Plan

Project No.: 156789.061/2

Technical Memorandum

Subject: Wastewater Treatment Plant (WWTP) Historical Performance

Date: January 13, 2023

To: Brad Albert, P.E., District Engineer, Oak Lodge Water Services (OLWS)
Sarah Jo Chaplen, General Manager, OLWS

From: Art Molseed, P.E., WWTP Lead, Brown and Caldwell

Copy to: David Hawkins, Plant Superintendent, OLWS
Scott Duren, P.E., Project Manager, Water Systems Consulting

Prepared by: ______________________
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Reviewed by: ______________________
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EXPIRES: DECEMBER 31, 2024

* Professionally licensed in the State of Washington.

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AAF	annual average flow
ADWF	average dry weather flow
AWWF	average wet weather flow
BOD	biochemical oxygen demand
BC	Brown and Caldwell
BFP	belt filter press
CBOD	carbonaceous biochemical oxygen demand
DEQ	Oregon Department of Environmental Quality
GBT	gravity belt thickener
hp	horsepower
MMDWF	maximum month dry weather flow
MMWWF	maximum month wet weather flow
MMF	maximum month flow
mgd	million gallons per day
mg/L	milligrams per Liter
m/L	milliliters
mL/g	milliliters per gram
MLSS	mixed liquor suspended solids
NPDES	National Pollutant Discharge Elimination System
OLWS	Oak Lodge Water Services
ppd	pounds per day
psi	pounds per square inch
psig	pounds per square inch gage
SCADA	Supervisory Control and Data Acquisition
scfm	standard cubic feet per minute
SRT	solids retention time
SVI	sludge volume index
TSS	total suspended solids
WWTP	water reclamation facility

Section 1: Introduction

This Technical Memorandum (TM) provides an overview of the Oak Lodge Water Services (OLWS) Wastewater Treatment Plant (WWTP) including current permit limits, design data for existing facilities, descriptions of major unit processes, current flow, loadings, and wastewater characteristics. The document also summarizes a review of plant performance data. This analysis was prepared as part of the OLWS Wastewater Master Plan work to satisfy the Oregon Department of Environmental Quality's (DEQ) requirements for an evaluation of WWTP performance.

Section 2: WWTP Description

OLWS owns and operates an activated sludge WWTP that serves approximately 30,000 customers within the service area. The influent is primarily domestic wastewater and treated effluent is discharged into the Willamette River. All flow enters the WWTP through the Influent Pump Station. Figure 1 provides an aerial photo of the OLWS WWTP and the surrounding area.

Figure 1. OLWS WWTP aerial photo

The WWTP was originally constructed in 1960 with a capacity of 1.5 million gallons per day (mgd) on an annual average flow (AAF) basis. At that time, treatment processes at the WWTP included primary clarification, activated sludge secondary treatment, and anaerobic digestion. Since then, the plant has undergone a comprehensive range of upgrades and improvements, which are summarized in Table 1.

Table 1. Summary of Oak Lodge WWTP Upgrades and Improvements

Year	Type of Upgrade/Improvement
1960	Original construction–AAF capacity of 1.5 mgd
1970 and 1973	Treatment capacity expanded to 2.0 and 4.0 mgd, respectively
1986	Influent screening and fine bubble aeration processes added
1995 - 1996	• Original secondary clarifiers replaced • Return activated sludge pumping added • Waste activated sludge pumping added
1999	New outfall and diffuser brought online
2002 [a]	• Dissolved air flotation thickener replaced with a gravity belt thickener (GBT) • Belt filter press (BFP) for dewatering installed
2005	New blowers and air piping installed
2008	Influent screens replaced
2012 [b]	AAF capacity increased to 4.3 mgd (peak wet weather capacity of 18 mgd)

a. Solids handling facility improvements.

b. Phase 1A and 1B improvements projects.

A separate report, the *WWTP Description and Condition Assessment TM*, prepared by Brown and Caldwell (BC), provides a more detailed description of the existing facilities.

Figure 2 illustrates the overall process flow schematic of the facility for liquid and solid stream treatment.

2.1 Plant Design Criteria

Design flows and loadings, as well as design data for the major unit processes, are listed in Table 2.

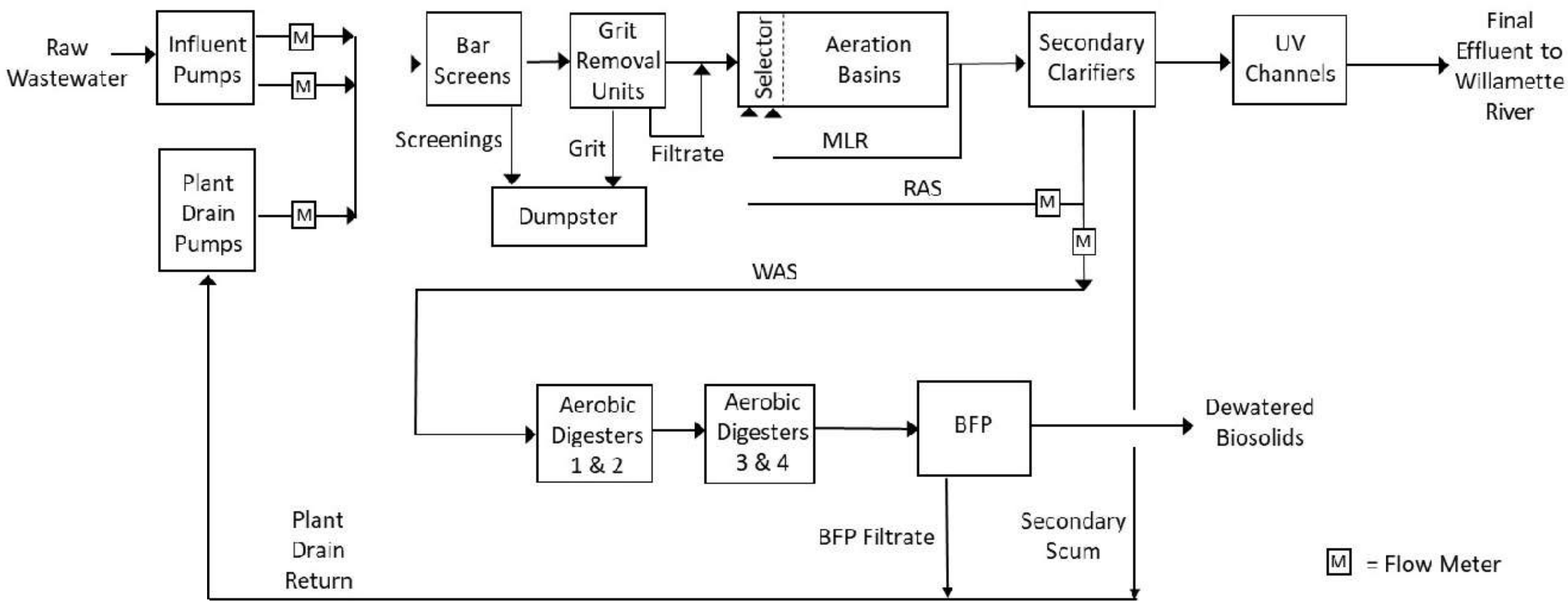

Figure 2. WWTP wastewater treatment process schematic

(Note: Existing gravity belt thickener [not shown in the schematic] could be used in the future to thicken WAS prior to digestion)

Table 2. Major Equipment Design Data		
Process Element	**Number of Units**	**Design Value**
Plant flow, mgd	–	
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 [a]		18
Biochemical oxygen demand (BOD) 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 (TSS) 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
Influent mechanical screens	2	
Type		Multi-rake
Screen opening, in.		0.25
Hydraulic capacity, mgd, each		11.75
Manual bar screen	1	
Bar spacing, in.		0.5
Hydraulic capacity, mgd		11.75
Grit removal tanks	2	
Type		Eutek Head-Cell
Hydraulic capacity, mgd, each		11.75
Aeration basins	4	

Table 2. Major Equipment Design Data		
Process Element	Number of Units	Design Value
Total length, ft		109
Total width, ft		35
Sidewater depth, ft		20
Liquid volume each, gallons		571,000
Aeration blowers		
Units	4 (3 duty, 1 stand-by)	
Type		High speed turbo (3), Hybrid Screw (1)
Max capacity (total), standard cubic feet per minute @ pounds per square inch gage (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	4	
Diameter, ft		70
Sidewater depth, ft		18
Peak-hour surface overflow rate, gallons per day, 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[b]	2	
Dimensions, length x width, ft, each		40 x 80
Sidewater, ft		18
Volume, each, gallons		431,000
Aerobic digesters, circular	2	
Diameter, ft		35
Sidewater, ft		1 @ 25, 1 @ 25
Volume, each, gallons		1 @ 185,400, 1 @ 189,000
BFP	1	
Hydraulic capacity, gallons per minute		120
Solids loading capacity, pounds per hour		500

a. Hydraulic carrying capacity of all process areas is designed to pass a peak instantaneous flow of 20 mgd to avoid overtopping wall, flooding of weirs, etc.

b. Formerly the Interchange Bioreactors.

2.2 Permit Requirements

The OLWS WWTP is currently rated by its National Pollutant Discharge Elimination System (NPDES) permit for a maximum month dry weather flow of 5.9 mgd and maximum month wet weather flow of 10.5 mgd. Table 3 summarizes the current NPDES limits regarding effluent concentrations and loadings for dry and wet weather periods. Compared with the previous permit, the monthly and weekly concentration and loading limits during the dry weather period (May 1 to October 31) have decreased. The monthly and weekly CBOD concentration limits have decreased from 15 and 25 mg/L in the old permit to 10 and 15 mg/L in the new permit, respectively. The monthly and weekly TSS concentration limits have decreased from 20 and 30 mg/L in the old permit to 10 and 15 mg/L in the new permit, respectively.

Table 3. NPDES Permit Requirements					
Parameter	Average Effluent Concentrations		Monthly Average, ppd [a, b]	Weekly Average, ppd [a, b]	Daily Maximum, pounds
	Monthly	Weekly			
May 1–October 31					
CBOD (5-day)	10 mg/L	15 mg/L	490	740	980
TSS	10 mg/L	15 mg/L	490	740	980
November 1–April					
BOD (5-day)	30 mg/L	45 mg/L	2,600	3,900	5,200
TSS	30 mg/L	45 mg/L	2,600	3,900	5,200
Year-round					
E. coli [b]	126/100 mL	406/100 mL (single sample)	-	-	-
pH	Instantaneous limit between a daily minimum of 6.0 and a daily maximum of 9.0		-	-	-

Source: Adapted from NPDES permit effective May 1, 2022

a. Summer average monthly and average weekly mass emission rates based on maximum month dry weather design flow of 5.9 mgd.

b. Winter average monthly and average weekly mass emission rates based on maximum month wet weather design flow of 10.5 mgd.

c. Limits for E. coli are monthly geometric mean and single sample maximum.

Abbreviations:

CBOD = carbonaceous biochemical oxygen demand

mg/L = milligrams per Liter

mL = milliliters

2.3 Historical Data Analysis

Plant data from 2016 to 2021 were reviewed 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 sections provide a discussion of these data.

2.4 Plant Influent

The plant influent data for the 6-year period from 2016 to 2021 are summarized in Table 4. Figure 3 shows the monthly average and peak day plant influent flows, and Figures 4 and 5 show the monthly average and maximum day loadings for BOD and TSS, respectively. The current design influent flows and loadings are also shown on these figures.

In both Table 4 and Figure 3, the influent flow data from 2019 to 2021 are based on measurements recorded by the influent flow meter. There are large gaps in the earlier influent flow records. Therefore, for data prior to 2019 (and for periods after 2019 when the influent flow data are not available), influent flows were estimated from measured effluent flows using an effluent flow to influent flow ratio calculated from the 2019 to 2021 data.

Table 4. Raw Wastewater Flows and Loadings, 2016–21							
Parameter	2016	2017	2018	2019	2020	2021	Average
AAF, mgd	3.6	4.0	3.4	2.9	2.9	3.3	3.4
Average dry weather flow (ADWF), mgd	2.4	2.5	2.2	2.3	2.2	2.1	2.3
Average wet weather flow (AWWF), mgd	4.8	5.4	4.6	3.5	3.6	3.9	4.3
Max month dry weather flow (MMDWF), mgd	4.0	3.4	2.7	2.7	2.7	2.5	3.0
Max month wet weather flow (MMWWF), mgd	6.1	7.9	6.7	4.5	5.2	6.1	6.1
Max day flow, mgd	13.2	14.5	11.5	8.2	9.8	13.2	11.7
Minimum day flow, mgd	1.8	2.0	1.7	1.7	1.8	1.7	1.8
Peaking factors							
Average dry weather flow/AAF	0.67	0.64	0.64	0.78	0.76	0.62	0.69
MMWWF/AAF	1.68	1.98	1.98	1.58	1.78	1.84	1.80
Minimum day/AAF	0.49	0.49	0.51	0.60	0.62	0.51	0.54
Max day/MMWWF	2.17	1.84	1.72	1.81	1.88	2.17	1.93
Annual average BOD loading, ppd	4,240	4,010	4,890	4,920	4,760	5,200	4,670
Max month BOD loading, ppd	4,870	4,820	7,990	5,880	5,440	6,820	5,970
Peak day BOD loading, ppd	10,160	5,540	11,720	15,690	11,130	15,870	11,690
Peaking factors							
Max month/annual average	1.15	1.20	1.63	1.20	1.14	1.31	1.27
Peak day/max month	2.09	1.15	1.47	2.67	2.04	2.33	1.96
Annual average TSS loading, ppd	4,080	3,960	4,860	4,700	4,590	4,960	4,530
Max month TSS loading, ppd	4,890	5,110	7,970	6,030	5,830	6,840	6,110
Peak day TSS loading, ppd	11,680	10,250	12,420	16,530	8,940	13,910	12,290
Peaking factors							
Max month/annual average	1.20	1.29	1.64	1.28	1.27	1.38	1.34
Peak day/max month	2.39	2.01	1.56	2.74	1.53	2.04	2.04

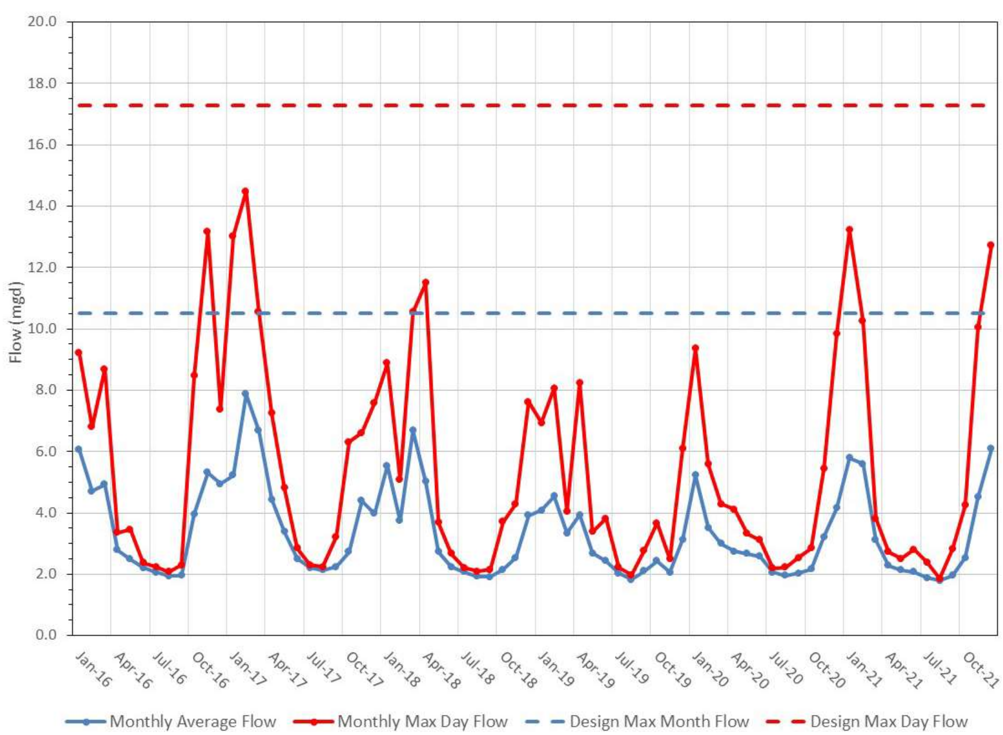

Figure 3. Monthly average and monthly max day influent flows, 2016–21

On Figures 4 and 5, the fluctuating lines for the design loadings represent the different design loadings for dry (May to October) and wet (November to April) weather periods. Influent flow data from 2019 to 2021 were obtained from Supervisory Control and Data Acquisition (SCADA) downloads, while effluent flow data for the 6-year period are available in monthly discharge monitoring reports. Therefore, influent flows and loads for 2019 and 2021 listed in Table 4 and shown on Figures 3 to 5 are based on the measured influent flows. Flows and loads prior to 2019 (and for a short period around December 2019/January 2020 when influent flow data are not available in the SCADA downloads) were based on measured effluent flows, adjusted using a ratio of 0.98 calculated from the measured effluent and influent flows from 2019 to 2021.

Inspection of the flow data from 2016 to 2021 indicates that the average plant flows have generally remained relatively steady over the 6-year period. The monthly average flow fluctuates widely between dry and wet weather periods, with peak day flows often significantly higher than the monthly average flows during wet weather periods. The highest peak day flow occurred in February 2017. Both monthly average and peak day flows remain below the corresponding design flows. The average MMF to AAF ratio (1.80) is lower than that calculated from the design flows (2.44), while the average peak day flow to MMF ratio (1.93) is higher than that calculated from the design flows (1.65).

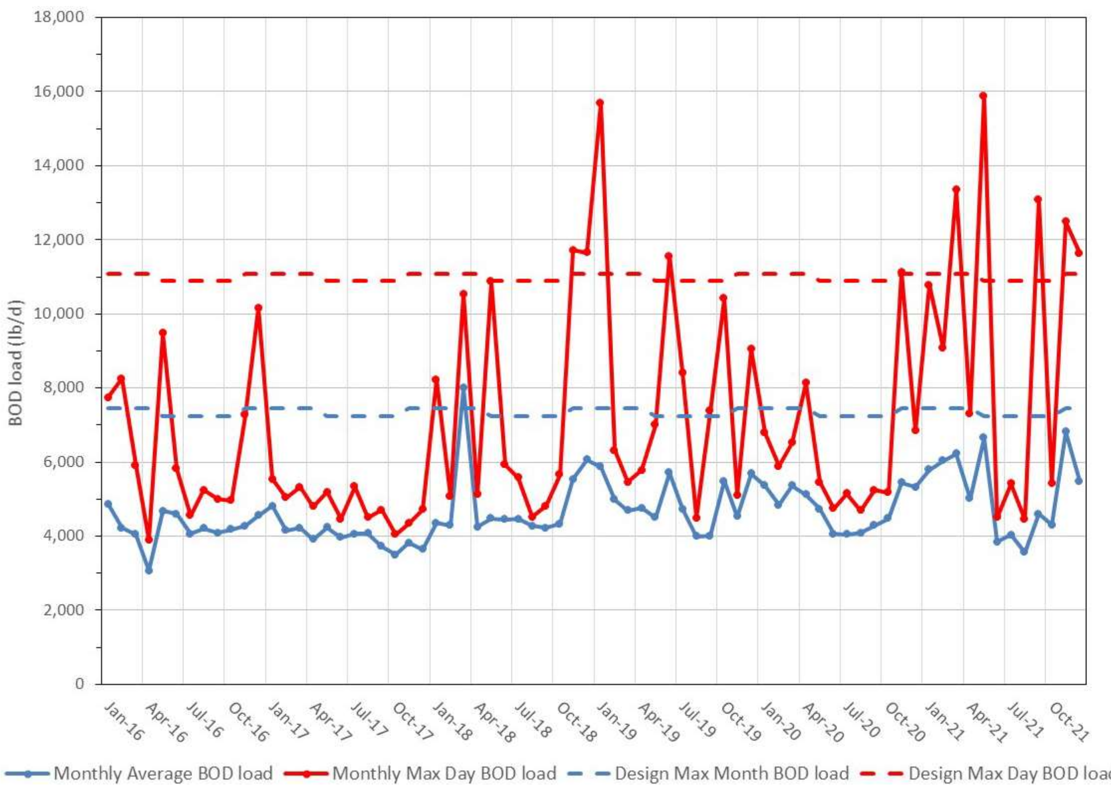

Figure 4. Monthly average and monthly peak day influent BOD loadings, 2016–21

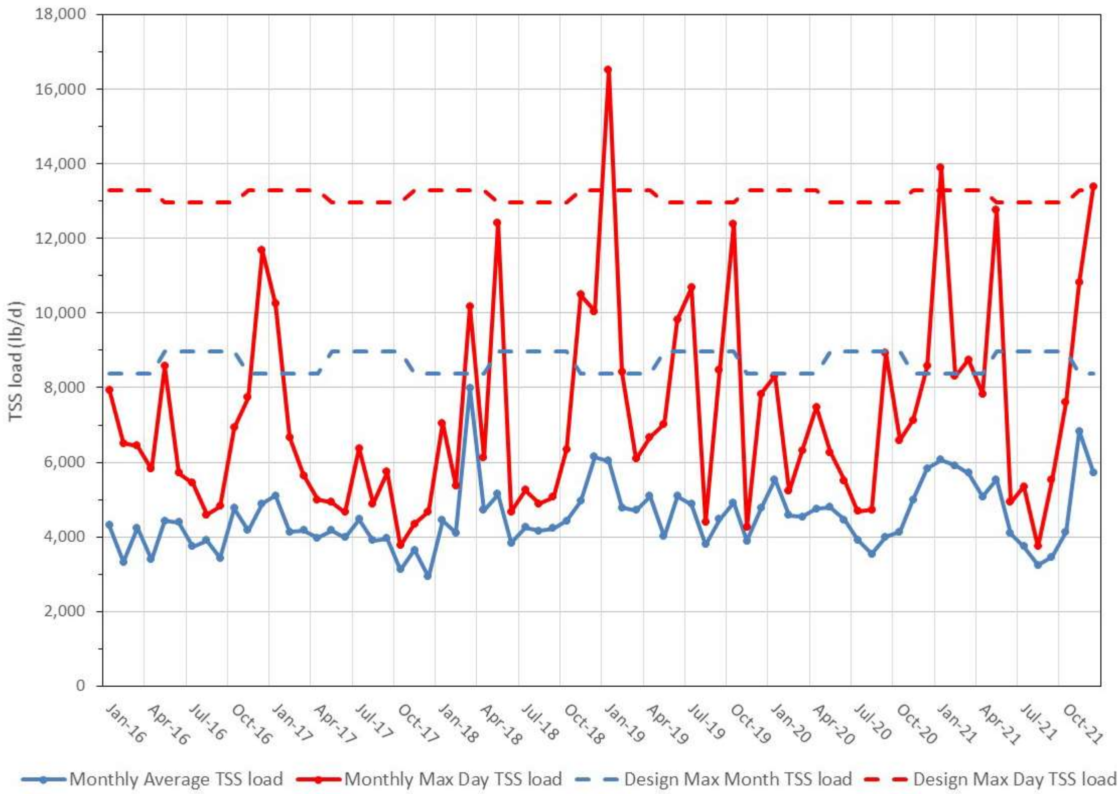

Figure 5. Monthly average and monthly peak day influent TSS loadings, 2016–21

Average BOD loadings show a slight upward trend over the 6-year period. The loadings are generally higher during the wet weather period, with maximum monthly average loads typically occurring in the winter or spring. The data show significant spikes in BOD loadings during a number of months. The monthly average BOD load exceeded the design value in March 2018 and approached it in May and November 2021. Maximum day BOD loads exceeded or approached the corresponding design values several times, particularly between November 2020 and December 2021. Both the average maximum month to annual average (1.27) and maximum day to maximum month (1.96) BOD loading ratios are higher than the corresponding ratios calculated from the design loadings (1.11 and 1.49, respectively).

Average TSS loadings similarly show a slight upward trend over the 6-year period. The loadings are typically higher during the wet weather periods, with maximum monthly average loads occurring in the winter or spring. The data also show significant spikes in TSS loadings during a number of months. While the monthly average TSS loadings remain below the design value, with the average loading in March 2018 close to it, the maximum day TSS loads exceeded the design value in January 2019, January 2021, and December 2021.

Similar to BOD, both the average maximum month to annual average (1.34) and maximum day to maximum month (2.04) TSS loading ratios are higher than the corresponding ratios calculated from the design loadings (1.20 and 1.48, respectively).

Influent wastewater characteristics during the 2016 to 2021 period are summarized in Table 5. 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.

Table 5. Raw Wastewater Concentrations, 2016–21							
Parameter	2016	2017	2018	2019	2020	2021	Average
BOD concentrations, mg/L							
Annual average	171	150	203	227	213	226	198
During MMF	99	78	147	133	134	114	118
During maximum month load	99	130	147	189	229	381	196
TSS concentrations, mg/L							
Annual average	163	149	201	211	202	206	189
During MMF	85	80	149	123	132	116	114
During maximum month load	116	140	149	191	187	123	151

2.5 Activated Sludge

Historical data available for the activated sludge system at the Oak Lodge WWTP include the solids retention time (SRT), mixed liquor suspended solids (MLSS) concentrations, and sludge volume index (SVI). These data are shown on Figures 6 through 8. As shown on Figure 6, the MLSS concentration fluctuated widely between approximately 1,500 and 6,000 mg/L. The extent of the fluctuations was reduced in 2021, with an average MLSS of 3,800 mg/L in 2021.

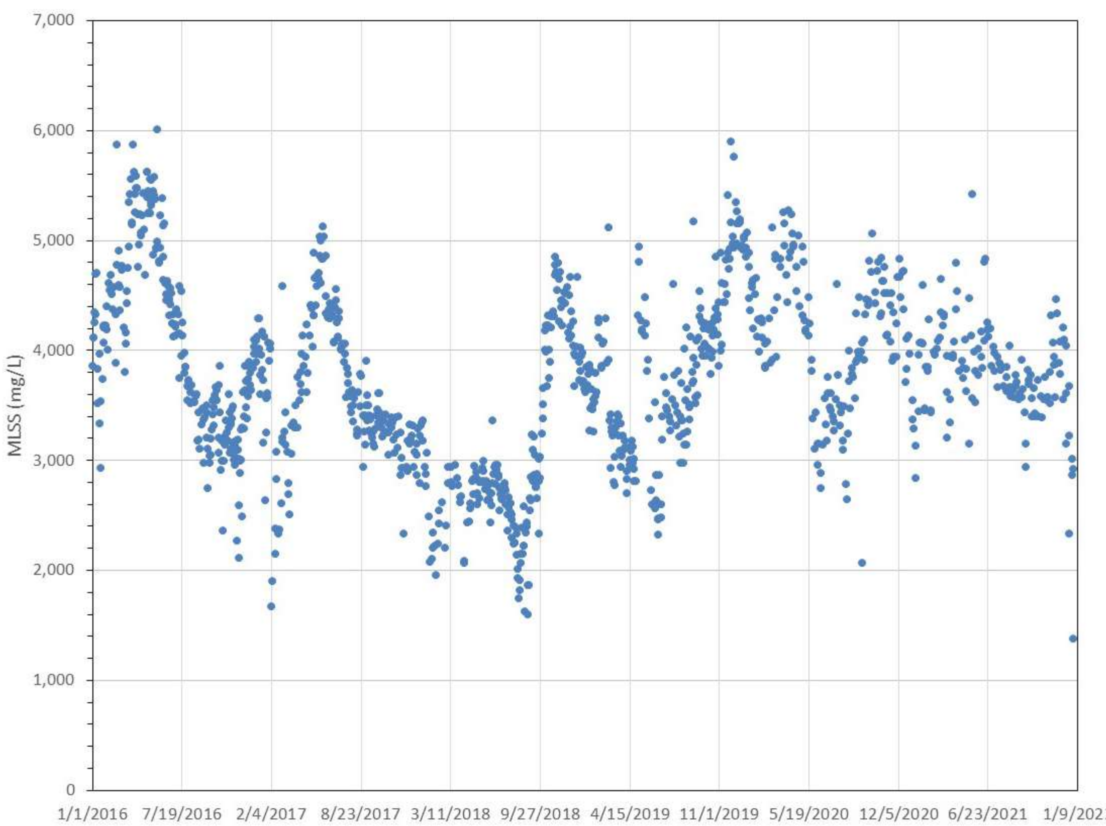

Figure 6. Historical trend in MLSS concentration, 2016-21

The calculated SRT data show a decreasing trend from over 20 days in 2017 to about 5 to 15 days in 2021. The decreasing SRT has not been observed in conjunction with decreasing MLSS concentration. MLSS concentration has not decreased noticeably during the same period. However, MLSS concentration is also affected by other factors, including influent loadings and number of basins in service.

The SVI measurement can be used as an indicator of sludge settleability and a surrogate for determining the secondary clarifier capacity. The historical SVI data for the OLWS WWTP show large variations in SVI during the period from 2016 to 2021. There was a noticeable decrease in the summer of 2019 and the SVI remained below 150 milliliters per gram (mL/g) until around October 2020. Since then, the SVI has increased up to around 250 mL/g and decreased again to below 150 mL/g toward the end of 2021.

No seasonal trends can be observed from the SVI data. The plant has often experienced excessive foaming at the aeration basins, but it is usually less severe in the winter when higher flows help move foam downstream. *Nocardia*, a foam causing microorganism which may cause high SVIs, has been identified previously in a microbiological assessment. The low effluent CBOD, BOD, and TSS concentrations (shown in Figures 9 and 10) even during periods of high SVI suggests that there is adequate secondary clarifier capacity to accommodate any deterioration in sludge settling characteristics.

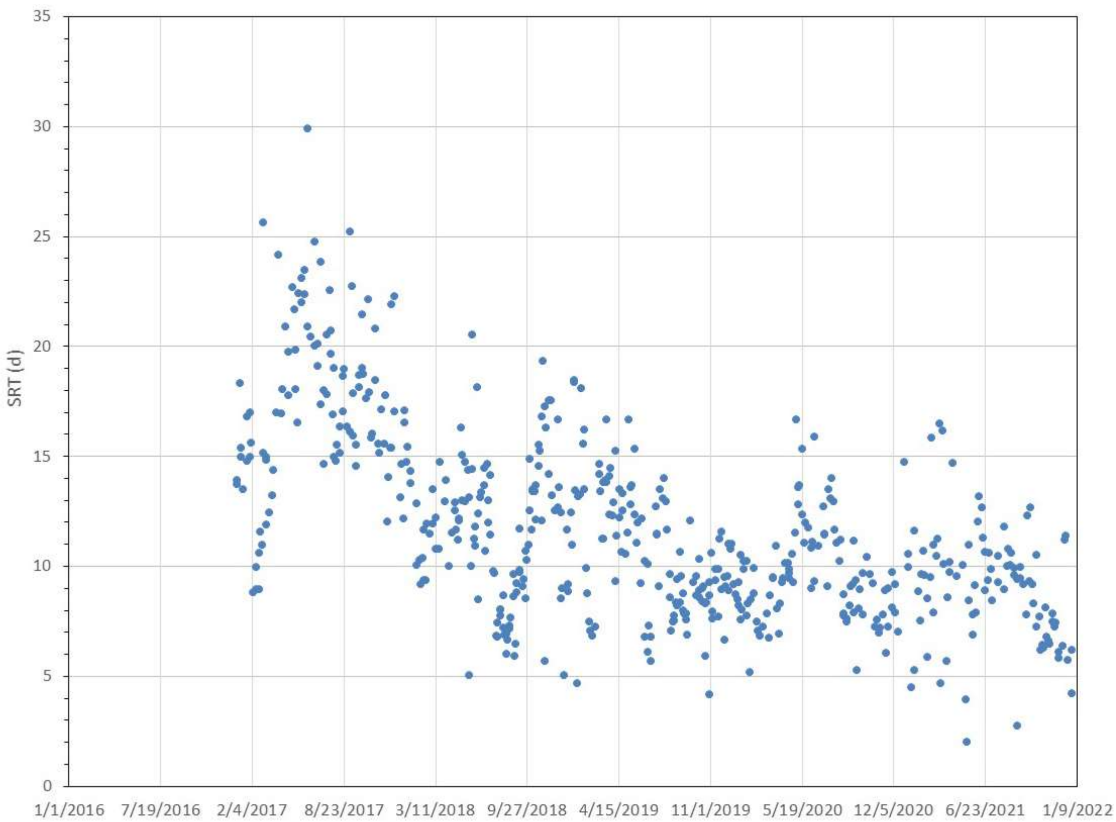

Figure 7. Historical trend in SRT, 2016-21

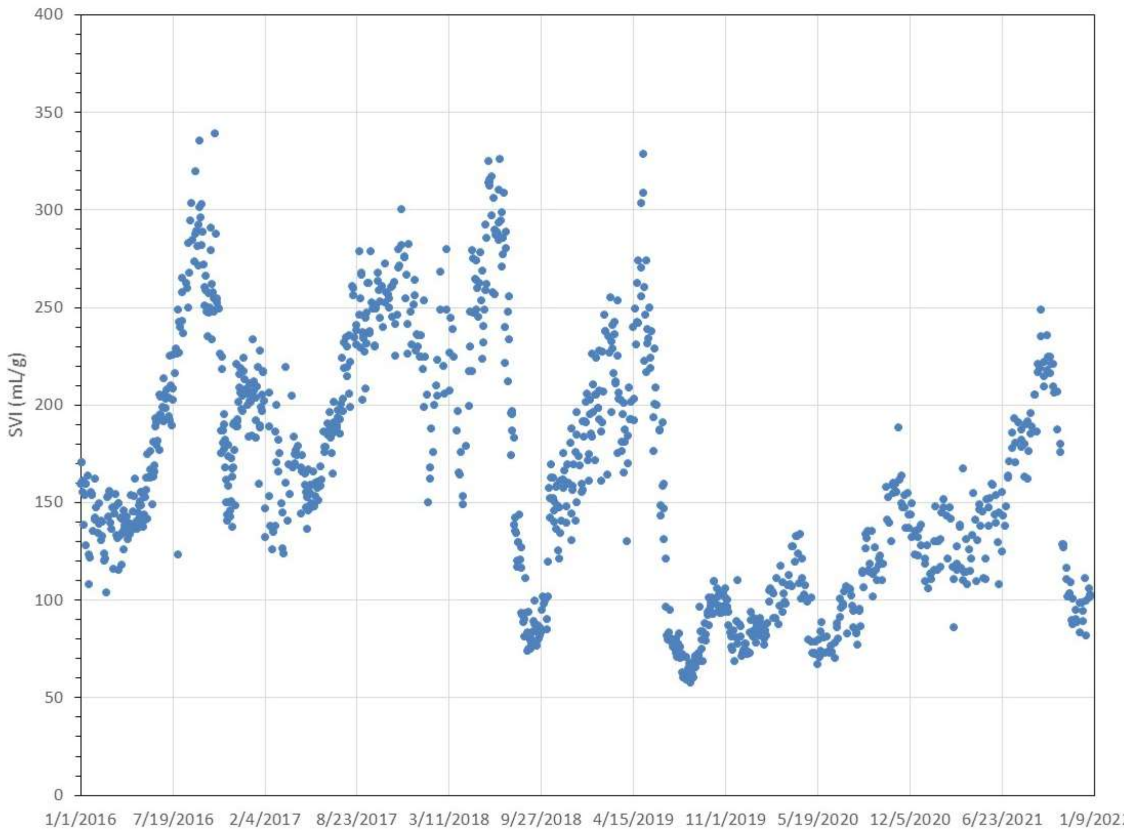

Figure 8. Historical trend in SVI, 2016-21

2.6 Plant Effluent

Plant effluent monthly average CBOD and BOD concentrations from 2016 to 2021 and the permit limits are plotted on Figure 9. The permit includes CBOD limits during dry weather periods and BOD limits during wet weather periods. Figure 10 shows the effluent monthly average TSS concentrations, along with the dry and wet weather limits. The permit limits shown on Figures 9 and 10 correspond to the limits in the old permit as the current permit became effective in 2022. The plant has consistently produced very good effluent quality during the 6-year period, with monthly average concentrations for CBOD, BOD, and TSS typically below 15 mg/L.

However, the plant effluent monthly average TSS concentration in January 2021 exceeded the permit limit, at 43 mg/L. The corresponding BOD concentration was also high at 22 mg/L. The plant experienced very high flows of above 10 mgd (daily average) for 2 days of the month, which might have led to the deterioration in plant performance and the high effluent concentrations.

As mentioned in Section 2.2, the dry weather monthly and weekly average CBOD and TSS limits have decreased since DEQ renewed the NPDES permit for the WWTP in 2022. Comparing the current limits with the data shown on Figures 9 and 10 indicates that the plant could meet the current CBOD limit but may not reliably meet the current TSS limit based on the current plant operation.

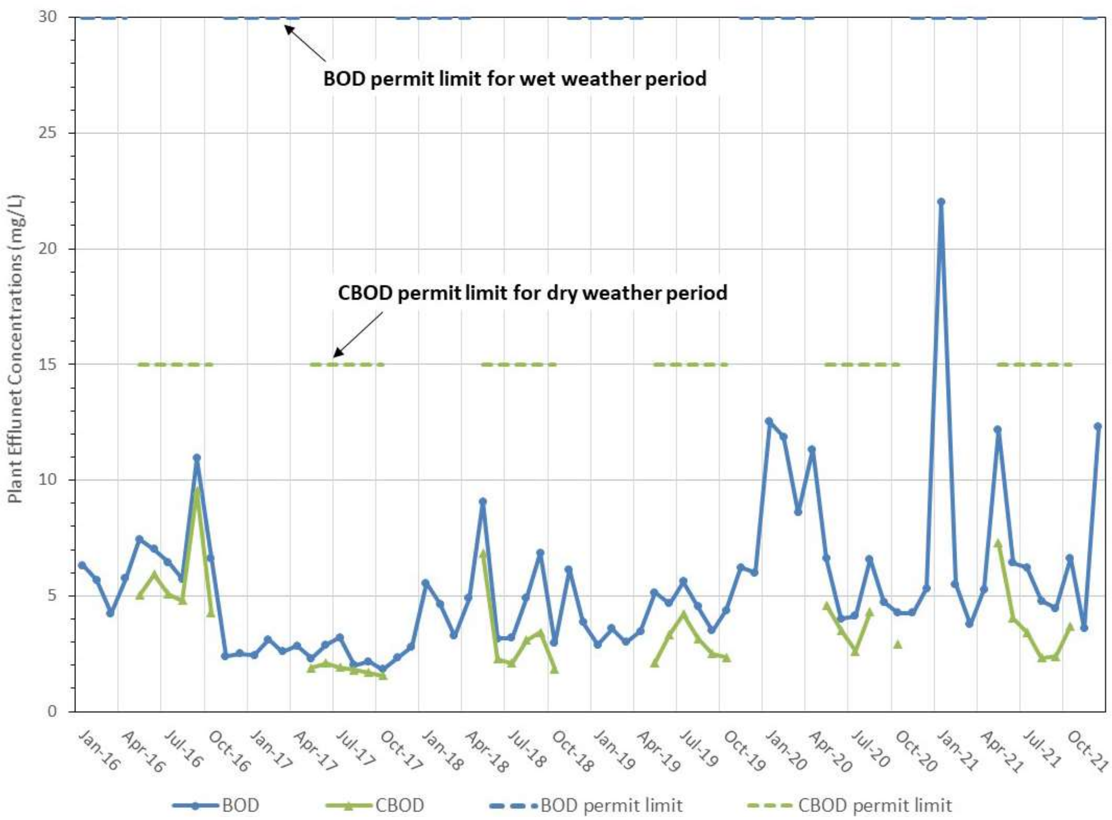

Figure 9. Monthly average effluent CBOD and BOD concentrations, 2016-21

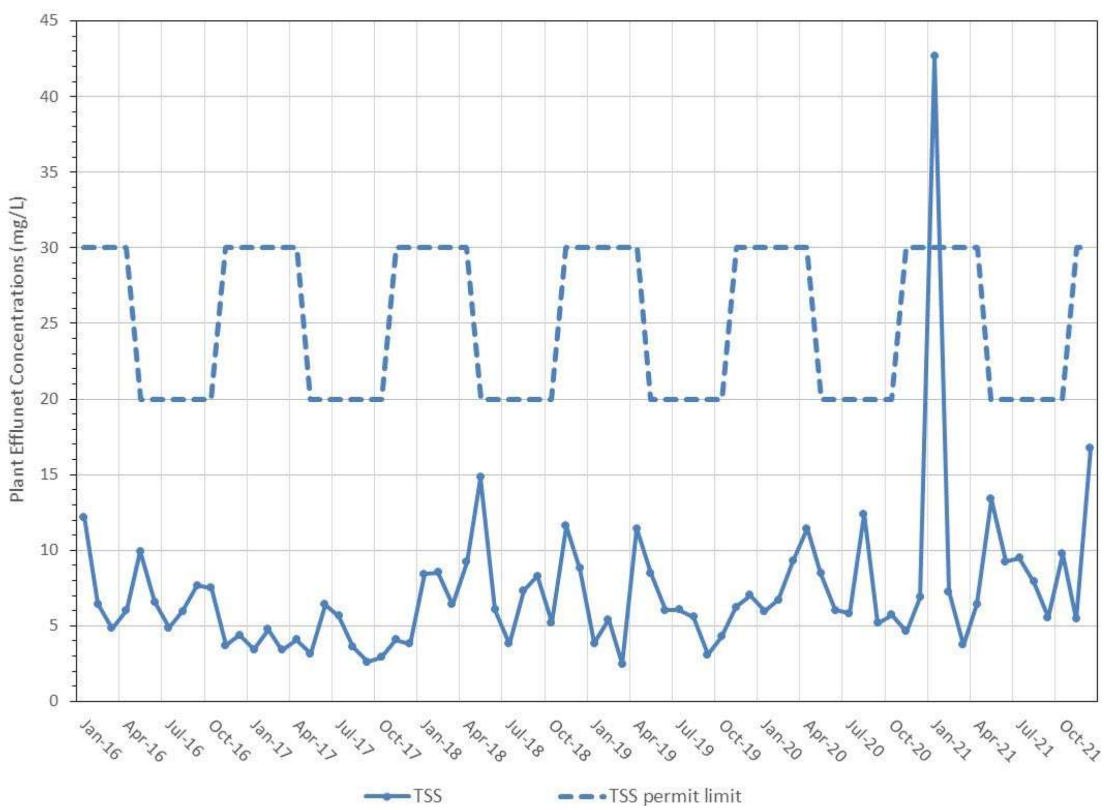

Figure 10. Monthly average effluent TSS concentrations, 2016-21

While the current NPDES permit does not include any ammonia limits, the plant monitors effluent ammonia concentration about three times a week. Figure 11 shows the monthly average ammonia concentration from 2016 to 2021. The data show monthly average effluent ammonia concentrations mostly below 8 mg/L, except in June 2021, when the monthly average concentration increased to 16 mg/L. These data indicate that the plant has been partially or fully nitrifying. With a portion of the aeration basins operated as an anoxic zone, the system also provides denitrification. However, because effluent nitrite and nitrate have not been regularly monitored, the extent of denitrification cannot be examined. The current NPDES permit requires that effluent oxidized nitrogen (nitrite- plus nitrate-nitrogen) be measured in quarterly grab samples. That will provide some data to access denitrification capability, but more frequent monitoring is recommended.

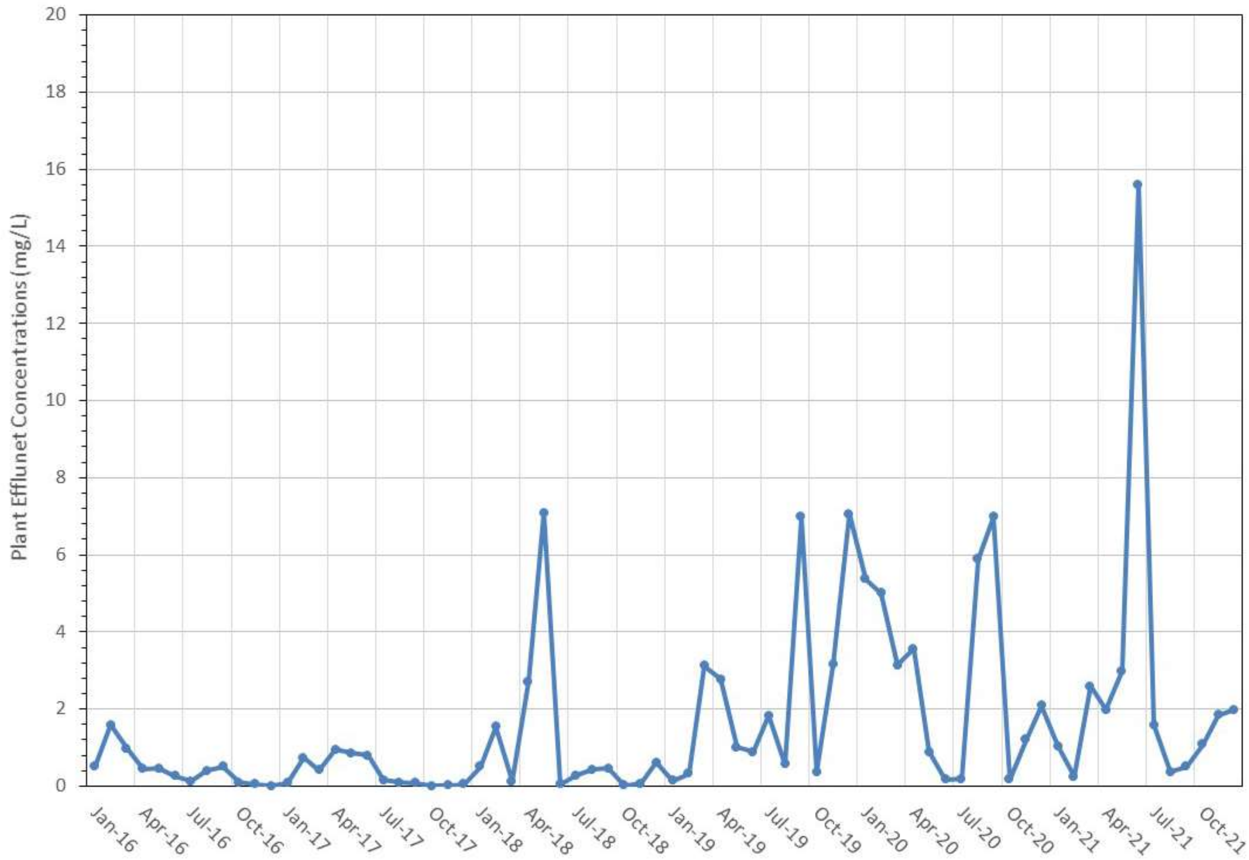

Figure 11. Monthly average effluent ammonia concentrations, 2016-21

Section 3: Observations and Conclusions

Analysis of the historical plant data from 2016 to 2021 for the Oak Lodge 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.
- Periodic episodes of elevated SVI occur but SVI has decreased since 2019 and remained below 250 mL/g. The high SVIs may be correlated with excessive foaming at the aeration basins. The good effluent quality, even during periods of high SVI, suggests that there is adequate secondary clarifier capacity to accommodate any deterioration in sludge settling characteristics.

Appendix C WWTP Operations

C

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Technical Memorandum

Prepared for: Oak Lodge Water Services

Project Title: Wastewater Master Plan

Project No.: 156789.061.001

Technical Memorandum

Subject: Existing Wastewater Treatment Plant (WWTP) Operations

Date: January 13, 2023

To: Brad Albert, P.E., District Engineer, Oak Lodge Water Services (OLWS)
Sarah Jo Chaplen, General Manager, OLWS

From: Art Molseed, P.E., WWTP Lead, Brown and Caldwell

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Limitations:

This document was prepared solely for Oak Lodge Water Services (OLWS) and Water Systems Consulting, Inc (WSC) in accordance with professional standards at the time the services were performed and in accordance with the contract between WSC and Brown and Caldwell dated May 18, 2021. This document is governed by the specific scope of work authorized by OLWS and WSC; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by OLWS and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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List of Figures

List of Abbreviations

BC	Brown and Caldwell
CFR	Code of Federal Regulations
CIP	capital improvement program
DEQ	Oregon Department of Environmental Quality
DO	dissolved oxygen
GBT	gravity belt thickener
IBR	interchange bioreactor
IR	interchange return
mg/L	milligrams per Liter
MLE	modified Ludzack-Ettinger
MLR	mixed liquor recycle
NPDES	National Pollutant Discharge Elimination System
OLWS	Oak Lodge Water Services
RAS	return activated sludge
WWMP	Wastewater Master Plan
SRT	solids retention time
SVI	sludge volume index
TM	technical memorandum
UV	ultraviolet
WAS	waste activated sludge
WWTP	wastewater treatment plant

Section 1: Introduction

In accordance with Oregon Department of Environmental Quality (DEQ) guidelines, the Oak Lodge Water Services (OLWS) Wastewater Master Plan (WWMP) includes a performance evaluation of the existing wastewater treatment plant (WWTP). This technical memorandum (TM) summarizes an evaluation of the treatment system based on a review of background documents and completion of a workshop with OLWS operations staff. The site visit and workshop are documented in minutes included as Attachment A to this TM.

Separate TMs are being prepared to describe and provide additional performance evaluations of the WWTP as listed below:

1. Historical Performance
2. Capacity Assessment
3. WWTP Description and Condition Assessment

Figure 1 provides a process flow schematic of the existing liquid and solid stream treatment systems.

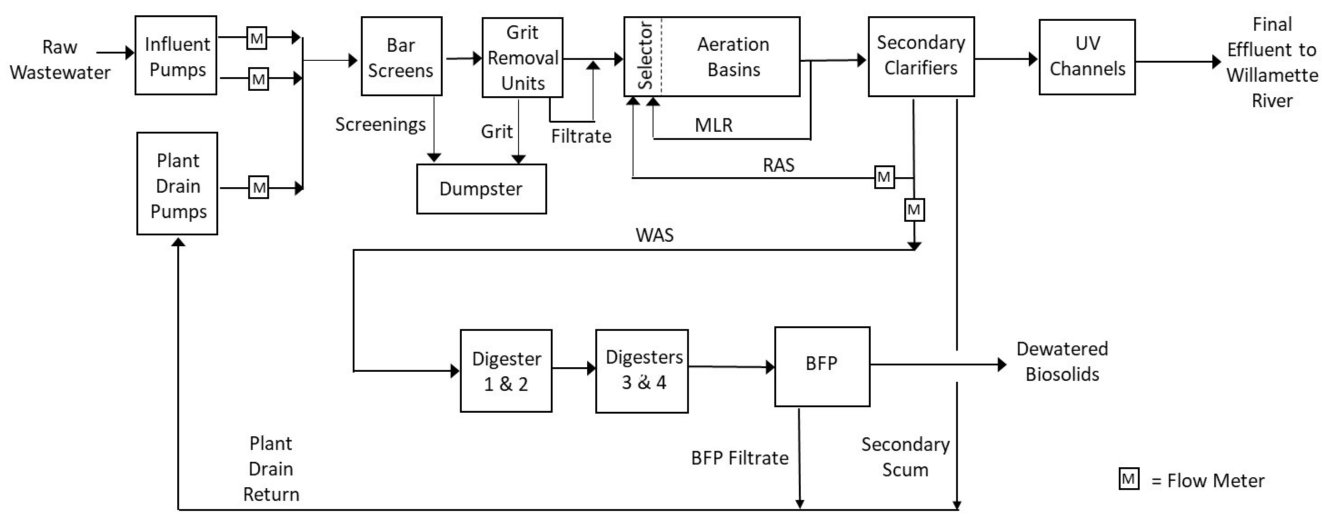


Figure 1. WWTP process schematic

Figure 2 provides an aerial view of the OLWS WWTP site and identifies major facilities.

Figure 2. Aerial view of WWTP with major facilities labeled

Section 2: Approach

This section describes the approach used to perform an operations evaluation of the OLWS WWTP that included review of background documents and a site visit and workshop with OLWS operations staff.

2.1 Review of Previous Reports and Documents

A variety of historical data and previous reports and documents were reviewed to prepare for the WWTP operations evaluation. One of these reports included the Aeration Basin Evaluation prepared by Murraysmith in 2019 to evaluate various aeration system components (basins, blowers, and aerobic digesters). The evaluation identified alternatives and made recommendations for improving operation of these systems for current and future flows and loads. Design of the recommended improvements has been completed and construction and startup performed in 2022. Some of the findings from this evaluation are incorporated into the discussion of existing WWTP operations in this TM.

The following documents, prepared as part of OLWS's ongoing coordination with DEQ in renewal of the WWTP NPDES permit, were also reviewed:

- Updated Fact Sheet Facility Description
  - In 2021, DEQ and OLWS staff worked together to prepare an updated Fact Sheet Facility Description that was incorporated into a new NPDES permit for the WWTP. Information from this updated Fact Sheet Facility Description is reflected in this evaluation of existing WWTP operations.
- Biosolids Management Plan
  - Also in 2021, OLWS staff coordinated with DEQ to prepare an updated Biosolids Management Plan that was included in the public notice for the NPDES permit renewal. Information from this updated Biosolids Management Plan is incorporated into this evaluation of existing WWTP operations.

2.2 WWTP Operator Workshop

The consultant team met virtually with OLWS staff on September 1, 2021, to conduct a workshop to discuss WWTP operations. Attachment A includes the minutes and PowerPoint slide deck from this workshop.

Section 3: Assessment of WWTP Operations

On September 1, 2021, the consultant team and OLWS staff met in a virtual Operator Workshop to collect additional information needed to perform an operations evaluation of existing facilities for future incorporation into the WWMP. The WWMP will include alternatives and project recommendations to address operational needs of the WWTP. As such, the evaluation will address DEQ requirements to consider operations as part of the master planning process.

This section summarizes information collected during the review of previous reports, historical data, and workshop discussions. This section is organized by process treatment units at the WWTP including liquid stream, solids stream, and support facilities. For process treatment unit design criteria, refer to the WWTP Description, NPDES Permit Requirements and Historical Performance TM.

3.1 Liquid Stream

The OLWS WWTP is a secondary treatment system that uses conventional activated sludge without primary treatment. The Headworks Building receives pumped flow from the Influent Pump Station and Plant Drain Pump Station. At the Headworks Building, wastewater passes through multi-rake bar screens and then flows through a Eutek Headcell degritting system. Screenings are washed and compacted, and grit is classified before both are transported off-site for disposal.

The screened and degritted wastewater then continues to flow by gravity to the activated sludge secondary treatment system. The aeration basin train includes an anoxic zone that is used to promote denitrification, with nitrification occurring in the aerobic zones. The activated sludge system is configured with the ability to operate in different modes based on operational and effluent permit goals. The secondary process was previously operated as a Cannibal process resulting from the Phase 1A expansion completed in 2012 but the Cannibal process has since been abandoned.

Aeration basin effluent flows by gravity to secondary clarifiers where settled solids can be returned to the aeration basins as return activated sludge (RAS) or pumped as waste activated sludge (WAS) to the solids treatment system. The effluent passes through an ultraviolet (UV) disinfection system before being discharged into the Willamette River. Treated effluent is also reused as 3-water (3W) as described under Section 3.3.

The following provides an operational assessment of individual process and pump systems associated with the OLWS WWTP liquid stream.

3.1.1 Influent Pump Station

All flow into the OLWS WWTP is conveyed to the Influent Pump Station that was constructed as part of Phase 1A expansion. The Influent Pump Station is a below grade structure that houses five submersible solids handling pumps. The wet well is partitioned into two sections with a manually operated gate separating the two sumps. Three pumps are placed in one wet well and the other two pumps are in the second wet well. The original KSB submersible pumps were replaced with Flygt submersible pumps. Discharge check valves and isolation valves for the influent pumps are in a valve vault. As described below, the Plant Drain Pump Station was built adjacent to the Influent Pump Station with a common wall separating the two facilities. Figure 3 shows the Influent Pump Station and Plant Drain Pump Station at grade.

Figure 3. Influent Pump Station and Plant Drain Pump Station at grade

The original submersible pumps experienced frequent plugging with rags and other debris. The replacement Flygt submersible pumps are more effective at passing rags to the screening channel at the Headworks Building. To maintain the minimum pumping capacity required by DEQ, the manually operated gate is typically kept open so that the wet well functions as a single sump. At lower dry weather flows, the wet well is oversized, and debris can collect in the corners of the rectangular wet well. As discussed at the September workshop, rounding the corners of the wet well, retrofitting the Flygt pumps with the Flygt Flush Valve, and adding an automatic actuator to the wet well separation gate may improve operability of the influent pumping system. These will be considered as projects for future upgrades as they are developed.

The lack of a built-in lifting system at the Influent Pump Station makes maintenance of the pumps more difficult. Currently, staff must bring in a mobile crane to lift the submersible pumps out of the wet well. Structural support for a lifting device such as a bridge crane and extending electric power to new equipment at the Influent Pump Station have been identified as challenges to implementing these improvements. These upgrades will be evaluated as part of alternatives development.

The Meltric plugs at the Influent Pump Station are uncovered and can become wet; the addition of covers would provide protection from moisture. OLWS has included budget in its capital improvement program (CIP) for reconstruction of the Influent Pump Station in 2025.

3.1.2 Plant Drain Pump Station

The two plant drain pumps are the submersible solids handling type located in a shallower wet well located to the east of the Influent Pump Station wet well. The original KSB pumps installed in 2012 are still used and are operated in a constant speed, fill-and-draw mode. Solids tend to settle out in the wet well when pumps are not operating. A system to stir the contents of the wet well such as the Flygt Flush Valve may help to minimize collection of solids and other debris in the plant drain pump wet well.

The plant drain wet well is connected to the plant drain inlet box. The plant drain inlet box receives flow from the plant drain manhole and drainage from the aeration basins. Discharge check valves and isolation valves for the plant drain pumps are in a valve vault. Figure 4 shows the Plant Drain Pump Station wet well taken from an open hatch at grade.

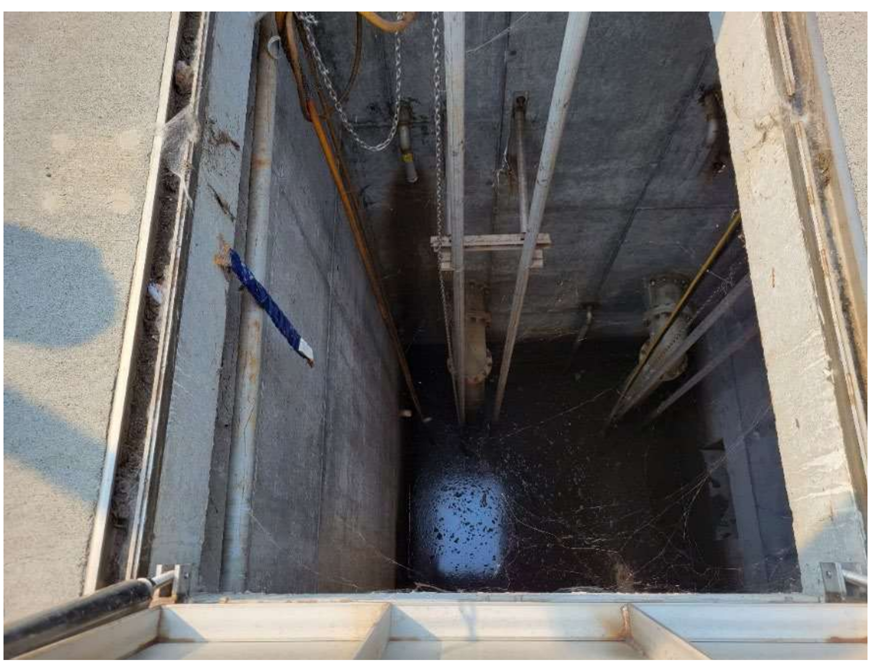


Figure 4. Plant Drain Pump Station wet well

3.1.3 Influent Channel and Sampler

Equipment associated with preliminary treatment at the OLWS WWTP is located at the Headworks Building. Figure 5 shows the Headworks Building.

Figure 5. Headworks Building

Raw sewage and plant drainage are pumped to the Headworks Building through force mains routed through the lower level of the Headworks Building as shown in Figure 6. Each force main is equipped with a magnetic flow meter to measure the raw wastewater and plant drainage. The raw sewage flow meters measure influent flow for NPDES permit reporting. The two raw sewage force mains combine into a single pipe before discharge at the Headworks Building. The influent pump force main discharges at one end of the raw sewage influent channel, and the plant drain pump force main discharges near the mid-point of that channel.

Figure 6. Influent pump and plant drain pump force mains

The upper level of the Headworks Building is not enclosed as shown in Figure 5. The raw sewage influent channel, the screens, and grit basins are covered and air is withdrawn for foul air treatment. Figure 7 shows a view of the raw sewage influent channel where the combined influent pump force main discharges into the end of the influent channel.

Figure 7. Raw sewage discharge into end of influent channel

The influent sampler collects a composite sample from this channel upstream of the discharge of the plant drain pump force main and is located as shown in Figure 8.

Figure 8. Influent composite sampler

Because debris tends to accumulate at the end of the influent channel, the strainer on the suction tubing for the influent sampler also occasionally plugs with debris, as shown by the rags in Figure 9. This photo was taken on August 11, 2021, which was the first day of the wastewater characterization sampling program implemented to help develop influent flow and loadings for the WWMP. Moving the influent sampler downstream of the screens is not an option as the screened sewage includes the plant drainage and the samples would then not be representative of plant influent.

Figure 9. Debris accumulation on influent sampler suction strainer

3.1.4 Influent Mechanical Screens and Influent Bypass Bar Screen

Raw sewage and plant drainage pass through multi-rake bar screens with ¼-inch spacing. Typically, one screen is in service and the other serves a standby. There is also a third channel fitted with a manual bar screen having ½-inch bar spacing.

As noted in the influent pump section above, installation of the Flygt submersible pumps has resulted in greater passage of rags and other debris to the influent screenings channel. This has reduced maintenance requirements of the influent pumps, but there is now a greater tendency for the rags to accumulate in the channel, and to even pass downstream of the screens and into the aeration basins where they can accumulate on the anoxic zone mixer blades and other locations. Rags reach downstream of the screens by passing through the bars and/or through gaps between the screen frame and channel. There is a rubber seal at the channel and frame opening, but it does not always provide an effective seal. OLWS has considered replacing the screens with equipment having finer spaced bars or perforated plates to minimize passage of rags. Figure 10 shows the Huber multi-rake screens.

Figure 10. Multi-rake influent screens

3.1.5 Screenings Conveyance

A sluice trough that uses 3W conveys screenings to the washer compactor. There is approximately a 30-foot drop from the screens to the washer/compactors as shown in Figure 11. The sluice system works well.

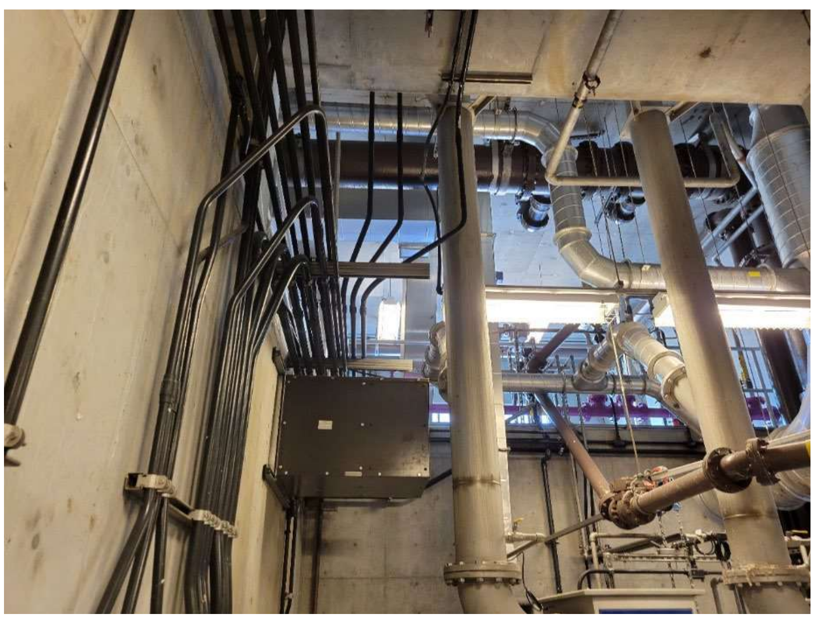


Figure 11. Screenings sluice system

When the 3W system is taken out of service for pump or other equipment maintenance, the sluice system must also be taken off-line. After an outage, there can be a slug load of debris to the compactors. Previously the compactor door would occasionally open when there was a slug load of screenings. However, WWTP staff have made modifications to address this issue as discussed in the next section.

3.1.6 Screenings Washer/Compactor

The screenings sluice discharges into the washer/compactors in the lower level of the Headworks Building shown in Figure 12. These are grinder/auger type that work well and rarely plug. WWTP staff added a baffle to prevent the door from opening when a slug load of screenings is received after an outage.

Figure 12. Screenings washer/compactors

3.1.7 Mixed Liquor Screen and Screenings Compactor

The mixed liquor screen and screenings compactor were installed as part of the Cannibal process. The mixed liquor screen is a rotary drum located on the upper level of the Headworks Building, and the mixed liquor screenings compactor is a screw press located on the lower level. A chute from the screen conveys the screenings to the press.

Although the Cannibal process was abandoned a few years ago, the mixed liquor screen and screenings compactor were used into 2020. WWTP staff found that the equipment is effective at removing depleted cellulose from mixed liquor. However, there have been stress fractures due to wear on the polyurethane guides at the compactor. Due to the difficulty of obtaining spare parts for the equipment, this system is no longer being used.

The City of Albany, Oregon, previously used a mixed liquor screening and compaction system for its Cannibal system which is also no longer in use. The compactor at Albany has a gear reducer while the unit at OLWS does not. The OLWS unit tends to trip out on high amperage draw, as well. There were some attempts to obtain the unit from Albany to replace the one at OLWS, but that never worked out. Figure 13 shows the mixed liquor screen at the upper level.

Figure 13. Mixed liquor rotary drum screen

3.1.8 Grit Removal

Screened influent flows by gravity to the Eutek Headcell grit removal system that uses stacked trays. The equipment is in the lower level of the Headworks Building and is difficult to access and maintain because of its cover. WWTP staff have been working with the manufacturer to design modifications that will improve accessibility.

3.1.9 Grit Pumps

Wemco recessed impeller pumps, also located on the lower level of the Headworks Building, are used to transfer grit to a grit washing and dewatering system. No issues with the grit pumping system were identified.

3.1.10 Grit Washing/Dewatering

A Eutek Slurry Cup and Snail located on the upper level of the Headworks Building provide grit washing and dewatering. The Cannibal system was based on maximizing transfer of biochemical oxygen demand to the aeration basins, so this system was designed to return finer solids to the liquid stream. Therefore, some grit passes through this equipment and is returned to the secondary treatment system where it collects in the aeration basins. Figure 14 shows the grit washing and dewatering equipment.

Figure 14. Grit washing and dewatering equipment

3.1.11 Aeration Basins

There are four aeration basins designed for use with the Cannibal system at a mixed liquor concentration of 15,000 to 20,000 milligrams per Liter (mg/L). Currently, the aeration system is operated as a modified Ludzack-Ettinger (MLE) process that assumes 25 percent of the basin is in an anoxic mode and the remaining 75 percent is aerobic. Two aeration basins are used during the dry weather and two or three are used during the wet weather, depending on flows and loads. Tanks 1, 2, and 3 or 2, 3, and 4 can be used in combination. Figure 15 provides a panoramic view of the aeration basin structure.

Figure 15. Aeration basin structure

3.1.12 Anoxic Zone Mixers

There are six vertical turbine-type anoxic zone mixers manufactured by Lightnin in each of the first two aeration basins. Mixers are taken off-line once per year to collect oil samples. There have been stress fractures on some of the mixers. Figure 16 shows the Aeration Basin 1 that was out of service. Rags that have passed through preliminary treatment are visible on the mixer blades.

Figure 16. Aeration Basin 1 with mixers visible

3.1.13 Aeration Diffusers

The fine bubble diffusers in the aeration basins are also visible in Figure 16. These are Sanitaire 9-inch disc type diffusers. The diffusers are from the original installation in 2012. OLWS has purchased enough new diffuser membranes for one basin and will be scheduling replacement for some of this equipment. The OLWS may only do second half of Basins 1 and 2 (as the first half would typically operate as the anoxic zone), so there would be enough diffusers for both basins.

When two aeration basins are in use, the first basin is operated with the first half without air (but with the mixers on) and the second half with constant air flow, and the second basin operated with dissolved oxygen (DO) control based on measurements by a DO probe at the U bend. When three aeration basins are in use, the first basin is half without air (and with mixing) and half constant air flow, the second basin has constant air flow, and the third basin uses DO control based on measurements by the probe at the U-bend. The DO probes in the first half of each basin are not reliable. Air cannot be balanced within each basin because there are no air flow meters and control valves on the drop legs.

As noted above, the system was designed for Cannibal process, which is no longer being used. Currently, both mixers and diffusers are used in the second half of basin 2 because the diffuser air (at a constant flow rate) alone does not provide sufficient mixing. There is risk of solids settling without adequate air.

OLWS had Michael Richards examine foam and crust that occurs on the aeration basins about 3 to 4 years ago. Three or four microorganisms including *Nocardia* were identified. Figure 17 shows an aeration basin with some foam evident at the surface. The aeration basins do not have a built-in spray system. However, as shown in Figure 17, spray hoses are used to help promote movement of the foam. Foaming is less severe in the winter when higher flows help move foam downstream.

Figure 17. Aeration basin showing use of hoses for spray water

3.1.14 Weir Gates and Hydraulics

Murraysmith prepared an aeration basin evaluation report in 2019 (Murraysmith 2019) to evaluate alternatives and make recommendations for process improvements. The report noted that there are no internal baffles or weirs within the basins that limits operational flexibility. The report adds that because of foaming and hydraulic challenges, WWTP staff have created a hydraulic drop across each train by adjusting level of the effluent weir gates. Figure 18 shows a hydraulic restriction at the weir gate. The Murraysmith report also notes restrictions at the horseshoe bends.

Figure 18. Hydraulic restriction at aeration basin weir gate

OLWS staff have added temporary baffles made of 2 x 4s to Aeration Basin 1. The temporary baffles have worked well. The OLWS is currently implementing an aeration basin improvements project that is partially funded by the Energy Trust and was constructed in 2022. The project originally included a smaller blower and baffle walls in Basins 1 and 2. However, the baffle walls were removed from the project and not installed.

A classifying selector might also help with removal of foam and could be considered as part of a future project. Consideration will need to be made where foam would be routed to (e.g., impact on aerobic digesters). Sludge volume index (SVI), which is a measure of sludge settleability, is usually less than 200 milliliters per gram. They operate at about an 8-day SRT in the winter and 11-12 days in the summer.

3.1.15 Aeration Blowers

There are three K-Turbo centrifugal blowers that serve the aeration basins. Each turbo blower with air-foil bearings has a 100 horsepower (hp) motor. A fourth blower manufactured by Aerzen was installed during the 2022 aeration upgrades project that will allow the OLWS to achieve greater energy efficiency. This blower replaced one of the K-Turbo blowers.

Blower control is currently cascade control with a DO set point of 2.0 mg/L in one basin, with the control valve for that basin adjusted and then the blower speed adjusted to maintain air header pressure. The DO set point is applied in the last aeration basin whether there are two or three aeration basins in service.

3.1.16 Mixed Liquor Recycle Pumps

Three vertical turbine, axial flow pumps recycle mixed liquor to the mixed liquor recycle (MLR)/RAS/interchange return (IR) conduit and then to the first aeration basin in service. These pumps are shown in Figure 19.

Figure 19. Internal MLR pumps

3.1.17 Screened Mixed Liquor Pumps

The two screened mixed liquor submersible pumps are not currently used because the mixed liquor screen and compactor are off-line.

3.1.18 WAS/Scum Pumps

The RAS/WAS Pump Station houses WAS and scum pumps, as well as interchange bioreactor (IBR) feed pumps. Figure 20 shows one of the two WAS pumps in the RAS/WAS Pump Station. The IBR feed pumps, shown in Figure 21, are used to pump WAS from the RAS header of Secondary Clarifiers 1 and 2 to these tanks that are now used as aerobic digesters. A WAS pump was also added to convey WAS to the gravity belt thickener (GBT). Once the programming for this new pump is completed, it will be operational, and OLWS will be able to thicken WAS prior to sending to the aerobic digesters. The new WAS pump will pull off the header from all four clarifiers rather than the RAS header that services only Secondary Clarifiers 1 and 2.

Figure 20. Older WAS pump

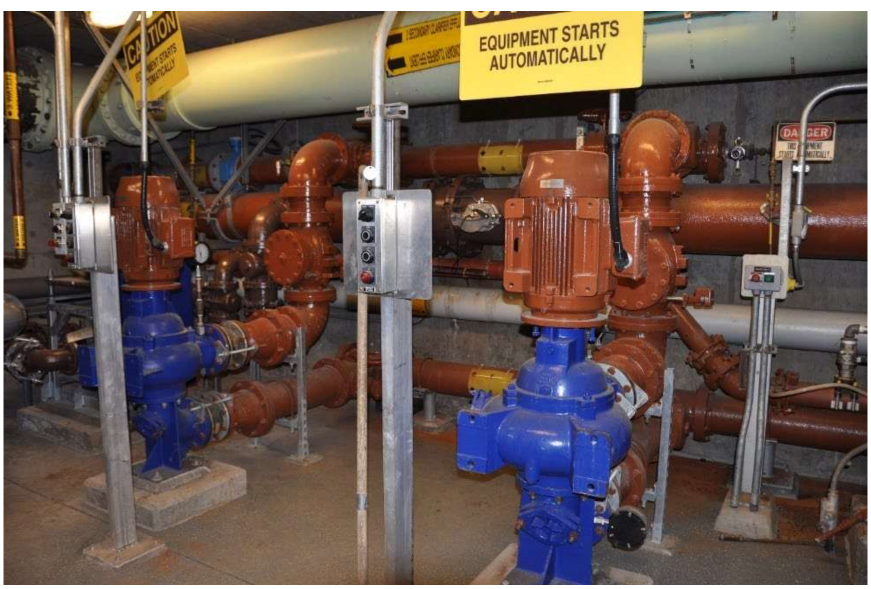


Figure 21. IBR feed pump in RAS/WAS Pump Station

3.1.19 Secondary Clarifiers

There are four secondary clarifiers. Secondary Clarifiers 1 and 2 were constructed in 1995, and Secondary Clarifiers 3 and 4 were built as part of the major upgrade in 2012. The OLWS is implementing a project to rebuild Secondary Clarifiers 1 and 2 in 2022 and 2023. The mechanisms and rotating catwalks will be replaced. Figure 22 shows one of the secondary clarifiers built in 1995, and Figure 23 shows one of the newer clarifiers.

Figure 22. Original secondary clarifier

Figure 23. Newer secondary clarifier

3.1.20 RAS Pumps

There are four RAS pumps for Secondary Clarifiers 1 and 2 in the RAS/WAS Pump Station. Two of the RAS pumps are shown in Figure 24.

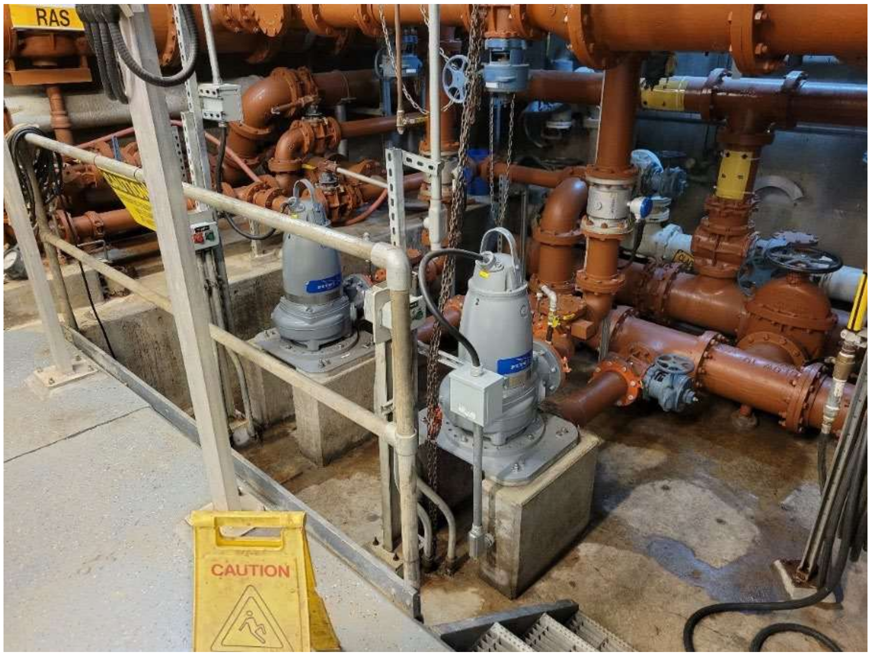


Figure 24. RAS pumps in RAS/WAS Pump Station

There are also three RAS pumps located at Secondary Clarifiers 3 and 4. One pump is dedicated to each clarifier and the third pump serves as a swing standby for both clarifiers. Figure 25 shows these RAS pumps.

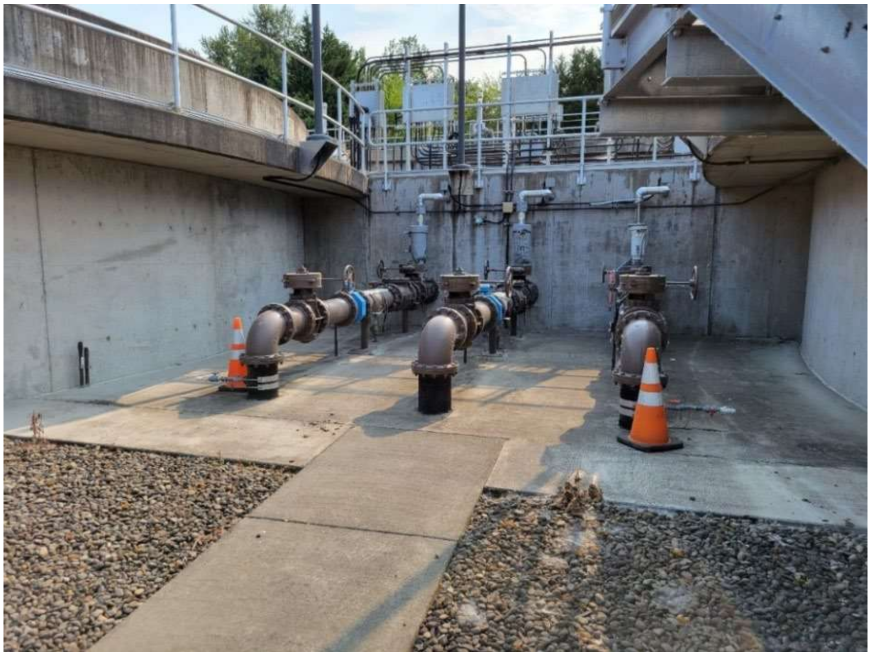


Figure 25. RAS pumps at Secondary Clarifiers 3 and 4

3.1.21 UV Disinfection

Secondary effluent flows to a Trojan UV3000 low pressure, high-intensity UV disinfection system. There are four banks with a total of 224 bulbs placed in two channels. The system was designed for a UV transmittance of 65 percent.

WWTP staff note that there are issues with both the upstream and downstream gates associated with the UV channels. The upstream gate gearboxes are located at the bottom of the channel but were apparently not designed for submerged service because they have Zerk fittings. This equipment has failed, so the gates are kept open all the time. The downstream gates do not effectively control flow through the UV system, and OLWS has been unable to modify the proprietary programming for the UV equipment. OLWS has budgeted gate modifications in its CIP for 2022 and 2023. OLWS uses an aftermarket supplier for replacement bulbs, and they have a satisfactory service life. Figures 26 shows the UV channels and equipment.

Figure 26. UV channels and equipment photo

3.1.22 Effluent Flow Measurement and Sampling

Two Doppler type Accusonic flow meters measure effluent flow in the UV channels. A composite sampler at this facility also collects effluent for NPDES reporting. Figure 27 shows the flow meter panels and the composite sampler.

Figure 27. Effluent flow meter panels and composite sampler

3.2 Solids Stream

The OLWS solids treatment train includes a GBT that has not been operated since the WWTP implemented the Cannibal system as part of the 2012 improvements project. WAS is pumped directly to the IBRs that currently function as rectangular aerobic digesters (1 and 2) in series with two circular aerobic digesters (3 and 4) constructed in 1995. Together, the aerobic digestion system produces a Class B biosolids that meets time and temperature criteria and volatile solids reduction requirements of the United States 40 CFR Part 503.

Digested sludge is pumped to a belt filter press that produces a cake having a concentration of 14 to 17 percent solids. Solids are conveyed by an auger into a dump truck and OLWS staff then move the dewatered solids to a storage shed near the plant entrance for temporary storage. A contract hauler then comes to load the solids for transport to land application sites.

OLWS is implementing a new solids project that will provide the ability to pump WAS to the GBT for thickening prior to sending to the IBRs for aerobic digestion. Currently solids into Digester 4 are around 1.7 percent solids, but with the piping modifications, feed to Digester 4 is expected to be around 2.3 to 2.4 percent solids.

3.2.1 Aerobic Digesters, Mixing Systems, and Blowers

The rectangular Aerobic Digesters 1 and 2 (converted from IBRs) have a combined volume of about 862,000 gallons. Figure 28 shows the top of these two aerobic digesters. Typically, one is in service while the second serves as a backup. These digesters are fed by the IBR feed pumps and have two vertical turbine mixers per tank as well as aeration diffusers. Sludge from these two digesters is transferred to Digester 3 by manually operating a pump. One K-Turbo blower with a 100 hp motor provides air to the diffusers. The addition of a pump at the GBT, along with piping improvements, will provide ability to use the thickening equipment and then transfer thickened sludge to the aerobic digesters.

Figure 28. Top of Aerobic Digesters 1 and 2

Digesters 3 and 4 are 35 feet in diameter and have an operating depth of about 25 feet. The combined volume of these two digesters is about 370,000 gallons. These were converted from anaerobic digesters in 2012. Figure 29 shows one of the circular aerobic digesters.

Figure 29. Circular aerobic digester

Aerobic Digesters 3 and 4 have radial jet pod, non-clog centrifugal mixing systems. Figure 30 shows the pump at Aerobic Digester 4.

Figure 30. Digester mixing pump

Aerobic Digesters 3 and 4 are served by two Neuros turbo blowers with 50 hp motors. The aeration basin evaluation project completed by Murraysmith in 2019 also considered solids treatment modifications including the impact of resuming operation of the GBT on the aerobic digester. The report notes that aerobic digester mixing, and aeration requirements may be impacted by this process change.

OLWS plans to replace the Neuros blowers with Aerzen blowers that are reportedly better suited for the environment within the partially enclosed equipment shelter. Blower cores have apparently required repair based on exposure to moisture.

3.2.2 Digested Sludge Pumps

Two rotary lobe pumps with 10 hp motors and adjustable speed drives serve as digested sludge pumps to convey the material to the belt filter press. Figure 31 shows one of the digested sludge pumps.

Figure 31. Digested sludge pump

3.2.3 Dewatering

Digested sludge is pumped to the belt filter press and dewatered to a concentration of 11 to 14 percent total solids and loaded into a dump truck using an auger/conveyor system. Figure 32 shows the belt filter press. Figure 3-3 shows the truck loadout facility at the Solids Handing Building. Biosolids are temporarily stored in a shed building located near the plant entrance before being picked up by a contract hauler and transported to Madison Farms in Echo, Oregon.

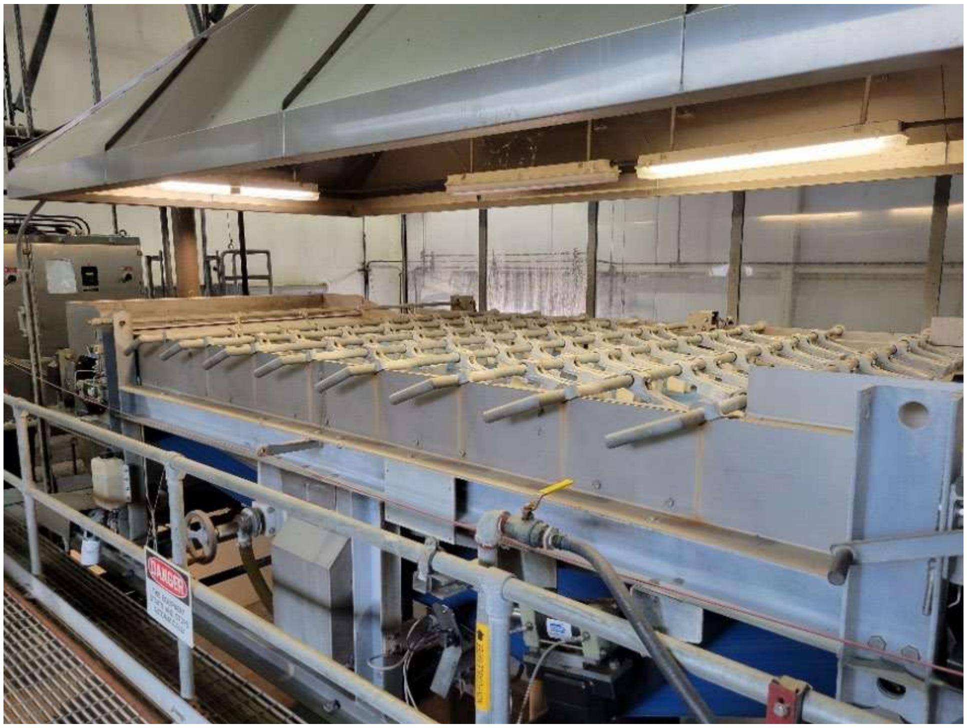


Figure 32. Belt filter press

Figure 33. Truck loadout at Solids Handling Building

3.3 Support Systems

Support systems at the OLWS WWTP include 3W disinfection system, 3W pumps, and odor control for the Headworks Building and Aerobic Digesters 1 and 2.

3.3.1 3W Disinfection and Pumps

Utility (3W) is disinfected with sodium hypochlorite before plant distribution and use. Two positive displacement metering pumps are used to dose the sodium hypochlorite. No issues with the 3W disinfection system were reported.

There are three vertical turbine pumps that supply 3W for plant use. Two of the pumps have 100 hp motors and the third has a 50 hp motor. Figure 34 shows the 3W pumps.

Figure 34. 3W pumps located at the disinfection facility

There are two strainers associated with the 3W system. The second unit is installed next to a wall making access difficult. The equipment could be shifted away from the wall but there is a road that limits its movement.

3.3.2 Headworks Foul Air Treatment

Foul air withdrawn at the Headworks Building is treated with a two-bed biofilter containing a 5-foot depth organic media. Two fiberglass reinforced plastic centrifugal fans with 7.5 hp motors are used to exhaust air and supply the biofilter.

Section 4: References

Murraysmith. Oak Lodge Water Services District, Aeration Basin Evaluation and Upgrades Project. 2019.

Oak Lodge Water Services District. Biosolids Management Plan. May 2021.

Oak Lodge Water Services District. Draft Facility Description for NPDES Permit Renewal. 2021.

Attachment A: Operator Workshop Meeting Minutes

OAK LODGE WATER SERVICES

WRF Operator Workshop

eptember 1, 2021

Goals Of Workshop, Part 1 of 2

Task 6.1 Existing WRF Operations*

- **Address DEQ requirements to incorporate operations considerations into Sanitary Sewer Master Plan**
- **Develop comprehensive list of operator concerns for liquids stream, solids stream, and support systems**

*** Under future tasks, information will be:**

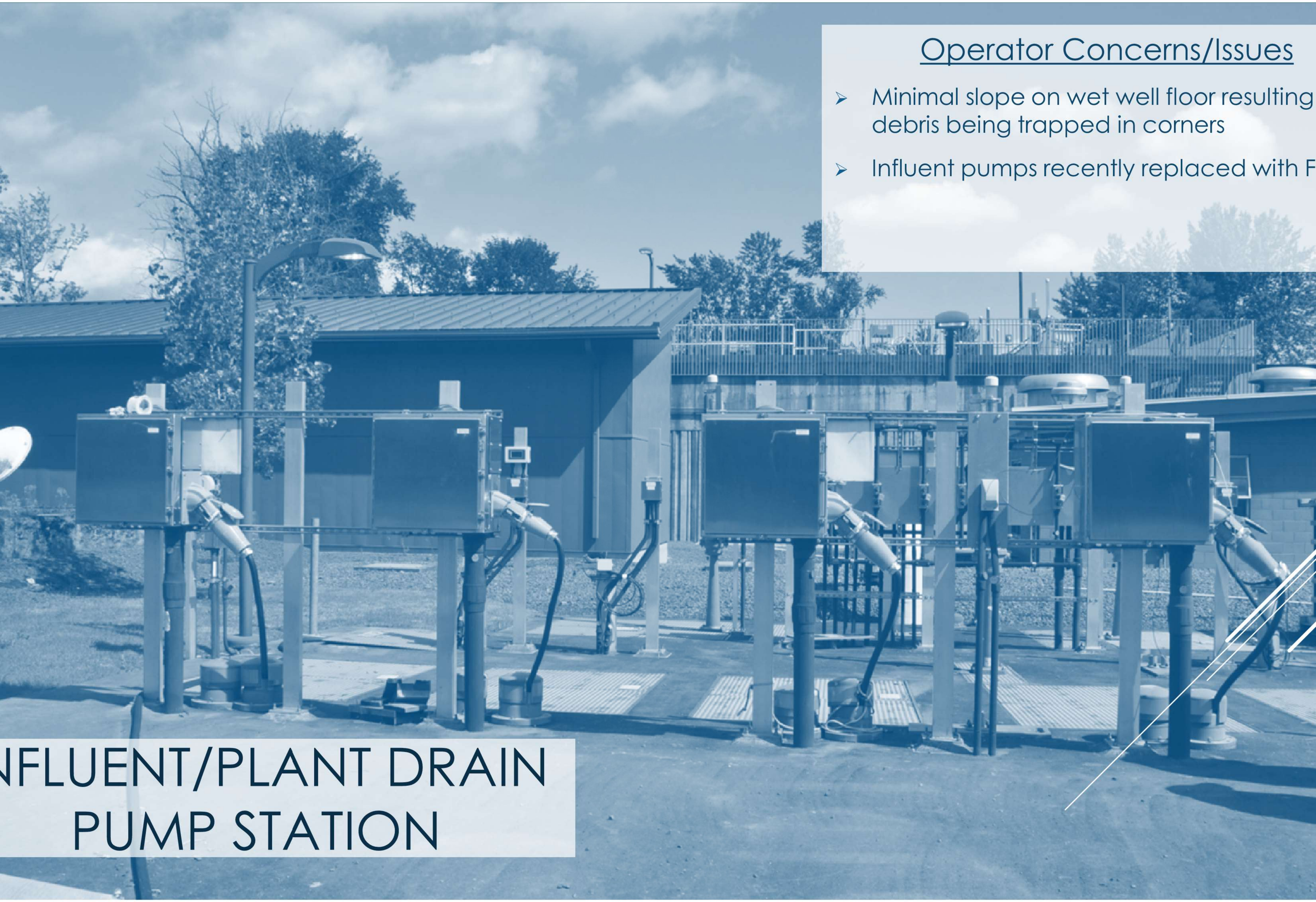
- **Incorporated into WRF capacity assessment**
- **Used to identify upgrades to address concerns as part of alternatives for future projects**

Goals Of Workshop, Part 2 of 2

Task 6.2 Influent Flow and Load Characterization

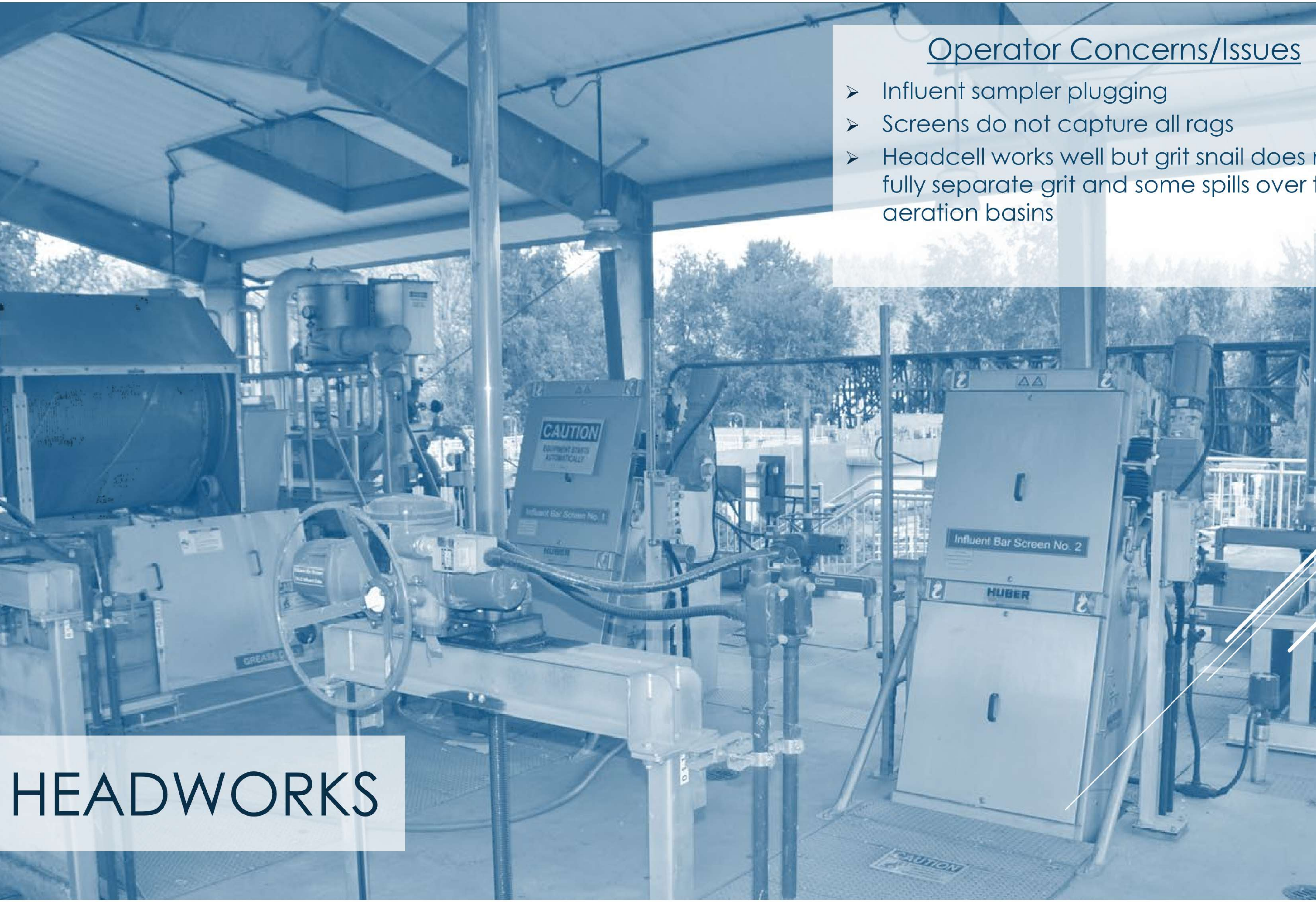
- **Discuss review of historical data**
- **Discuss wastewater characterization sampling program**

Task 6.1 Existing WRF Operations



Operator Concerns/Issues
➢ Minimal slope on wet well floor resulting
debris being trapped in corners
➢ Influent pumps recently replaced with F
NFLUENT/PLANT DRAIN
PUMP STATION

HEADWORKS



Operator Concerns/Issues

- Influent sampler plugging
- Screens do not capture all rags
- Headcell works well but grit snail does n fully separate grit and some spills over t aeration basins

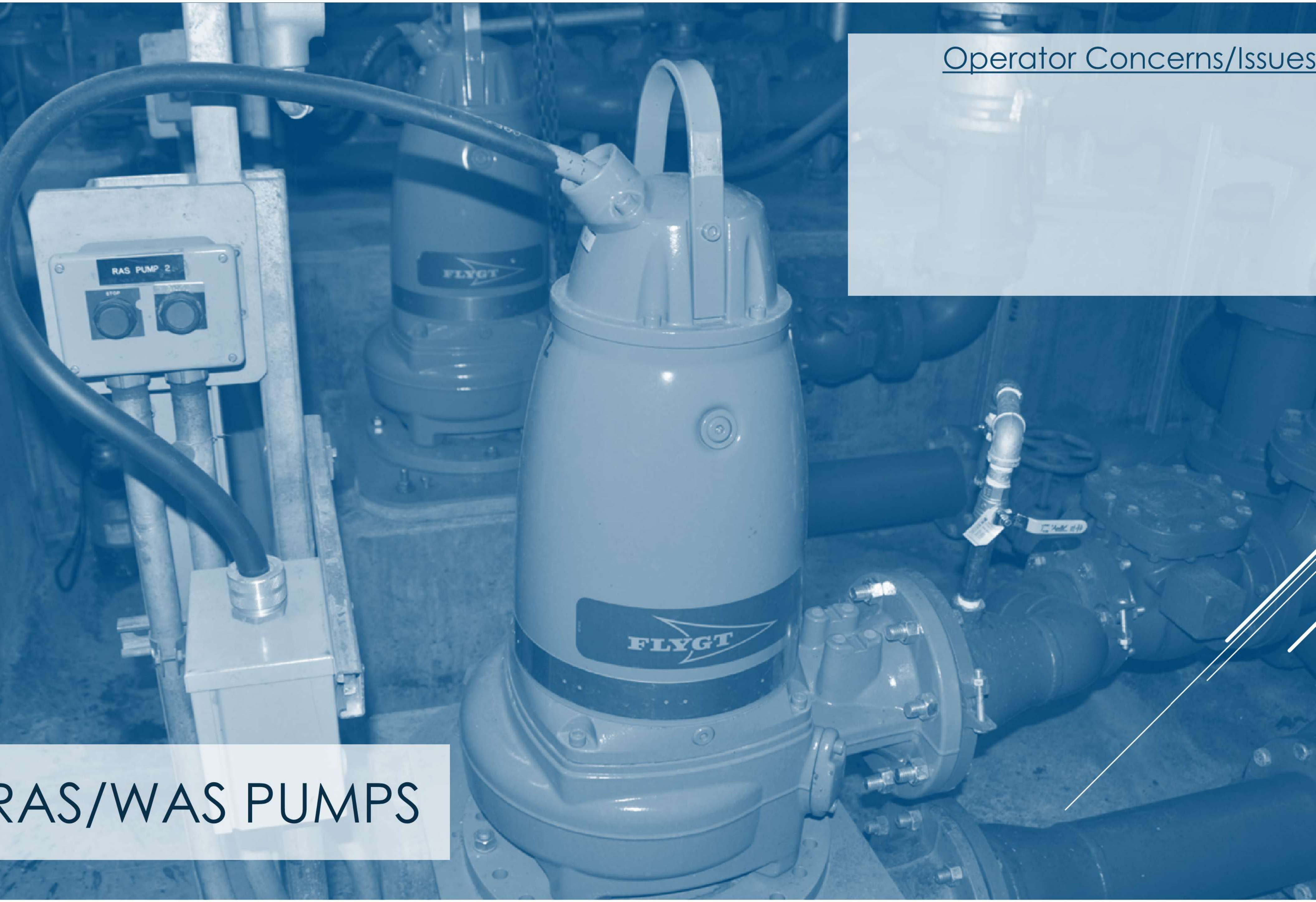
AERATION BASINS

Operator Concerns/Issues

- Foaming and crusting
- Lack of baffles limiting operating flexibi
- Need to install classifying selector and optimize anoxic selector operation to improve sludge settleability in clarifiers
- Some issues may be addressed by curr AB blower/baffle project

RAS/WAS PUMPS

Operator Concerns/Issues



SECONDARY CLARIFIERS

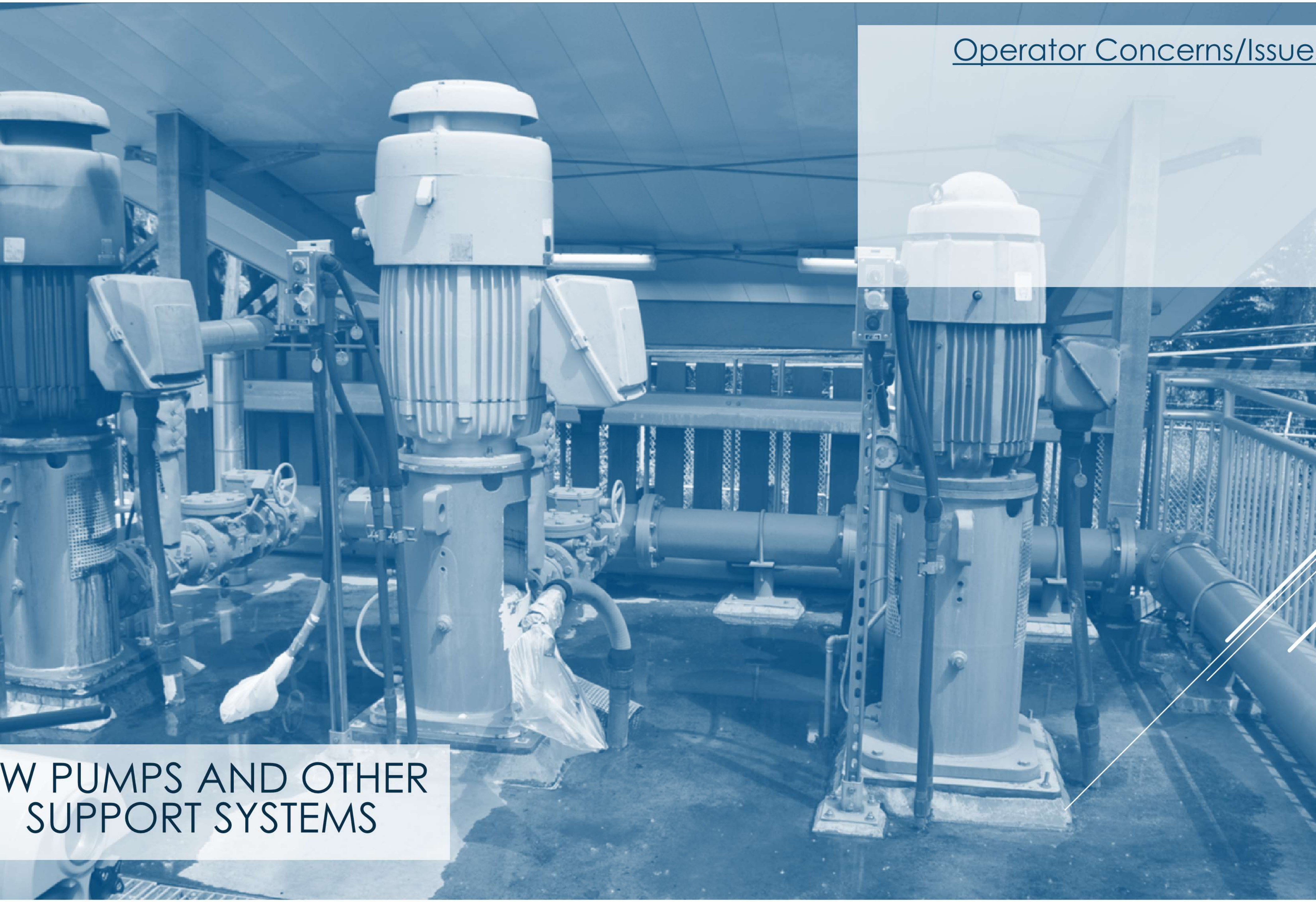
Operator Concerns/Issues

- Poor settling sludge (high SVI)
- Planning project to replace mechan Secondary Clarifiers 1 and 2 along w some piping improvements

UV DISINFECTION

Operator Concerns/Issue

- Uneven flow split/level between cha
- Continuous movement of gates for le control produces wear on gates.
- Gear box at the bottom of the tank
- Difficulty lifting bulbs out of the chan


Operator Concerns/Issue
W PUMPS AND OTHER
SUPPORT SYSTEMS

AEROBIC DIGESTERS

Operator Concerns/Issue

- Blowers operating at max capacity, evaluate capacity needs for thicken
- Overflow/spilling solids on upper lev

INTERCHANGE BIOREACTORS

Operator Concerns/Issue

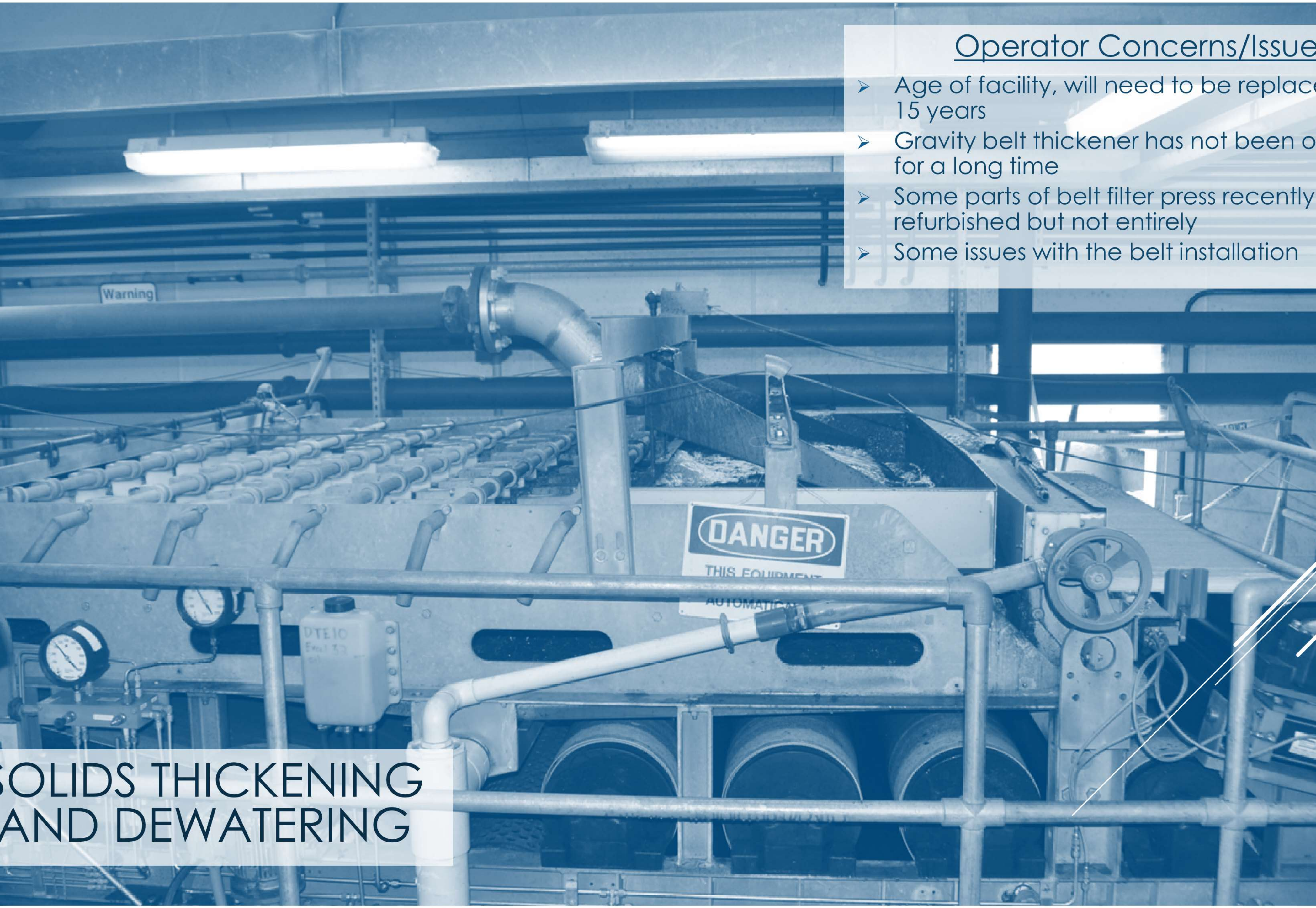
- No longer used as designed, curren as aerobic digesters

SOLIDS PUMPING

Operator Concerns/Issues

- Age of facility, will need to be replace
  15 years

SOLIDS THICKENING AND DEWATERING



Operator Concerns/Issues

- Age of facility, will need to be replace 15 years
- Gravity belt thickener has not been op for a long time
- Some parts of belt filter press recently refurbished but not entirely
- Some issues with the belt installation

OLIDS HANDLING

Operator Concerns/Issues

- Truck fills up quickly and require opera
transfer biosolids to storage facility on
- Using storage space previously used fo
vehicles and equipment to store bioso
- Biosolids storage is open and can be s
odors, especially in summer

ask 6.2 Influent Flow and Load
haracterization

Wrap-up

Appendix D WWTP Regulatory Framework

D

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TECHNICAL MEMORANDUM

DATE: February 6, 2023

Project No.: 1001-50-21-03
SENT VIA: EMAIL

TO: Sarah Jo Chaplen, General Manager, Oak Lodge Water Services

CC: Scott Duren, PE, Water Systems Consulting
Art Molseed, PE, Brown & Caldwell

FROM: Raj Kapur, Engineering Manager

REVIEWED BY: Walter Meyer, PE, RCE 22399

SUBJECT: Regulatory Framework

This Technical Memorandum (TM) presents regulatory framework for the Sanitary Sewer Master Plan for the Oak Lodge Water Services (OLWS) Water Reclamation Facility (WRF). The regulatory framework along with current requirements and potential longer-term requirements that may be implemented during the planning period are presented in the TM.

1.0 FRAMEWORK

Oregon Department of Environmental Quality (DEQ) establishes and enforces water quality standards that ensure the protection of the beneficial uses of the Willamette River. Discharges from wastewater treatment plants are regulated by the National Pollutant Discharge Elimination System (NPDES) requirements in the federal Clean Water Act. All discharges of treated wastewater to a receiving stream must obtain and comply with the conditions of an NPDES permit. In Oregon, the Environmental Protection Agency (EPA) has delegated the implementation of the NPDES permit program to DEQ; EPA provides an oversight role in the implementation of the NPDES permit program.

1.1 Beneficial Uses

To assist in the development of water quality standards, a list of beneficial uses is established for each water body in the state. Oregon Administrative Rule (OAR) 340-041-0340 lists the beneficial uses for the Willamette River in the vicinity of the OLWS WRF (Table 1).

Table 1. Designated Beneficial Uses for the Willamette River from the Mouth to the Willamette Falls

Beneficial Uses
Public Domestic Water Supply[a]
Private Domestic Water Supply[a]
Industrial Water Supply
Irrigation
Livestock Watering
Fish & Aquatic Life
Wildlife & Hunting
Fishing
Boating
Water Contact Recreation
Aesthetic Quality
Hydro Power
Commercial Navigation & Transportation
[a] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards. Source: OAR 340-041-0340.

1.2 Oregon Administrative Rules for Wastewater Treatment

The state surface water quality and waste treatment standards for the Willamette Basin are detailed in the following sections of the Oregon Administrative Rules (OARs):

- OAR 340-041-0004 lists policies and guidelines applicable to all basins. DEQ's policy of antidegradation of surface waters is set forth in this section.
- OAR 340-041-0007 through 340-041-0036 describes the standards that are applicable to all basins.
- OAR 340-041-0340 through 340-041-0345 contain requirements specific to the Willamette Basin including beneficial uses, approved Total Maximum Daily Loads (TMDLs) in the basin, and water quality standards and policies.

The surface water quality and waste treatment standards in the OARs are viewed as minimum requirements. Additional, more stringent limits developed either through the TMDL process or a water quality analysis for the renewal of the NPDES permit would supersede the basin standards.

1.3 Integrated Report and 303(d) Listing

Section 305(b) of the federal Clean Water Act requires states to develop a status report on the quality of its surface waters. Section 303(d) of the federal Clean Water Act requires states to develop a list of impaired streams (i.e., streams that do not meet water quality standards). DEQ recently completed the 2022 Integrated Report that meets both objectives of the federal Clean Water Act. The 2022 Integrated Report was approved by EPA on September 2, 2022.

The Integrated Report categorizes all assessed waterbodies. Waterbodies in Category 4A represent the pollutants for which TMDLs have been completed. For the segment of the Willamette River where the

OLWS WRF discharges, TMDLs have been completed for 2,3,7,8-TCDD (dioxin), methylmercury, and bacteria. A discussion of the TMDLs is presented in the next section.

Waterbodies in Category 5 constitute the 303(d) list and require the development of a TMDL to address impairments of water quality standards. The 303(d) listings provide an insight to new TMDLs that may be developed in the Willamette River Basin. The assessment unit where the OLWS WRF discharges is the segment of the Willamette River from the confluence of the Clackamas River to Johnson Creek. Johnson Creek to the confluence with the Columbia River is the segment of the Willamette River immediately downstream of the OLWS WRF discharge. Category 5 listings in the 2022 Integrated Report for these segments of the Willamette River are listed below:

Table 2. 2022 Integrated Report for the Willamette River:

Category 5 Listings

Segment	Pollutant
Clackamas River to Johnson Creek (Assessment Unit ID: OR_SR_1709001201_88_104019)	Biocriteria
	Temperature
	Cyanide
	Ethylbenzene
	Hexachlorobenzene
	Polycyclic Aromatic Hydrocarbons (PAHs)
	Legacy Pollutants: aldrin, DDE 4,4', DDT 4,4', dieldrin, Polychlorinated Biphenyls (PCBs)
Johnson Creek to the Columbia River (Assessment Unit ID: OR_SR_1709001202_88_104175)	Biocriteria
	Harmful algal blooms
	Temperature
	Dissolved oxygen
	Cyanide
	Polycyclic Aromatic Hydrocarbons (PAHs)
	Legacy Pollutants: aldrin, DDE 4,4', dieldrin, Polychlorinated Biphenyls (PCBs)

The segment of the Willamette River where the OLWS discharges is listed for biocriteria; the segment of the Willamette River immediately downstream is listed for both biocriteria and harmful algal blooms. In its 2022 Integrated Report frequently asked questions, DEQ noted the following regarding these listings:

> *In most cases, DEQ does not have information regarding the specific pollutant(s) of concern that is responsible for the algal blooms, biocriteria impacts, etc. Often the stressor is not known until a TMDL is developed, which will identify the cause of the impairment, including linking a pollutant to the water quality condition. The TMDL will identify the pollutant of concern for the impairments and derive the wasteload allocations for the relevant pollutants from discharging facilities. When a permit is developed prior to having the pollutant(s) of concern identified, no reasonable potential analysis can be conducted. However, when DEQ undertakes a revision of a permit and has information related to the*

pollutant of concern that is relevant to the facility, DEQ may include monitoring or other appropriate requirements in the permit.

DEQ does not plan to conduct a reasonable potential analysis and establish effluent limits based on the listings for biocriteria and harmful algal blooms. DEQ plans to develop a TMDL to identify the stressor(s) that are the cause of the water quality impairments. DEQ has not established a time frame for developing a TMDL to address these impairments.

DEQ developed a temperature TMDL for the mainstem Willamette River in 2006 based on the natural conditions criteria. Since the development of the TMDLs, the natural conditions criteria have been set aside by court action. Additionally, DEQ has been ordered to update the TMDLs that were based on the natural conditions criteria. The Willamette Temperature TMDL is being updated in phases. The schedule for updating the TMDL for the mainstem Willamette River is slated to be submitted to EPA for approval by February 2025.

This segment of the Willamette River is listed for cyanide, ethylbenzene, and hexachlorobenzene. Cyanide and hexachlorobenzene were listed in 2010; and ethylbenzene was listed in 2012. These listing were based on limited data (one sample) and predate the more rigorous approach that DEQ adopted in its methodology document as part of its 2018/20 Integrated Report. However, absent additional data, the older listings continue to remain on the 303(d) list.

Currently, DEQ does not have plans to develop TMDLs for the legacy pollutants (i.e., aldrin, DDE 4,4', DDT 4,4', dieldrin, and PCBs) and PAHs. Permit limits are not anticipated for these pollutants, but DEQ has included monitoring requirements to characterize effluent concentrations of these pollutants in municipal wastewater discharges.

1.4 Total Daily Maximum Loads

The Clean Water Act requires DEQ to establish TMDLs and corresponding waste load allocations for all water bodies on the 303 (d) list. The TMDLs include waste load allocations and other requirements that apply to the OLWS WRF. Table 3 presents the TMDLs that have been developed for the Willamette River basin.

Table 3. Willamette River Basin TMDLs

Parameters (1991)	Parameters (2006)	Parameters (2021)
2,3,7,8-TCDD (dioxin)	Bacteria Temperature Mercury	Mercury (reissued)

The following is a brief discussion of the TMDLs that apply to the Willamette River and the implications of the TMDL on the OLWS WRF discharge:

- **2,3,7,8-TCDD (dioxin)** – EPA developed a TMDL for dioxin in 1991. The TMDL defined waste load allocations for pulp and paper mills in the Columbia River Basin. Municipal wastewater treatment facilities are not impacted by the TMDL.
- **E. coli Bacteria** — To address elevated bacteria levels in surface waters, DEQ developed a TMDL for E. coli bacteria. The TMDL includes allocations for municipal stormwater, wastewater, and non-point sources (e.g., agriculture). The TMDL wasteload allocations for

wastewater treatment facilities are the same as the water quality criteria for E. coli bacteria that are typically included in municipal wastewater permits as effluent limits. Thus, the TMDL does not establish any additional requirements for the OLWS WRF discharge.

- **Mercury** — In February 2021, U.S. EPA issued the final Willamette Basin Mercury TMDL. The TMDL notes that the predominant source of mercury in the basin is from atmospheric deposition. The mercury in air originates from national and global sources. Once mercury is deposited on the landscape, the major pathways to streams are surface runoff and erosion of sediment-bound mercury in soils. The TMDL estimated that municipal wastewater treatment facilities contribute about 1% of the mercury load to the Willamette River basin. As a result of their minimal contribution, the TMDL utilizes a management practice-based approach to reduce mercury levels from municipal treatment facilities.
- **Temperature** – As noted above, DEQ was ordered to update the temperature TMDLs that were based on the natural conditions criteria. Until the temperature TMDLs are updated, DEQ's procedure is to include the more stringent of the wasteload allocations from the 2006 TMDL or thermal load limits based on the application of the biologically based numeric criteria "after mixing with either twenty-five (25) percent of the stream flow, or the temperature mixing zone, whichever is more restrictive". [OAR 340-041-0028(12)(b)(A)]. For the OLWS WRF, the TMDL waste load allocations are more stringent than thermal load limits based on the application of the biologically based numeric criteria.

2.0 2022 NPDES Permit

The OLWS WRF discharges to the Willamette River at River Mile 20.1 just upstream of the BNSF Railroad Bridge. The following is a discussion of the NPDES Permit that applies to the OLWS WRF discharge.

2.1 Permit Limits

The NPDES permit for the OLWS WRF was recently issued by DEQ with an effective date of May 1, 2022, and an expiration date of March 31, 2027. The permit renewal application is due at least 180 days before the expiration date of the permit (i.e., October 3, 2026).

Table 4 presents the permit limits that apply during the dry season, wet season and year-round basis.

Table 4. NPDES Permit Limits

Parameter	Monthly Average, mg/L	Weekly Average, mg/L	Monthly Average, lb/day	Weekly Average, lb/day	Daily Maximum, lbs
May 1 – October 31 (Dry Season)					
$CBOD_5$	10	15	490[a]	740	980
TSS	10	15	490[a]	740	980
November 1 – April 30 (Wet Season)					
BOD_5	30	45	2600[b]	3900	5200
TSS	30	45	2600[b]	3900	5200
Other Parameters	Limitations				
E. coli Bacteria (year-round)	Shall not exceed 126 organisms per 100 ml monthly geometric mean. No single sample shall exceed 406 organisms per 100 ml.				
pH (year-round)	Shall be within the range of 6.0-9.0				
$CBOD_5$/BOD_5 Percent Removal (year-round)	Shall not be less than 85 percent monthly average				
TSS Percent Removal (year-round)	Shall not be less than 85 percent monthly average				
Excess Thermal Load Limit (ETLL) (June 1 – September 30)	Option A: 47 million kcal/day (7-day rolling average)				
	Option B: (0.001686 x Qr) + 32.3 million kcal/day (7-day rolling average)				

(a) Dry season mass load limits for $CBOD_5$ and TSS based on average dry weather design flow of 5.9 MGD and rounded to two significant figures.
(b) Wet season mass load limits for BOD_5 and TSS based on an average wet weather design flow of 10.5 MGD and rounded to two significant figures.

The previous NPDES permit for the OLWS WRF was issued in 2004. The 2004 NPDES permit specified dry season limits for $CBOD_5$ of 15 mg/L as a monthly average and 25 mg//L as a weekly average; TSS limits were 20 mg/L as a monthly average and 30 mg/L as a weekly average. These limits were updated in the 2022 NPDES permit in accordance with OAR 340-041-0061(3)(c), which states the following:

> *Wherever minimum design criteria for waste treatment and control facilities set forth in this plan are more stringent than applicable federal standards and treatment levels currently being provided, upgrading to the more stringent requirements will be deferred until it is necessary to expand or otherwise modify or replace the existing treatment facilities. Such deferral will be acknowledged in the permit for the source.*

With the recent upgrades to the WRF, the 2022 NPDES permit includes more stringent $CBOD_5$ and TSS concentration limits of 10 mg/L as a monthly average and 15 mg/L as a weekly average during the dry season. The updated $CBOD_5$ and TSS concentration limits in the 2022 NPDES permit are based on the "Minimum Design Criteria for Treatment and Control of Sewage Wastes" for the Willamette River basin (OAR 340-041-0345). Dry season mass load limits for $CBOD_5$ and TSS reflect the average dry weather design flow of the upgraded OLWS WRF (i.e., 5.9 MGD).

There is no change in the wet season concentrations limits for BOD_5 and TSS. Wet season mass load limits for BOD_5 and TSS are higher than in the 2004 NPDES permit and reflect the higher average wet weather design flow of the upgraded WRF (i.e., 10.5 MGD).

The 2004 NPDES permit also included a waiver of the daily mass load limit when flows to the facility exceeded twice the average dry weather design flow. For facilities that have expanded average dry weather treatment capacity after 1992, the daily mass load limit waiver is no longer available. Accordingly, the 2022 NPDES permit does not include the waiver of the daily mass load limit. Since OLWS was able to secure a mass load increase for the wet season based on the expanded capacity of the WRF, the removal of the daily mass load limit waiver will likely be limited.

The 2022 NPDES permit includes effluent limits for *E. coli* bacteria, pH, and percent removal for $CBOD_5$/BOD_5 and TSS. These limits are either based on federal secondary treatment standards (pH and percent removal) or water quality criteria (*E. coli* bacteria). No changes are expected to these requirements in the near-term.

2.2 Temperature

As noted above, DEQ's procedure is to include the more stringent of the wasteload allocations from the 2006 Willamette Temperature TMDL or thermal load limits based on the application of the biologically based numeric criteria until the TMDL is updated. For the OLWS WRF, the 2006 TMDL waste load allocations are more stringent than thermal load limits based on the application of the biologically based numeric criteria. Thus, the 2022 NPDES permit also includes effluent limits for temperature in the form of an excess thermal load limit from the 2006 Willamette Temperature TMDL. The excess thermal load limits apply from June 1 – September 30 of each year.

OLWS can use two options to demonstrate compliance with the excess thermal load limits - Option A, which includes a static excess thermal load limit or Option B, which enables the calculation of excess thermal load limits based on Willamette River flow. With the static Option A limit, OLWS was granted a portion of the TMDL reserve capacity which equated to 1.127 times the TMDL waste load allocation in addition to the allocation in the TMDL. With the inclusion of the reserve capacity, the static thermal load (Option A) is higher for most dry season flow conditions (Figure 1). Only when Willamette River flows as measured at Portland are greater than 8720 cfs is it more advantageous to use Option B for defining excess thermal load limits.

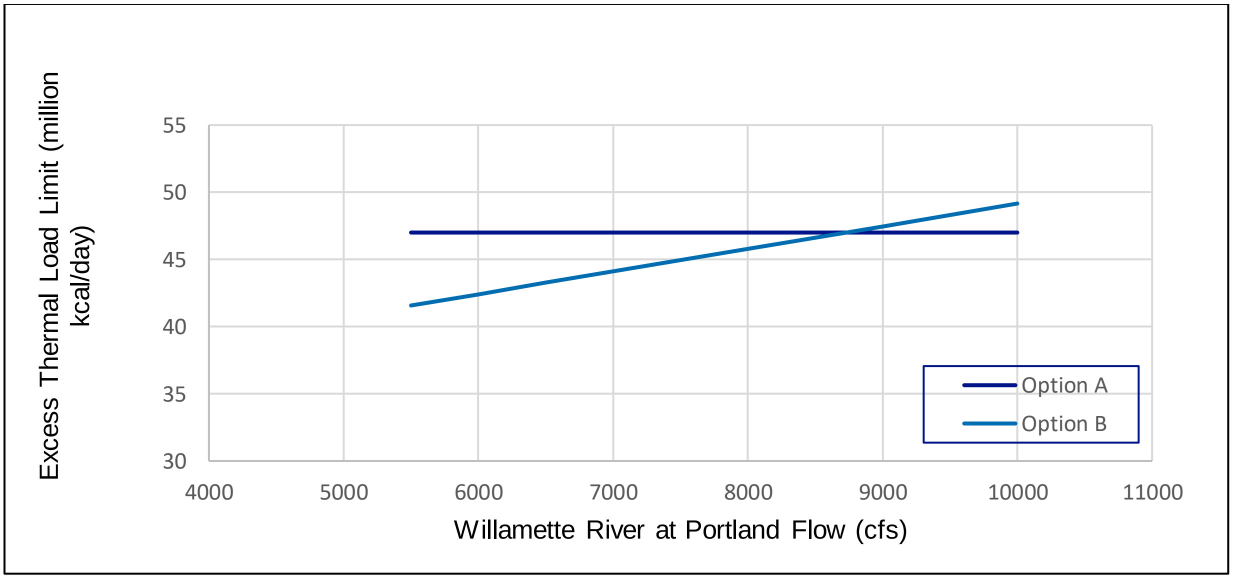


Figure 1. Excess Thermal Load Limits vs. Willamette River Flow

Temperature and excess thermal loads over six summers (June 2016 to September 2021) were reviewed. Figure 2 presents effluent temperature data, excess thermal loads, and the excess thermal load limit from June to September of each year from 2016 – 2021. It should be noted that the excess thermal load limits were not incorporated into the NPDES permit until 2022 but were reviewed as an indication of future performance and the ability of the WRF to comply with these requirements.

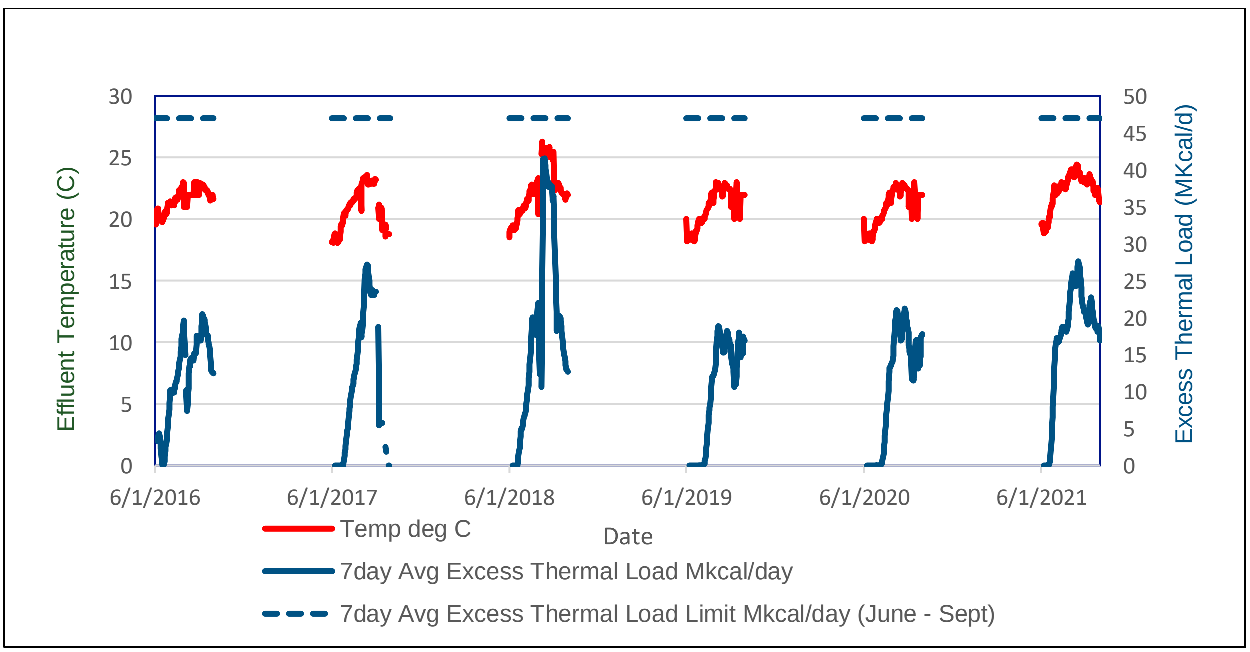


Figure 2. Effluent Temperature and Excess Thermal Load (2016 – 2021)

Over this period, the WRF would have consistently met the excess thermal load limits. Note that effluent temperature from August 6 – 31, 2018 were near or above 25 °C; this resulted in excess thermal loads in the range of 34 million kcal/day to 41.6 million kcal/day during this period. Temperatures immediately before and after this period were several degrees C cooler. Temperature data that led to the higher excess thermal load in August 2018 may not be representative of discharge characteristics. More recent data including data from 2021 during the heat dome conditions suggest that the discharge should be able to meet thermal load limits during the 5-year NPDES permit cycle.

There is uncertainty regarding the excess thermal load limits in the longer-term. As noted above, DEQ is updating the temperature TMDL for the Willamette River to reflect the removal of the natural conditions provision in the water quality standard for temperature. This may result in changes to the excess thermal load limit particularly the reserve capacity that was allocated to the OLWS WRF.

2.3 Mixing Zones

The OLWS WRF has two outfalls. Outfall 001 is the primary outfall with an 18-port diffuser and Outfall 001A is a wet weather outfall with a 4-port diffuser that is expected to be used only during extreme flow events. A mixing zone study was conducted in 2017 that documented environmental conditions, mixing characteristics and resulting dilutions at the two outfalls. The mixing zone dimensions of the primary outfall were revised based on the study. The applicable water quality standard, the stream flow statistic, and the resulting dilutions at the Zone of Immediate Dilution (ZID) and the Regulatory Mixing Zone (RMZ) are presented in Table 5.

Table 5. Mixing Zone Dilution

Outfall	Water Quality Standard	Stream Flow Statistic	Zone of Immediate (ZID) Dilution	Regulatory Mixing Zone (RMZ) Dilution
Outfall 001	Aquatic Life (acute)	1Q10 (6,108 cfs)	108	N/A
	Aquatic Life (chronic)	7Q10 (6,146 cfs)	N/A	457
	Human Health (non-carcinogen)	30Q5 (7,431 cfs)	N/A	380
	Human Health (carcinogen)	Harmonic mean (16,966 cfs)	N/A	778
Outfall 001 and 001A	Aquatic Life (acute)	100-year flood (375,000 cfs)	Outfall 001: 32 Outfall 001A: 9	N/A
	Aquatic Life (chronic)	100-year flood (375,000 cfs)	N/A	Outfall 001: 158 Outfall 001A: 44

The mixing zone provisions in the Oregon Administrative Rules include requirements regarding thermal plumes [OAR 340-041-0053(2)(d)]. These include provisions for protection of salmonid spawning areas, acute impairment, thermal shock, and migration blockage. In the NPDES Permit Renewal Fact Sheet (Section 3.3.6.2), DEQ concluded that there are no salmonid spawning areas near the discharge from the OLWS WRF; the discharge temperatures are well below 32 °C and will not result in acute impairment; the discharge does not cause thermal shock; and does not result in a migration blockage. No additional requirements were included in the 2022 NPDES permit based on the thermal plume criteria.

2.4 Toxicity (Reasonable Potential Analysis)

The results of the mixing zone study were used by DEQ for conducting a reasonable potential analysis (RPA) for the 2022 NPDES permit renewal. The RPA is the process that DEQ uses to determine whether the discharge meets water quality criteria. If the results of the RPA show that the discharge has potential to exceed water quality criteria at the dilutions that occur at the ZID and RMZ, effluent limits are established to ensure compliance with water quality criteria.

DEQ conducted an RPA to determine compliance with water quality criteria for ammonia, metals, cyanide, and priority pollutant organics. The following is a discussion of the results of the RPA.

Ammonia: The water quality criteria for ammonia are dependent on pH, temperature and alkalinity. The 2022 NPDES permit used a maximum effluent ammonia concentration of 15.6 mg/L recorded between 2016 – 2021 in the analysis. The analysis concluded that the discharge does not have reasonable potential to exceed water quality criteria for ammonia at the defined ZID and RMZ. Using the DEQ input values, an additional analysis was conducted using a higher effluent ammonia concentration of 30 mg/L (Figure 3).

RPA Run Information	
Facility Name:	Oak Lodge Water Services
DEQ File Number:	DEQ File Number:
Permit Writer Name:	Permit Writer Name:
Outfall Number:	1
Date of RPA Run:	9/14/2022
RPA Run Notes: Effluent ammonia concentration of 30 mg/L	
KEY:	-- Intermediate calc.s
* Enter data here	-- Calculated results

Please complete the following General Facility Information		
1. Enter Facility Design Flow (MGD)		*
2. Do I have dilution values from a mixing zone study? (Yes/No)		Yes
3. If answered "No" to *Question 2*, then fill in the following table		
Stream Flow: 7Q10	CFS	na
Stream Flow: 30Q5	CFS	na
Stream Flow: 1Q10	CFS	na
% dilution at ZID	%	10%
% dilution at MZ	%	25%
Calculated Dilution Factors		
Dilution @ ZID		na
Dilution @ MZ (7Q10)		na
Dilution @ MZ (30Q5)		na

4. If answered "Yes" to *Question 2*, then fill in dilution factors from mixing zone study		
Dilution @ ZID (from study)		108
Dilution @ MZ 7Q10 (from study)		457
Dilution @ MZ 30Q5 (from study)		380
5. Is the receiving waterbody fresh or salt water? (Fresh/Salt)		Fresh
6. If answered "*Salt*" to *Question 5*, then enter salinity (ppt)		
Ambient Salinity	ppt	na
Effluent Salinity	ppt	na
7. Are Salmonid present? (Yes/No) (Mussels presumed present)		Yes
8. Please enter statistical *Confidence* and *Probablity* values (note: defaults already entered)		
Confidence Level	%'ile	99%
Probability Basis	%'ile	95%

Dilution Calculations

Inputs

		ZID	MZ (7Q10)	MZ (30Q5)
Dilution Factors		108.0	457.0	380.0

Upstream Characterization		**Acute**	**Chronic**
Temperature	deg. C	23.8	23.8
pH		8	8
Alkalinity	mg/L $CaCO_3$	28	28

Effluent Characterization			
Temperature	deg. C	23.4	23.4
pH		7	7
Alkalinity	mg/L $CaCO_3$	64	64

*Calculation of pH of a mixture of two flows based on the procedure in EPA's DESCON program (EPA, 1988. Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling. USEPA Office of Water,

** Selection of acute alkalinity %ile is based on pH of effluent vs ambient. For the chronic criteria, average alkalinity values are used.

Outputs

		ZID	MZ (7Q10)	MZ (30Q5)
Upstream				
pKa		6.4	6.4	6.4
Ionization Fraction		1.0	1.0	1.0
Total Inorganic Carbo	mg/L $CaCO_3$	28.6	28.6	28.6
Effluent				
pKa		6.4	6.4	6.4
Ionization Fraction		0.8	0.8	0.8
Total Inorganic Carbo	mg/L $CaCO_3$	78.6	78.6	78.6
Mixing Zone				
Temperature	deg. C	23.8	23.8	23.8
Alkalinity	mg/L $CaCO_3$	28.3	28.1	28.1
Total Inorganic Carbo	mg/L $CaCO_3$	29.1	28.8	28.8
pKa		6.4	6.4	6.4
pH		7.9	8.0	8.0
Salinity	ppt	--	--	

Reasonable Potential Analysis

Pollutant Parameter	Identify Pollutants of Concern					Determine In-Stream Conc.				WQ CRITERIA			
	# of Samples	Highest Effluent Conc.	Coefficent of Variation	Est. Maximum Effluent Conc.	RP at end of pipe?	Ambient Conc.	Max Total Conc. at ZID	Max Total Conc. at RMZ (7Q10)	Max Total Conc. at RMZ (30Q5)	Acute CMC	Chronic Calc. (4-day avg.)	Chronic Calc. (7Q10)	Chronic Calc. (30 day avg.)
		mg/l	Default=0.6	mg/l	(Yes/No)	mg/l	mg/l	mg/l	mg/l	mg/l	mg/L	mg/l	mg/l
Ammonia (Freshwater Salmonids)	217	30	0.6	30.0	Yes	0.0499	0.33	0.12	0.13	**3.28**	1.57		0.6
Ammonia (Freshwater, Salmonids absent)	--	--	--	--	--	--	--	--	--	**--**	--		--
Ammonia (Salt Water)	--	--	--	--	--	--	--	--		**--**		--	

Pollutant Parameter	Det. Reasonable Potential: Is there Reasonable Potential to Exceed? (Yes/No)			
	Acute	Chronic (4 day avg.)	Chronic (7Q10)	Chronic (30 day avg.)
Ammonia (Freshwater Salmonids)	NO	NO		NO
Ammonia (Freshwater, Salmonids absent)	--	--		--
Ammonia (Salt Water)	--		--	

Figure 3. Reasonable Potential Analysis with Effluent Ammonia Concentration of 30 mg/L

The results of this analysis also do not show reasonable potential to exceed water quality criteria for ammonia. Thus, it is unlikely that toxicity-based effluent limits for ammonia would be established during the planning period based on the current water quality criteria, and the dilution at the ZID and RMZ.

Metals (except copper and aluminum) and Cyanide: Data collected in 2015 and 2016 were used in the RPA for the 2022 NPDES permit renewal. The analysis concluded that the discharge does not have reasonable potential to exceed water quality criteria for metals and cyanide at the defined ZID and RMZ. Based on the current water quality criteria for metals and cyanide, and the dilution at the ZID and RMZ, it is unlikely that the toxicity-based effluent limits for metals and cyanide would be established during the planning period.

Copper: In 2017, Oregon adopted water quality criteria for copper based on the application of the biotic ligand model (BLM), a bioavailability model. The BLM calculates applicable acute and chronic water quality criteria based on 10 water quality parameters including dissolved organic carbon, pH, temperature, alkalinity and several anions and cations in the effluent and receiving stream. Concurrent, site-specific effluent and receiving stream data were not available. DEQ used available effluent and receiving stream data for the analysis and concluded that the results "do not indicate any immediate concerns for the discharge from the WRF." Thus, effluent limits for copper were not deemed to be necessary.

The analysis also notes that "the lack of data did not allow DEQ to fully assess reasonable potential." The 2022 NPDES permit includes monitoring requirements to obtain sufficient data during the next permit cycle to conduct a more thorough reasonable potential analysis. The 2022 NPDES permit requires the collection of data for a 24-month period from January 2025 onwards. It is unlikely that additional copper BLM data will lead to a different conclusion. For planning purposes, it can be assumed that additional treatment for copper will not be necessary.

Aluminum: In December 2020, EPA issued a rule establishing aquatic life criteria for aluminum applicable to Oregon. The water quality criteria for aluminum are dependent on dissolved organic carbon, pH, and hardness data in the effluent and receiving stream. Due to lack of data, DEQ did not make a conclusive finding regarding aluminum. As such, the 2022 NPDES permit requires the collection of aluminum data along with copper for a 24-month period from January 2025 onwards. Conventional secondary treatment facilities such as the OLWS WRF that do not use alum for nutrient removal will likely not have reasonable potential to exceed the water quality criteria for aluminum. For planning purposes, it can be assumed that additional treatment for aluminum will not be necessary.

Priority Pollutant Organics: Priority pollutant organic compounds include volatile organic compounds, acid-extractable compounds, base-neutral compounds, and pesticides. DEQ used data collected in 2015 and 2016 for conducting the RPA. The RPA concluded that the discharge from the OLWS WRF "did not result in any priority pollutant organics exceeding water quality standards either at the end-of-pipe or regulatory mixing zones". For planning purposes, it can be assumed that additional treatment for priority pollutant organic compounds will not be necessary.

2.5 Mercury Minimization Plan

As noted above, the Willamette Basin Mercury TMDL utilizes a management practice-based approach to reduce mercury levels from municipal treatment facilities. The 2022 NPDES permit includes a requirement to submit a Mercury Minimization Plan by May 15, 2024. Oregon Association of Clean Water Agencies (ACWA) has developed a template for preparing an MMP. This template has undergone review by DEQ so there is greater assurance that utilization and adherence to the template will result in an approvable plan.

2.6 Solids Management

OLWS land applies biosolids for beneficial use. The 2022 NPDES Permit specifies the land application requirements for biosolids. The biosolids management plan was recently updated and approved by DEQ as part of the NPDES permit renewal. Solids are aerobically digested to meet 40 CFR Part 503 Class B biosolids requirements. The biosolids are then dewatered by a belt filter press and then transported to land application sites at Madison Farms in Umatilla County.

3.0 Developing Regulatory Issues

The following is a discussion of regulatory issues that OLWS should continue to monitor. These issues are still in the development stage and additional requirements may be incorporated into NPDES permit upon renewal.

- **PFAS (Per and Poly fluoroalkyl Substances)—** EPA has issued a roadmap that identifies several actions that it plans to take over three years (2021 – 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. Refer to the EPA PFAS Road Map for additional details regarding the planned actions and timeframes.
- **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 draft coliphage criteria, this topic is often listed as an EPA priority (Recreational Water Quality Criteria and Methods | US EPA).

  While the development and incorporation of effluent limits based on coliphage criteria is still several years away, OLWS should consider the effect of the application of the coliphage criteria on disinfection technology used at the WRF as part of its planning process.
- **Nutrients**: Nutrients are a key issue at the state and national level. As noted above, the segment of the Willamette River that the WRF discharges is listed on the 303(d) list for biocriteria; the segment of the Willamette River immediately downstream is listed for both biocriteria and harmful algal blooms.

  The listings for biocriteria in the segment where the OLWS WRF discharges and the listings for biocriteria, harmful algal blooms and dissolved oxygen in the segment of the Willamette River immediately downstream of the OLWS discharge is likely related to nutrient loading to the Willamette River basin. DEQ has not evaluated the conditions in the river to determine if the river is either 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.

  Additionally, the United States Environmental Protection Agency (EPA) has recently issued a memo emphasizing the need to evaluate for nutrients as part of NPDES permit renewals (2022 EPA Nutrient Reduction Memorandum | US EPA).

  While there is still uncertainty regarding the scope and timing of nutrient controls that would be required, consideration should be given to incorporate nutrient removal technology (both phosphorus and nitrogen) during the 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. Most treatment facilities in U.S. are designed to bypass a portion of the treatment facility to accommodate peak flows. 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. To address this discrepancy between design and operation, and regulatory requirements, EPA put together a workgroup in 2019 to help define a comprehensive wet weather strategy. However, EPA has not defined a wet weather strategy and has no defined timeframe for doing so. This is not a significant issue for OLWS as the WRF has the hydraulic capacity to treat wet weather flows and does not bypass secondary treatment facilities.

Appendix E Model Development TM

E

Technical Memo

Date:	1/31/2023
To:	Brad Albert, PE
Prepared By:	Adam Donald, PE
Reviewed By:	Scott Duren, PE
Project:	1100-10060 Wastewater Master Plan
Subject:	Modeling Approach Technical Memo

Oak Lodge Water Services (OLWS) has contracted Water Systems Consulting (WSC) to prepare their Wastewater Master Plan. The Wastewater Master Plan will evaluate the adequacy of the wastewater collection and treatment systems to provide safe and reliable service to customers and recommend capital improvements necessary to maintain that level of service into the future. The analysis will be based on estimated wastewater loading projections and a set of evaluation criteria designed to meet regulatory requirements, accepted engineering practices, and OLWS preferences.

This Technical Memorandum (TM) describes the development of the hydraulic model while the capacity analysis and modeling results will be included in the updated Master Plan prepared by WSC. The purpose of this TM is to outline the model development process which includes the importation of infrastructure attribute data, assessment of model connectivity, development and allocation of existing and future flows, and model calibration.

This TM is organized in the following sections:

Section 1. Model Development

WSC has constructed an updated model of the OLWS wastewater collections system using SewerGEMS, a fully dynamic wastewater modeling platform developed by Bentley Systems, Inc. SewerGEMS is a Geographic Information System (GIS) friendly software capable of running within ArcGIS or as a stand-alone application.

The model was built using OLWS' wastewater system shapefiles, which have been maintained and routinely updated by OLWS and are reflective of the current wastewater collection system layout. Upon review of the OLWS' shapefiles, the collection system infrastructure including manholes, cleanouts, lift stations, gravity pipes, and force mains were imported into SewerGEMS. Unique identifiers were used to maintain the connection between the GIS and SewerGEMs features. Throughout the process, alterations were made to address connectivity or import errors and obtain a working SewerGEMS model. Alterations to the shapefiles and general configuration assumptions made during the model build are summarized below and detailed within the hydraulic model. Appendix A includes additional information pertaining to the notes within the model.

- Features identified in the geodatabase as abandoned, removed, proposed, or private were not included in the model build. Proposed features will be included in model scenarios representative of future conditions.
- Manholes were added upstream of gravity pipes if missing from GIS shapefiles
- Pipelines and manholes missing invert and rim elevation data were populated using the OLWS' record drawings when available. Minimum slopes were assumed when record drawings were unavailable.

In addition to the geospatial location of the collection system features, infrastructure attributes, such as pipe material and diameter, were carried over from the OLWS' shapefiles to SewerGEMS in the import process.

1.1. Elevation Data

Invert elevation data for the model was pulled from OLWS' manhole and pipeline shapefiles. A majority of OLWS' manholes were missing rim and/or invert elevations within the shapefile (Table 1-1). Similarly, about 16% of the pipelines within OLWS' pipeline shapefile were missing at least one invert elevation (Table 1-2). To mitigate these data gaps, WSC used record drawings to update invert and rim elevations. When the pipeline invert data was unavailable in the record drawings, WSC conservatively used the minimum slope from OLWS' design standards to estimate the slope of the main.

Table 1-1: Missing Data in Manhole Shapefile

Manholes Missing Rim Elevation	Manholes Missing Invert Elevation	Total Manholes
358	2,345	2,739

Table 1-2: Missing Data in Pipeline Shapefile

Pipelines Missing Start Invert	Pipelines Missing Stop Invert	Total Pipelines
398	400	2,578

Section 2. Wastewater Flow Development and Allocation

2.1. Wastewater Flows and Water Consumption

The OLWS wastewater collection system receives flow from approximately 8,239 parcels consisting of water users within OLWS' water service area and the City of Gladstone. Although wastewater flow is not typically metered, wastewater flow can be estimated using water meter data and applying a water to wastewater factor. A significant portion of water consumption eventually becomes wastewater flow and water meters have a geographic location. Therefore, water meter consumption and location data can be used to geographically allocate wastewater flows contributing to the collection system. Allocated flows are then assigned to pipes in the hydraulic model.

OLWS provided billed metered water consumption data for the purposes of analyzing historical consumption trends and estimating wastewater flows. The OLWS water consumption data included monthly consumption for 7,218 customer connections (6,743 parcels) from January 2018 through August 2021 as shown in Figure 2-1. Billing data associated with fire service meters was excluded from the analysis. Additionally, billing data associated with open space parcels was excluded as this water is assumed to be irrigation water that will not enter the wastewater collection system. Water consumption records were not available for customers served by the City of Gladstone. Wastewater flow for these parcels was estimated using a wastewater generation factor based on land use and spatially allocating flow to the centroid of its corresponding parcel. The wastewater generation factor development is discussed further in Section 2.3.

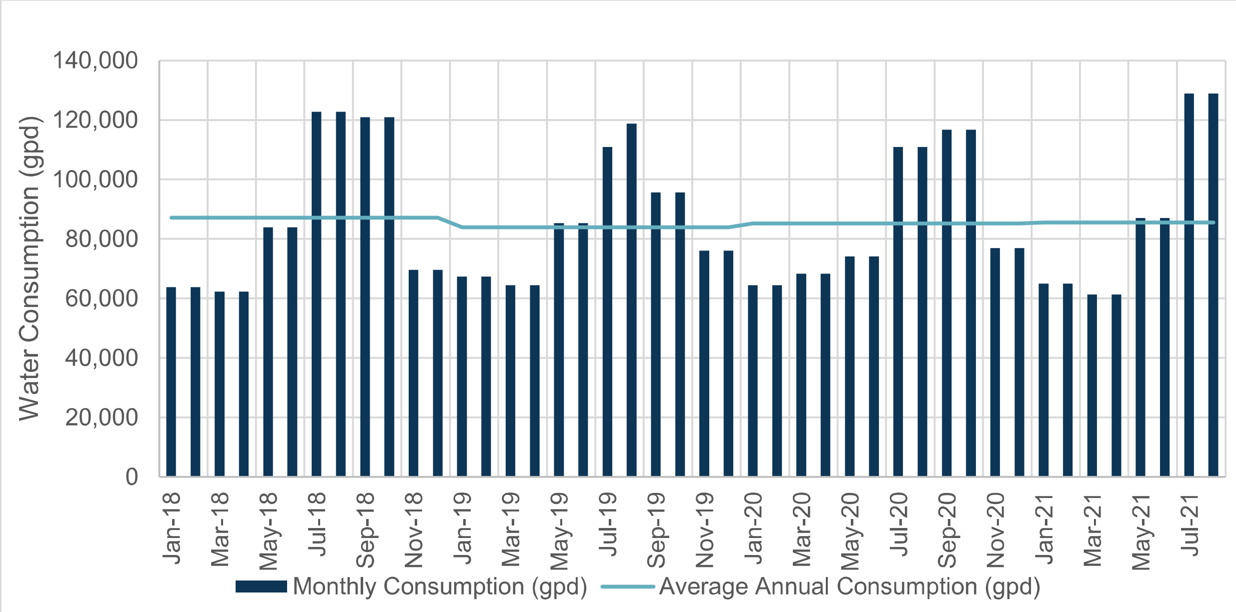


Figure 2-1. Monthly & Annual Average Water Consumption for January 2018 – August 2021

Wastewater flow is typically more closely related to winter water use than summer water use, given that there is generally less outdoor water use for landscape irrigation in the winter when rainfall amounts are high and evapotranspiration (ETo) is low. WSC reviewed the monthly water consumption data and selected the winter months of December, January, February, and March as the most representative months with the least amount of outdoor water use. The daily water consumption for each account was averaged from December through March to provide an estimate of water usage for each account. Water to wastewater factors were developed for each land use type and applied to each account's corresponding water usage to estimate the average wastewater flow within the collection system. For parcels without billing data, a wastewater generation factor was applied to the parcel area based on its land use. These water to wastewater factors were iterated to align with the influent flow into the wastewater treatment plant (WWTP) under dry weather conditions. This flow is representative of the average dry weather flow (ADWF) within the collection system and was estimated to be 1.85 million gallons per day (mgd).

The ADWF within the collection system was estimated using readings from the Influent Lift Station at OLWS' WWTP, which is representative of the flow within the collection system. To determine the ADWF, the available Influent Lift Station flow data and rain gauge data was analyzed to identify 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 data, the window of July 8, 2021 through July 28, 2021 was selected as the most representative dry weather period and the average flow over this time was calculated. Using the hourly breakdown of the flow data, diurnal multipliers were determined for each hour by dividing the average hourly flow by the ADWF. The dry weather flow multipliers are shown in Table 2-1. To understand if the COVID-19 pandemic had influenced the ADWF, a secondary dry weather period from July 18, 2019 through July 26, 2019 was evaluated as a check. This period revealed an ADWF of 1.88 mgd with similar peaking factors. Since the data was within 2% of each other, it was determined that COVID-19 did not significantly skew the wastewater flow in the collection system.

Table 2-1: Average Dry Weather Flow Diurnal Multipliers

Hour[1]	Average Hourly Flow (mgd)	Diurnal Multiplier
0	1.663	0.90
1	1.376	0.74
2	1.146	0.62
3	1.024	0.55
4	0.955	0.52
5	0.982	0.53
6	1.148	0.62
7	1.491	0.81
8	1.924	1.04
9	2.234	1.21
10	2.411	1.30
11	2.420	1.31
12	2.374	1.28
13	2.294	1.24
14	2.201	1.19
15	2.100	1.13
16	2.055	1.11
17	2.049	1.11
18	2.083	1.12
19	2.127	1.15
20	2.147	1.16
21	2.157	1.16
22	2.123	1.15
23	1.961	1.06
ADWF	1.852	1.00

[1]Hour 0 represents the period from 12 am – 1 am.

2.2. Spatial Allocation

OLWS' ADWF data was associated with GIS data to spatially allocate existing wastewater flows and develop wastewater generation factors used for projecting future wastewater flows. The process to establish wastewater generation factors for flow projection is shown in Figure 2-2.

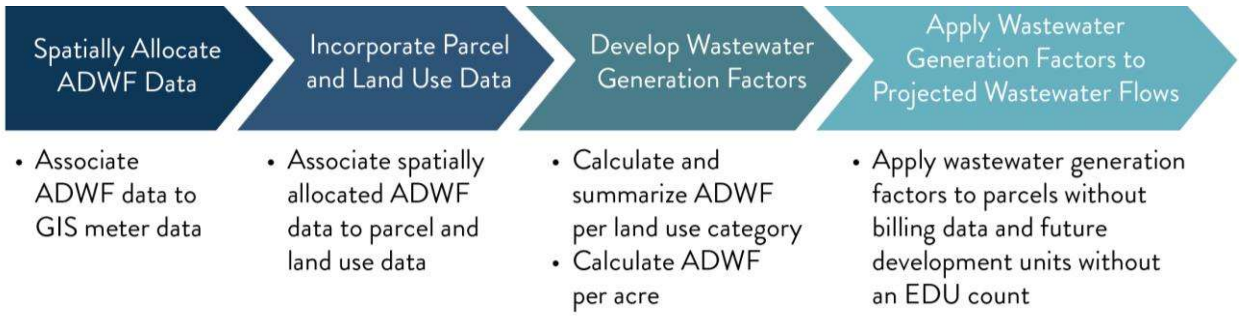


Figure 2-2. Spatially Allocated Wastewater Flow Projection Process

The original water consumption account data discussed in Section 2.1 was used to spatially allocate the ADWF data to geographic locations. Each consumption record consisted of a unique address that could be tied to an Assessor's Parcel Number (APN) for allocating the load in space.

As discussed in Section 2.1, water billing records were only available for parcels who receive water from OLWS but OLWS' collection system service area consists of customers served water by the City of Gladstone in addition to those by OLWS. As a result, 1,496 parcels were identified as having an existing load but not having water billing data. These parcels were assigned a flow using a wastewater generation factor based on their land use and area.

A map showing the spatially allocated existing loading by land use zone is attached as Appendix B.

2.3. Wastewater Generation Factors

As discussed in Section 2.2, ADWF data was associated with parcels' land use and development data to aid in developing wastewater generation factors to project flow when billing data was unavailable. The unassociated accounts discussed in Section 2.2 were excluded from wastewater generation factor development due to the lack of water billing data. However, these parcels were included as loads in the model by applying the calculated wastewater generation factors to approximate a load.

The parcel underlying each associated spatially allocated ADWF record was matched to the corresponding APN from GIS parcel data provided by Clackamas County. The acreage associated with each parcel and therefore each ADWF record, was used to calculate wastewater generation factors by land use category. A summary of the wastewater generation factors is shown in Table 2-2.

on Factors

tors

	A	B	C	D	E	F	G	H
			C=A*B				G=E*F	H=C+G
cation	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 BWF
				Residential				
acre tax lot	5,726	90	5,153	22.9	225	0.6	129	5,
),000 sq ft lot	511,491	90	460,342	1,163.1	396	82.1	32,523	49
000 sq ft lot	93,808	90	84,427	203.8	414	12.5	5,158	89
000 sq ft lot	284,254	90	255,829	440.6	581	31.8	18,455	27
000 sq ft lot	12,643	90	11,379	15.4	738	168.1	124,037	13
low Density	196,715	96	188,847	143.1	1,306	19.8	25,879	21
erate Density	157,202	96	150,914	39.0	3,500	31.3	109,447	26
tal	1,261,839		1,156,891	2,027.9		346.1	315,628	1,47
				Non-Residential				
cial	310,799	96	298,367	302.7	975	44.5	43,372	34
mmercial	1,372	100	1,372	2.3	710	0	0	1,
	16,092	100	16,092	33.3	600	5.2	3,145	19
Density	125	95	119	0.9	129	0	0	1
um Density	13,939	95	13,242	5.4	2,439	0	0	13
Space (Includes	5,149	95	4,892	56.1	80	9.8	781	5,
Subtotal	347,476		334,084	400.7		59.5	47,297	38
	1,609,315		1,490,975	2,428.6		405.6	362,926	1,85

n was calculated from the average water meter records from December-March between 2018-2020 within the OLWS water service area.
s 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 i
udes all parcels within OLWS' wastewater service area. The number of EDUs for non-residential customers is calculated specifically for this master plan and uses a different metho

zoning code associated with schools. The water use and subsequent wastewater load in the table is representative solely of schools served by the OLWS. Parks and other open sp
all assumed to be outdoor water use that will not contribute to the wastewater collection system.

= base wastewater flow gpad = gallons per acre per day EDU = equivalent dwelling unit OLWS = Oak Lodge Water Services MGD = million gallons per day WWTP = wa

WSC evaluated the sensitivity of each wastewater generation factor by excluding the largest and smallest parcels for each land use to understand if this skewed the factor such that it was not representative of the land use type. Four land use zones saw noticeable impacts when excluding the largest parcel –MFR3, CN, IL, and POS. The IL zone also saw significant changes when the smallest parcel was removed. Changes were made to these zones to adjust for the larger parcels skewing the flow factor. A summary of the sensitivity analysis is provided in .

Table 2-3: Wastewater Generation Factor Sensitivity Analysis

Zone	Calculated Wastewater Generation Factor (gpd/acre)	Wastewater Generation Factor with Largest Parcel Excluded (gpd/acre)	Wastewater Generation Factor with Smallest Parcel Excluded (gpd/acre)	Final Wastewater Generation Factor (gpd/acre)
SFR2	225	236	221	225
SFR3	396	394	396	396
SFR4	414	420	414	414
SFR5	581	583	581	581
SFR6	738	745	739	738
MFR1	1,320	1,328	1,314	1,306
MFR3	3,867	2,945	3,885	3,500
CG	986	976	985	975
CN	601	708	574	710
IL	483	598	219	600
MUR3	129	Only 1 Parcel	Only 1 Parcel	129
MUR7	2,439	Only 1 Parcel	Only 1 Parcel	2,439
POS	87	80	87	80

The single family residential (SFR) properties were evaluated to determine an estimated flow per equivalent dwelling unit (EDU). OLWS provided the EDU counts for all SFR properties served by their water system. The ADWF that was calculated from the water billing data for each SFR zone was then divided by the number of EDUs to predict a flow per EDU. This was iterated with different water to wastewater factors until the flow per EDU was approximately the same for each SFR land use zone. The resulting flow per EDU established for future development is shown in Table 2-4.

Table 2-4: Residential Flow Factor

Land Use Type	Flow Factor
Residential	131 gpd/EDU

2.4. Future Loading Projection

2.4.1. Buildout Development

Future loading projections were estimated using a buildable lands inventory (BLI) prepared by Angelo Planning Group (APG) that evaluated OLWS' collection system service area to estimate the amount of anticipated buildout at the parcel level. The BLI evaluated parcels to determine if they were developed, partially vacant, or vacant. Buildout development was assumed as follows:

- Vacant land is fully developable.
- Partially vacant land can be developed if the lot has greater than ½ acre of constrained land. For the purposes of development, it is assumed ¼ acre is retained for the existing home and the remaining acreage can be developed.
- Developed land consists of lots less than ½ acre that are currently occupied or meet the zoning's requirement for fully developed. These lots are considered unsuitable for future development.
- Land with slopes of 25% or greater is considered fully constrained and not developable.
- Riparian Habitat Class I and II are considered fully constrained and not developable.
- Upland Habitat Class A is considered fully constrained and not developable.
- Riparian Class III and Upland Class B and C land is considered to be 50% constrained.

Using these assumptions, APG estimated the number of additional units anticipated for each type of land use. The total number of new dwelling units is summarized in Table 2-5. APG determined that no additional non-residential development is anticipated. Additional information can be found in the BLI, which is attached as Appendix C.

2.4.2. Middle Housing

For the purposes of planning, some of the development on the vacant land and partially vacant land (Table 2-5) will likely be middle housing (duplexes, triplexes, quadplexes, townhomes, and cottage clusters). In the BLI, APG assumed that middle housing could be present in 25% of these developments, thus increasing the capacity by an additional 35 to 350 units.

In addition to some of the new development being middle housing, APG assumed 5% of developed tax lots in the study area would redevelop to include middle housing. For planning purposes, these lots would add an average of 1.5 additional units, which accounts for most of the development being duplexes but some being triplexes, quadplexes, or cluster developments. This is anticipated to add an additional 541 units of infill to OLWS' wastewater service area.

Table 2-5: Additional Dwelling Units at Buildout

	Zone	Zone Classification	Unit Capacity
Partially Vacant	HDR	MFR3	0
	MR1	MFR1	118
	R10	SFR3	531
	R20	SFR2	8
	R7	SFR5	183
	R7.2	SFR6	44
	R8.5	SFR4	134
Vacant	HDR	MFR3	30
	MR1	MFR1	38
	R10	SFR3	92
	R20	SFR2	0
	R7	SFR5	72
	R7.2	SFR6	15
	R8.5	SFR4	61
Total			1,326

2.4.3. Commercial Redevelopment

In conversations with Clackamas County, APG identified the possibility of redevelopment of under-utilized lots near the SE Park Avenue Transit Station. Additionally, long-term retail trends could result in redevelopment of some commercial properties into multi-family properties. APG estimated there could be an additional 400 units in the SE Park Avenue Corridor and an additional 400 to 800 units elsewhere along that corridor. For the purposes of future loading, WSC is only evaluating the 400 additional units near the SE Park Avenue Transit Station, as this scenario is considered more likely to occur than the other redevelopment.

2.4.4. Buildout Loading

Buildout loading was estimated using the wastewater generation factors developed in Section 2.3 and the number of new units estimated as part of 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. A summary of the additional buildout flows is provided in Table 2-6 and a summary of all flows is provided in Table 2-7. A map of the buildout loading is included in Appendix B.

Table 2-6: 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 2-2.
[2] All residential units were assigned a load of 131 gpd/EDU

gpd = gallons per day

e Flows

	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 Exis Buildout, Housing, Commerc Redevelo (gpd)
– ½	5,282	40	2,620	950	0	3,570	7,902	8,852	8,852
– t	492,865	3,762	88,425	51,054	0	139,479	581,290	632,344	632,344
–	89,585	684	20,305	11,004	0	31,309	109,890	120,894	120,894
–	274,283	2,094	29,344	27,271	0	56,615	303,627	330,898	330,898
–	135,416	1,034	7,336	9,380	0	16,716	142,752	152,132	152,132
/ery	214,725	1,639	21,091	5,175	0	26,266	235,816	240,991	240,991
nsity	260,361	1,987	4,585	1,114	0	5,699	264,946	266,060	266,060
	1,472,517	**11,240**	**173,706**	**105,948**	**0**	**279,654**	**1,646,223**	**1,752,171**	**1,752,17**
	341,739	2,609	3,560	0	52,400	55,960	345,299	345,299	397,699
	1,372	10	0	0	0	0	1,372	1,372	1,372
l	19,237	147	1,599	0	0	1,599	20,836	20,836	20,836
.ow	119	1	0	0	0	0	119	119	119
ity	13,242	101	0	0	0	0	13,242	13,242	13,242
en es	5,673	43	0	0	0	0	5,673	5,673	5,673
ial	**381,382**	**2,911**	**5,159**	**0**	**52,400**	**57,559**	**386,541**	**386,541**	**438,941**
	1,853,899	**14,151**	**178,865**	**105,948**	**52,400**	**337,213**	**2,032,764**	**2,138,712**	**2,191,11**

od = gallons per day EDU = equivalent dwelling unit

2.5. Peak Wet Weather Flow

2.5.1. 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 OAR 340-041-0009 (7) and (8), all sanitary sewer overflows (SSOs) are prohibited. However, DEQ may withhold enforcement action for an 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, 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. (1) Figure 2-3 shows a comparison of the storm hyetographs for reference.

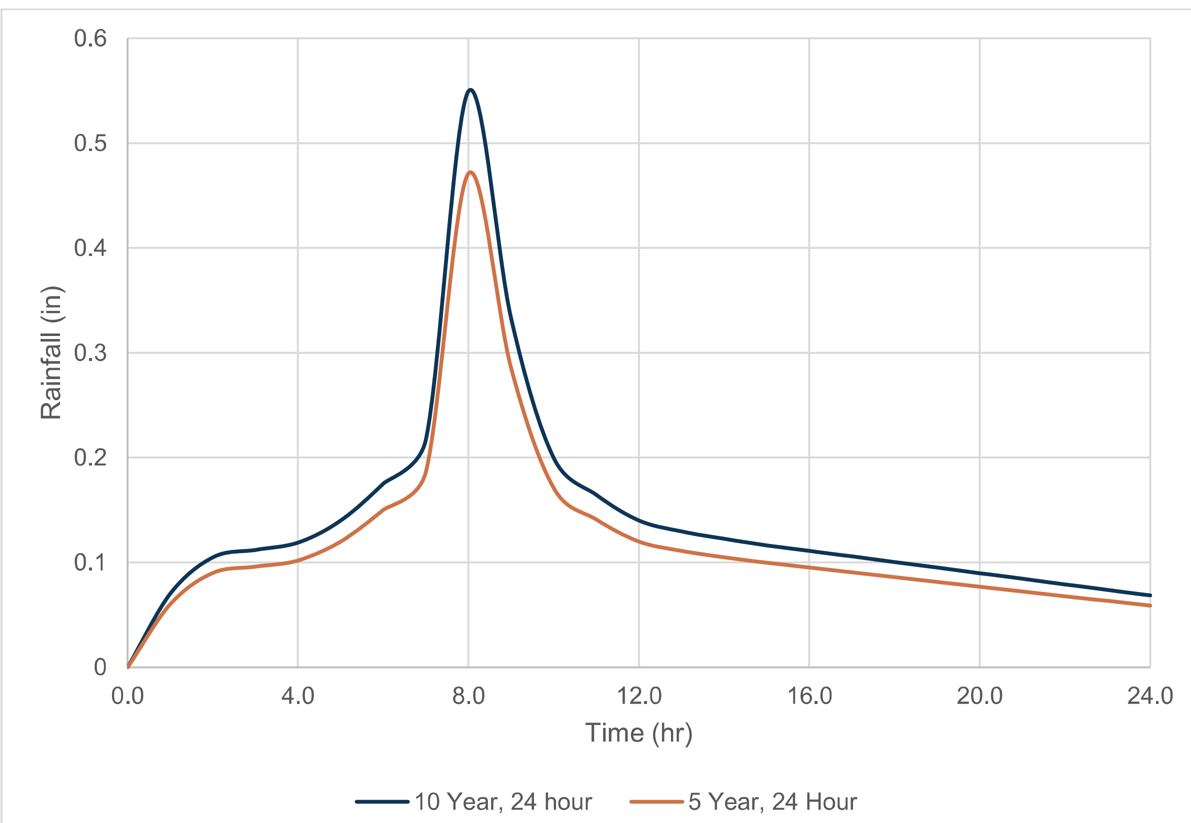


Figure 2-3: Comparison of Storm Hyetographs

2.5.2. Peak Wet Weather Flow

Peak hour wet weather flow (PHWWF) was estimated by running the calibrated model (see Section 4) with a 5-year, 24-hour design storm and extracting the flow at the Influent Lift Station. This was done under existing and buildout conditions. Buildout conditions included buildout, middle housing, and commercial redevelopment as described in Section 2.4. The results are shown below in Table 2-8.

Table 2-8: Flow Summary

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

Section 3. Model Loading

As discussed in Sections 2.2 and 2.3, estimated wastewater flows were spatially allocated based on the centroids of the parcels with water billing data or the parcels identified for development. Appendix B displays the loading nodes with respect to estimated flows.

The loading nodes were imported into the hydraulic model and flows were distributed to manholes based on the nearest manhole method. This method locates the manhole nearest to a loading node and allocates the total flow of that node to the nearest manhole. The nearest manhole method was also used for allocating the buildout flow.

Section 4. Calibration

The hydraulic model was calibrated to dry weather and wet weather conditions using a combination of Influent Lift Station data and flow monitoring data collected in the system. Flow meters were deployed from December 22, 2021 through February 28, 2022. Since they were deployed during the winter with wet weather conditions, the flow monitoring data is representative of conditions with an elevated groundwater table. To estimate dry weather flow, Influent Lift Station data from the summer months was used when the groundwater table was significantly lower.

4.1. Dry Weather Calibration

As discussed in Section 2.1, the dry weather flow was estimated at the WTTP using Influent Lift Station data from July 8, 2021 through July 28, 2021. This flow was then spatially allocated to parcels within the collection system as outlined ins Section 2.2. Dry weather flow calibration was achieved by comparing modeled flows to the observed flows at the Influent Lift Station to verify flow criteria such as the shape of the hydrograph, timing of peak flows and troughs, magnitude of peak flows, and total flow volume. A summary of the dry weather calibration criteria is provided in Table 4-1.

Table 4-1: Summary of Dry Weather Flow Calibration Criteria

Parameter	Criteria
Shape	The shape of the modeled hydrograph should visually align with the shape of the observed hydrograph.
Timing	Modeled peaks and troughs should be within 1 hour of the observed peaks and troughs.
Peak Flow	± 10% of observed peak flow
Flow Volume	± 10% of observed peak volume

A calibration hydrograph was developed for the collection system. Modeled dry weather flows were then compared to the average dry weather flows during the calibration period. The resulting hydrograph comparisons are shown in Figure 4-1. The spatial allocation of the loading satisfied all dry weather calibration criteria as shown by the results summary in Table 4-2.

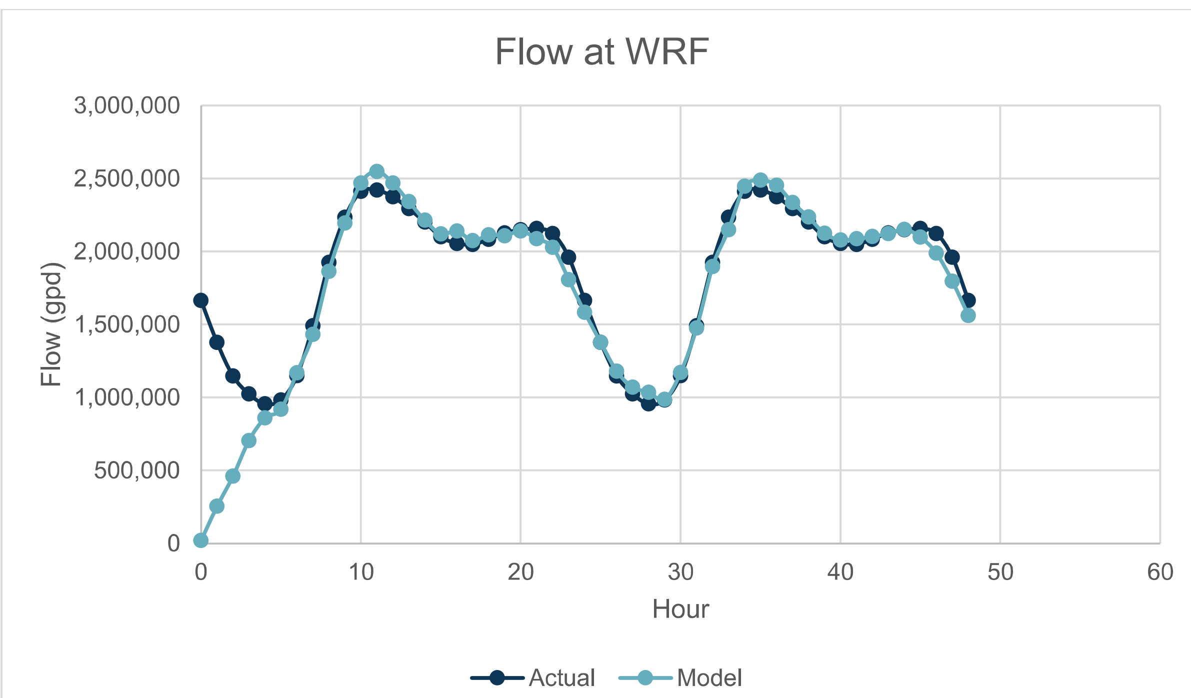


Figure 4-1: Dry Weather Flow Calibration Hydrograph at the Influent Lift Station

Table 4-2: Dry Weather Flow Calibration Results

Criteria	Influent Lift Station
Visually Aligned	Yes
Timing of Peaks and Troughs Aligned	Yes
Peak Flow (% of Observed)	+5.3%
Flow Volume (% of Observed)	+3.6%

4.2. Wet Weather Calibration

4.2.1. RTK Unit Hydrographs

Wet weather flow monitoring was used to capture rainstorm data and understand how OLWS' collection system responds to a storm. The goal of this monitoring was to capture a system stressing rain event to understand RDII within OLWS' collection system. According to ADS Environmental, "system stressing events are typically more than one inch of rainfall in a 24-hour period." (2) Table 4-3 shows the results of the top storms captured during the monitoring period.

Table 4-3: 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 4-2). 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. (3)

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 and the modeled wet weather hydrograph achieved the calibration criteria outlined in Table 4-4 when compared with observed flow monitoring results. 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.

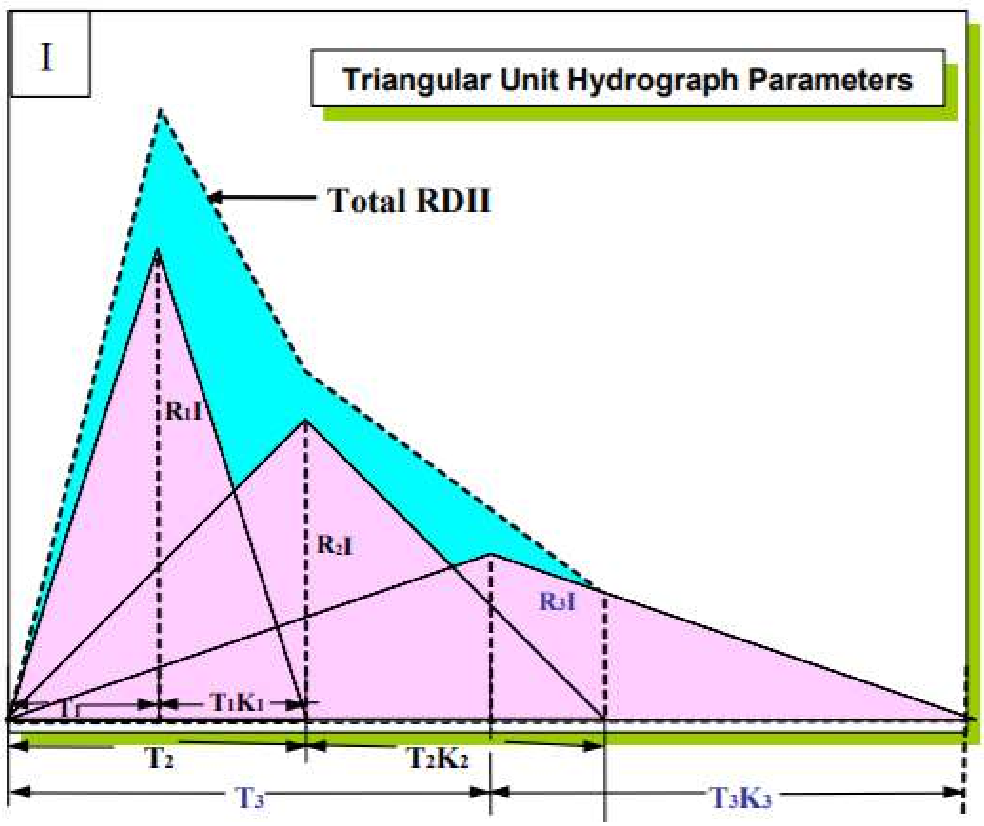


Figure 4-2: RTK Unit Hydrograph Parameters (3)

Table 4-4: Wet Weather Flow Calibration Criteria

Parameter	Criteria
Shape	The shape of the modeled hydrograph should visually align with the shape of the observed hydrograph.
Timing	Modeled peaks and troughs should be similar to the observed peaks and troughs.
Flooding	Predicted flooding locations align with field observations or historical records
Peak Flow	-15% to +25% of observed peak flow
Flow Volume	-10% to +20% of observed peak volume

4.2.2. Wet Weather Modeling

Catchments were established in the model using the Thiessen Polygon tool within SewerGEMS, which creates a catchment around each manhole within OLWS' collection system such that any point within the catchment is closer to the catchment's manhole than any other manhole within the system. RTK parameters were assigned to each catchment such that the R, T, and K values were the same for all catchments within a basin. These parameters were finalized by iterating through typical values for R, T, and K and observing the impact on the modeled hydrograph relative to the observed hydrograph. The resulting RTK parameters are presented in Table 4-5 and Figure 4-3.

Table 4-5: Model RTK Parameters

Basin	R_1	T_1	K_1	R_2	T_2	K_2	R_3	T_3	K_3
E-949	0.021	3.0	1.0	0.045	7.0	3.0	0.045	12.0	5.0
B-299	0.020	2.0	2.0	0.045	8.0	3.0	0.045	12.0	5.0
2E-566	0.010	3.0	1.0	0.035	8.0	4.0	0.035	11.0	6.0
2B-3820	0.008	1.0	1.0	0.005	3.0	2.0	0.005	10.0	3.0
System RTK 1	0.008	2.0	2.0	0.027	8.0	3.0	0.027	12.0	5.0
System RTK2	0.008	1.0	1.0	0.05	3.0	2.0	0.005	10.0	3.0
System RTK 3	0.010	3.0	1.0	0.015	7.0	3.0	0.015	12.0	5.0

The final wet weather calibration results are presented in Table 4-6 for the flow meters with high quality data. Flow meters with poor data quality were excluded from the calibration process. Calibration hydrographs are shown below.

Table 4-6: Wet Weather Flow Calibration Results

	2B-3820	2E-566	B-299	E-949
Visually Aligned	Yes	Yes	Yes	Yes
Timing of Peaks and Troughs Aligned	Yes	Yes	Yes	Yes
Flooding Align with Observations	Yes	Yes	Yes	Yes
Peak Flow (% of Observed)	+1.7%	+1.7%	+2.8%	+4.3%
Flow Volume (% of Observed)	+6.0%	-4.1%	-1.1%	+2.5%

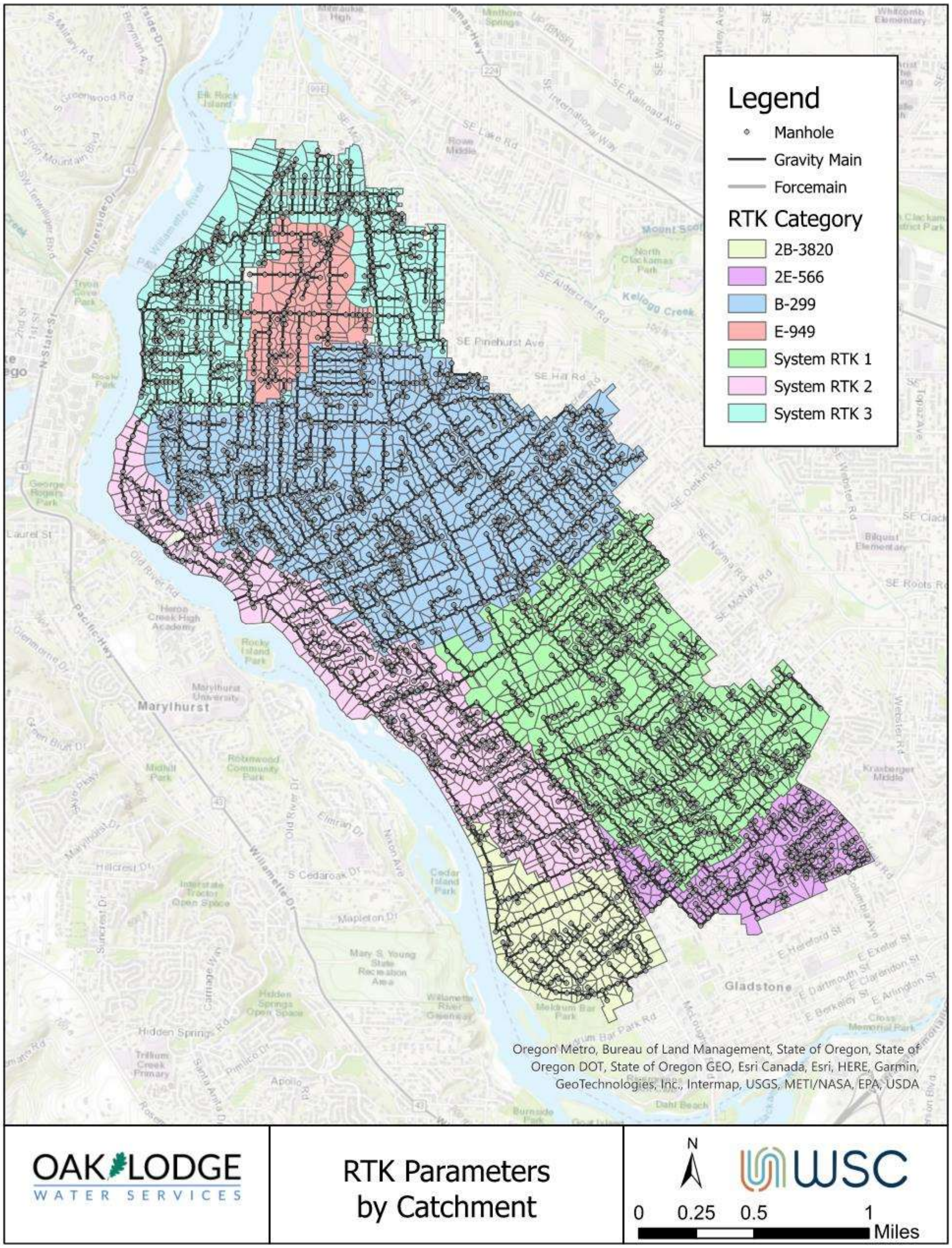


Figure 4-3: RTK Parameters by Catchment

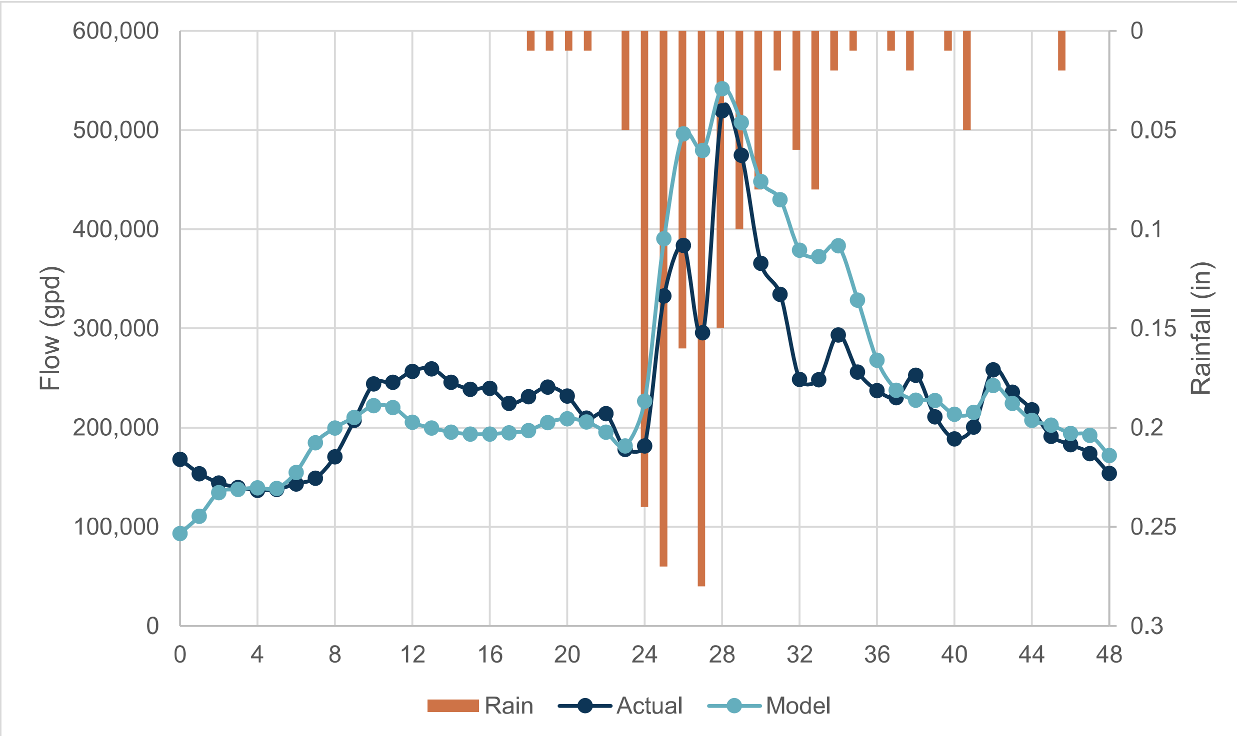


Figure 4-4: Calibrated Wet Weather Hydrograph at Manhole 2B-3820

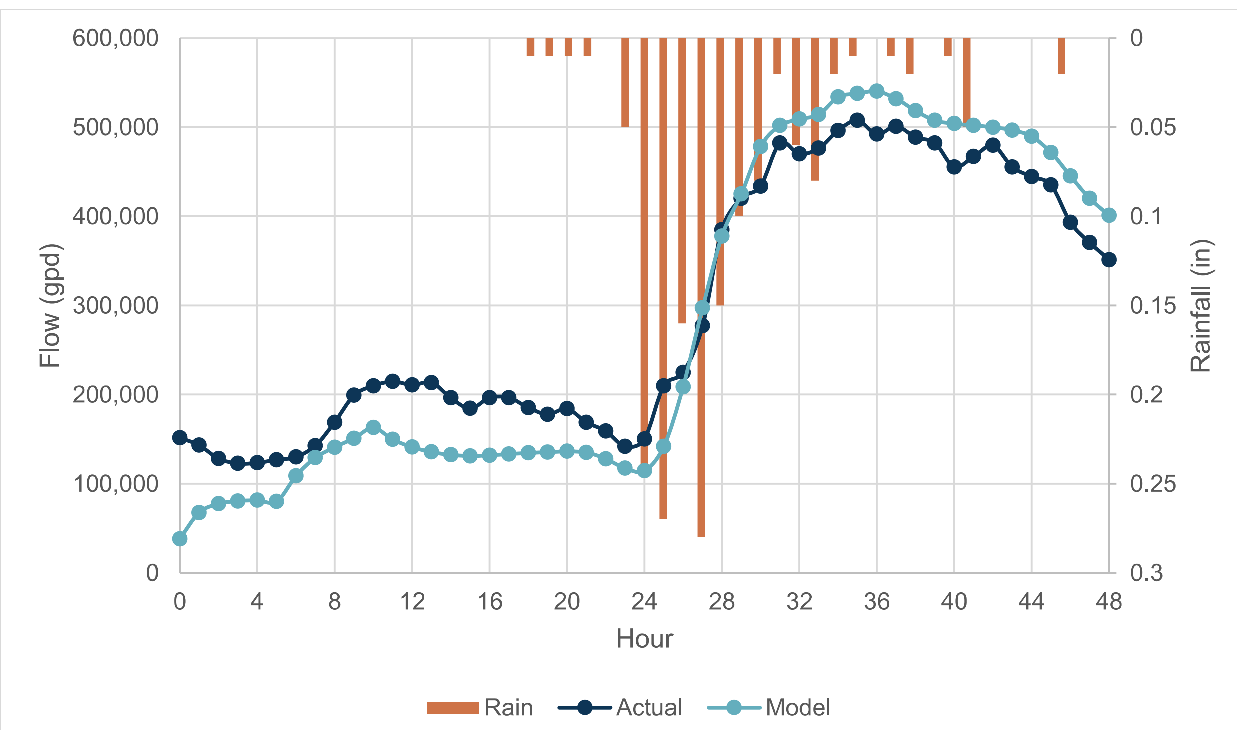


Figure 4-5: Calibrated Wet Weather Hydrograph at Manhole 2E-566

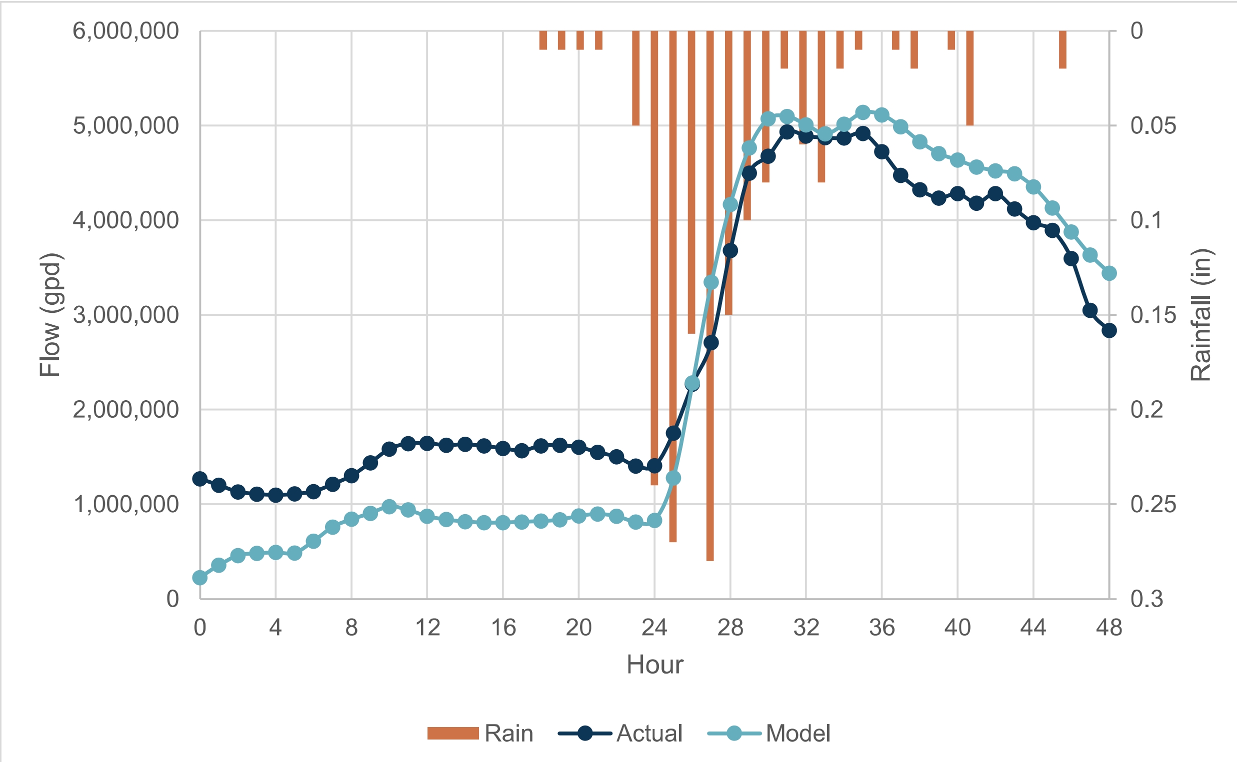


Figure 4-6: Calibrated Wet Weather Hydrograph at Manhole B-299

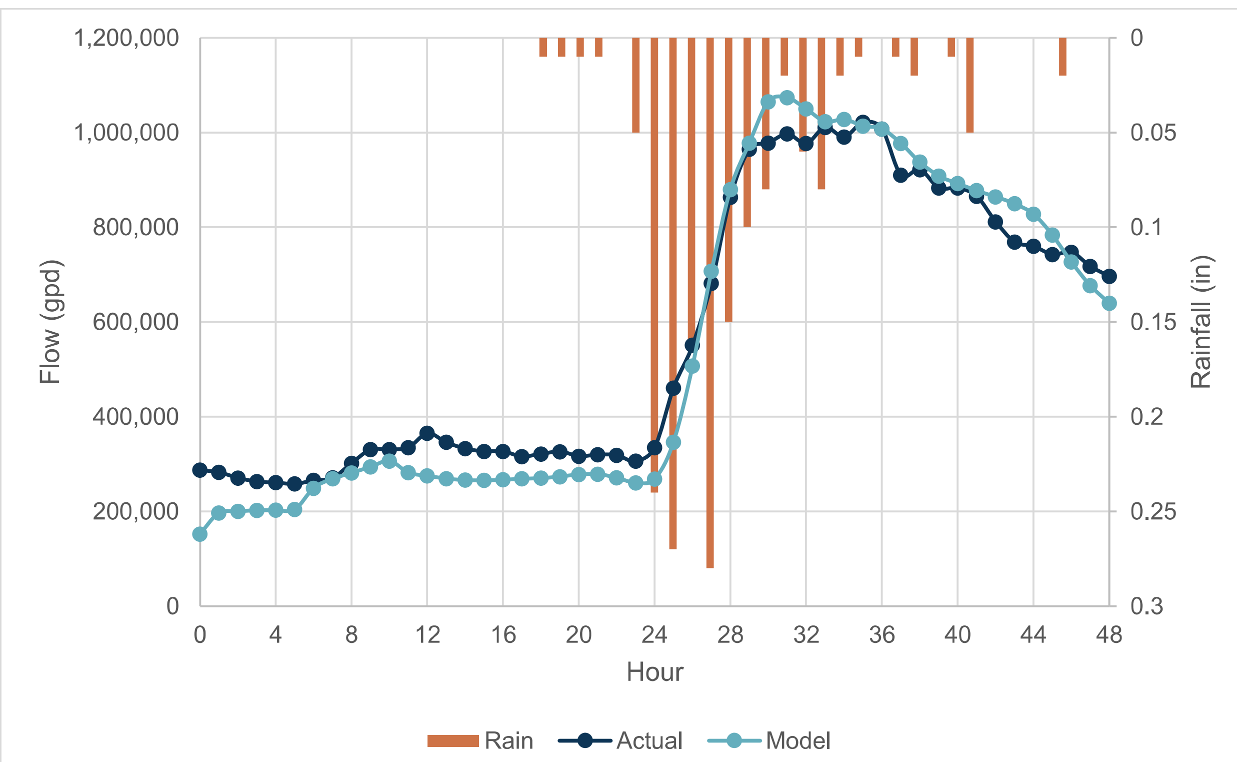


Figure 4-7: Calibrated Wet Weather Hydrograph at Manhole E-949

Section 5. References

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

2. *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.** Huntington Beach, CA : Water Environment Federation, 2005, Vols. Collection Systems 2005 - Sustaining Aging Infrastructure: System, Workforce, and Funding.

3. *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.

Appendix A Modifications to GIS Shapefiles

The following tables indicate common notes for assets within the model and what the notes mean.

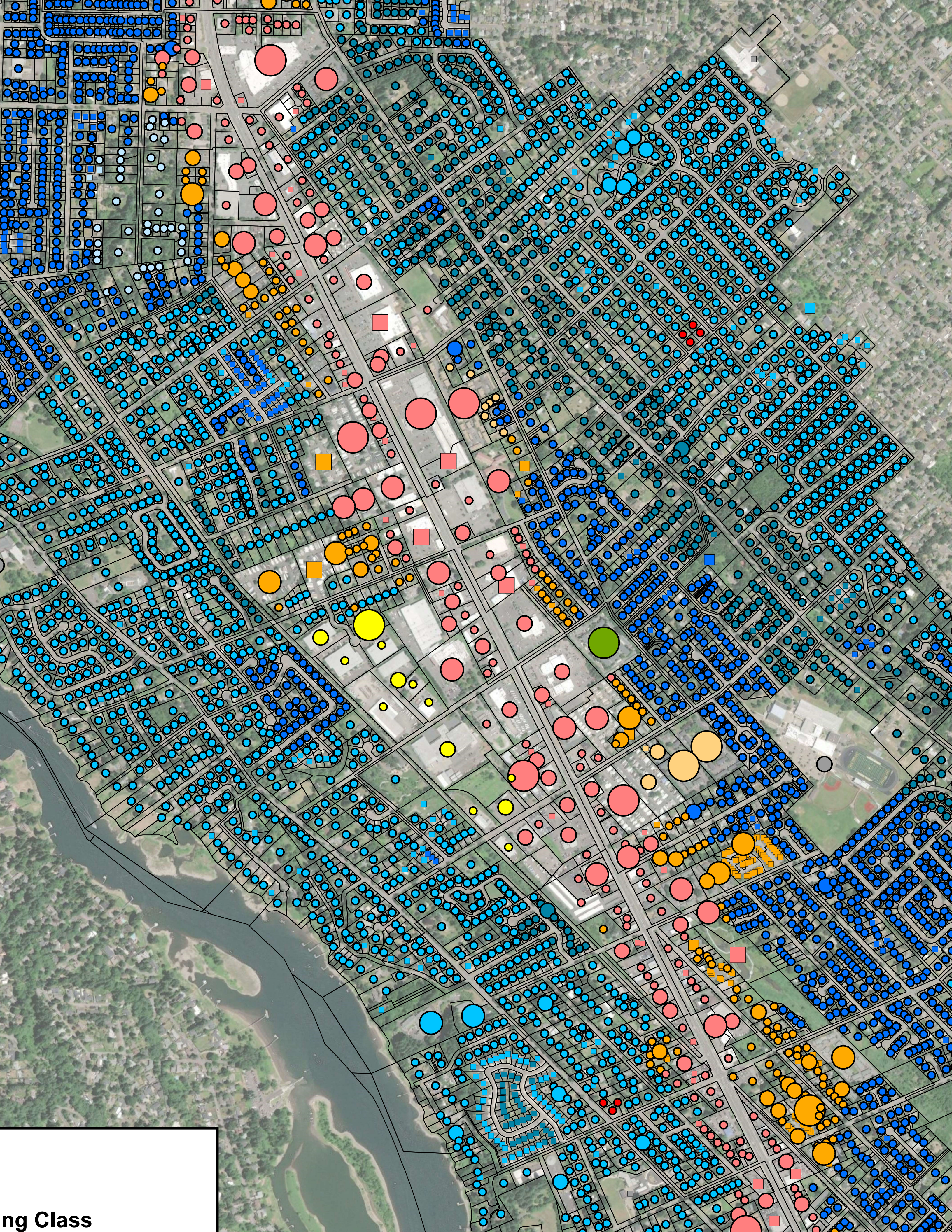
Gravity Mains

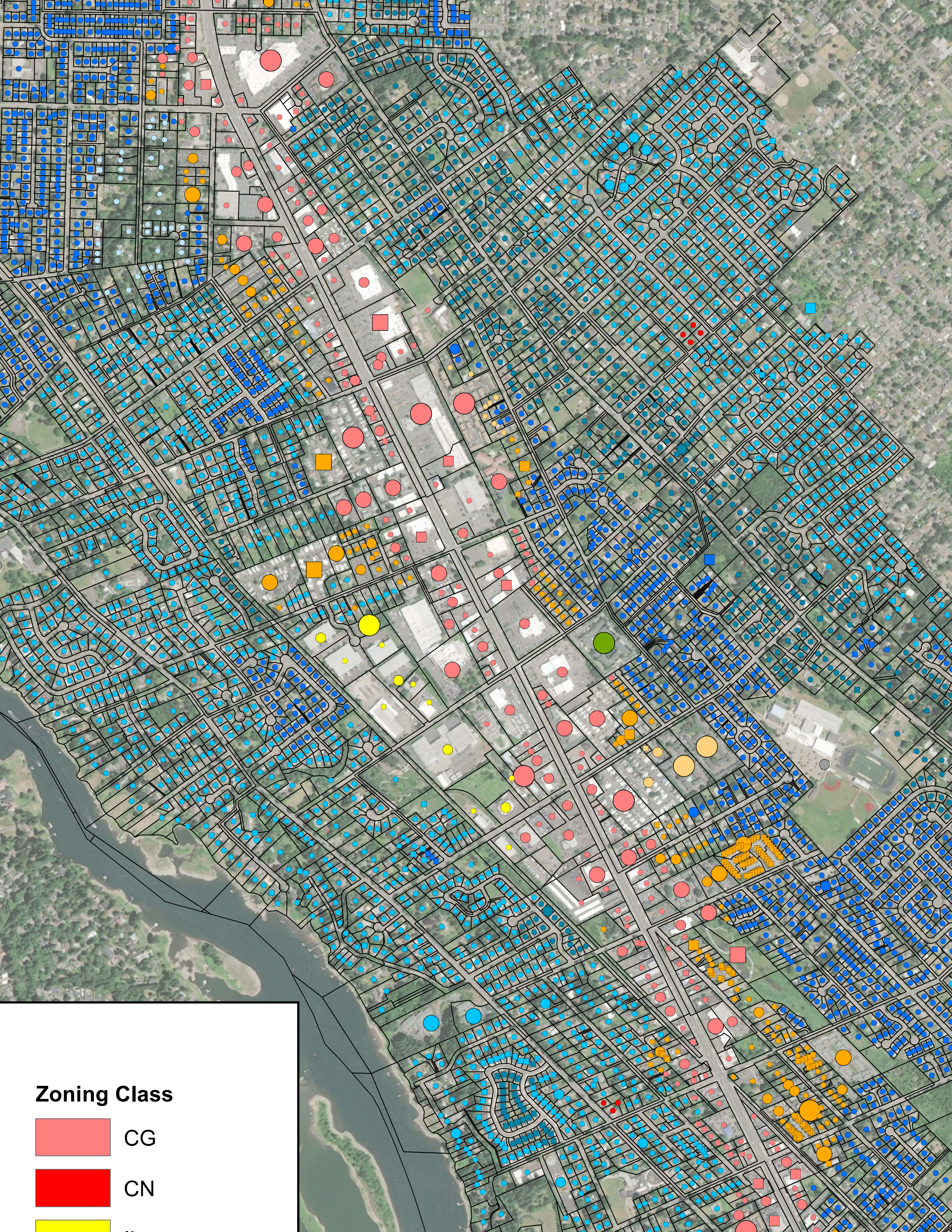
Note	Explanation
Set invert start and/or stop to match manhole.	The inverts provided in GIS did not align with those in the manhole such that there was a lack of continuity with the pipe missing the manhole. The inverts were updated to match the manhole for continuity.
Updated inverts per profile maps.	The inverts of the mains were updated to align with the historical profile maps (record drawings) for OLWS' collection system.
High slope	Mains with high slopes were flagged for confirmation. In most cases, the profile maps confirmed the steep slopes.
Minimum slope assumption	For mains not included in the profile maps with continuity errors, OLWS' minimum pipe slope was assigned to the main as a conservative estimate.

Manholes

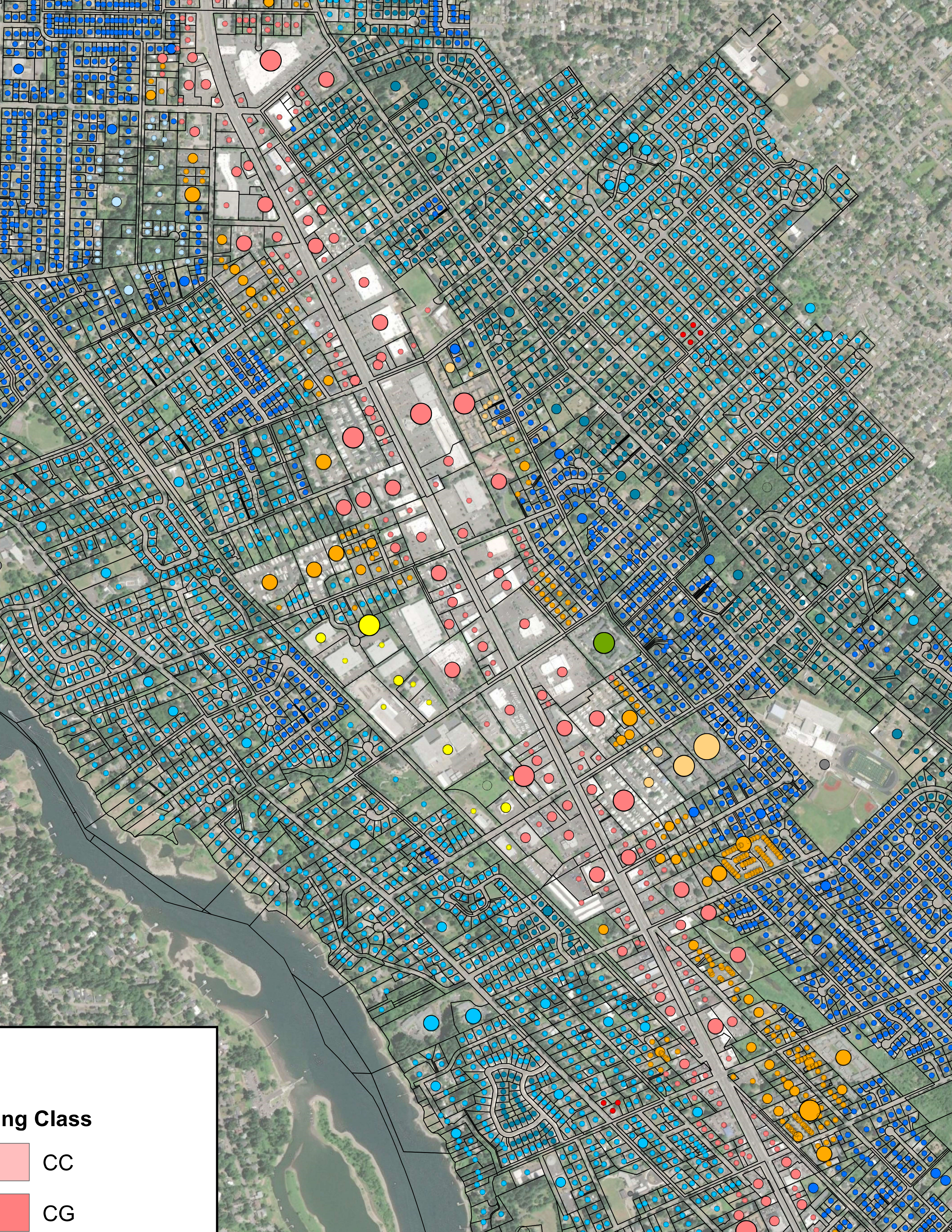
Note	Explanation
WSC estimated invert based on adjacent pipe invert values	Many of the manholes were missing invert elevations but the adjacent mains had invert data. In these cases, the invert was revised based on the corresponding invert for the pipe.
Minimum slope assumption	For manholes without profile map information that were missing invert data, OLWS' minimum pipe slope was used to interpolate and estimate an invert.
Missing Rim elevation	When the rim elevation was missing, it was either estimated using LIDAR data for the region or interpolated based on the rim elevation of adjacent manholes

Appendix B Existing and Future Flows


ng Class



Zoning Class
CG
CN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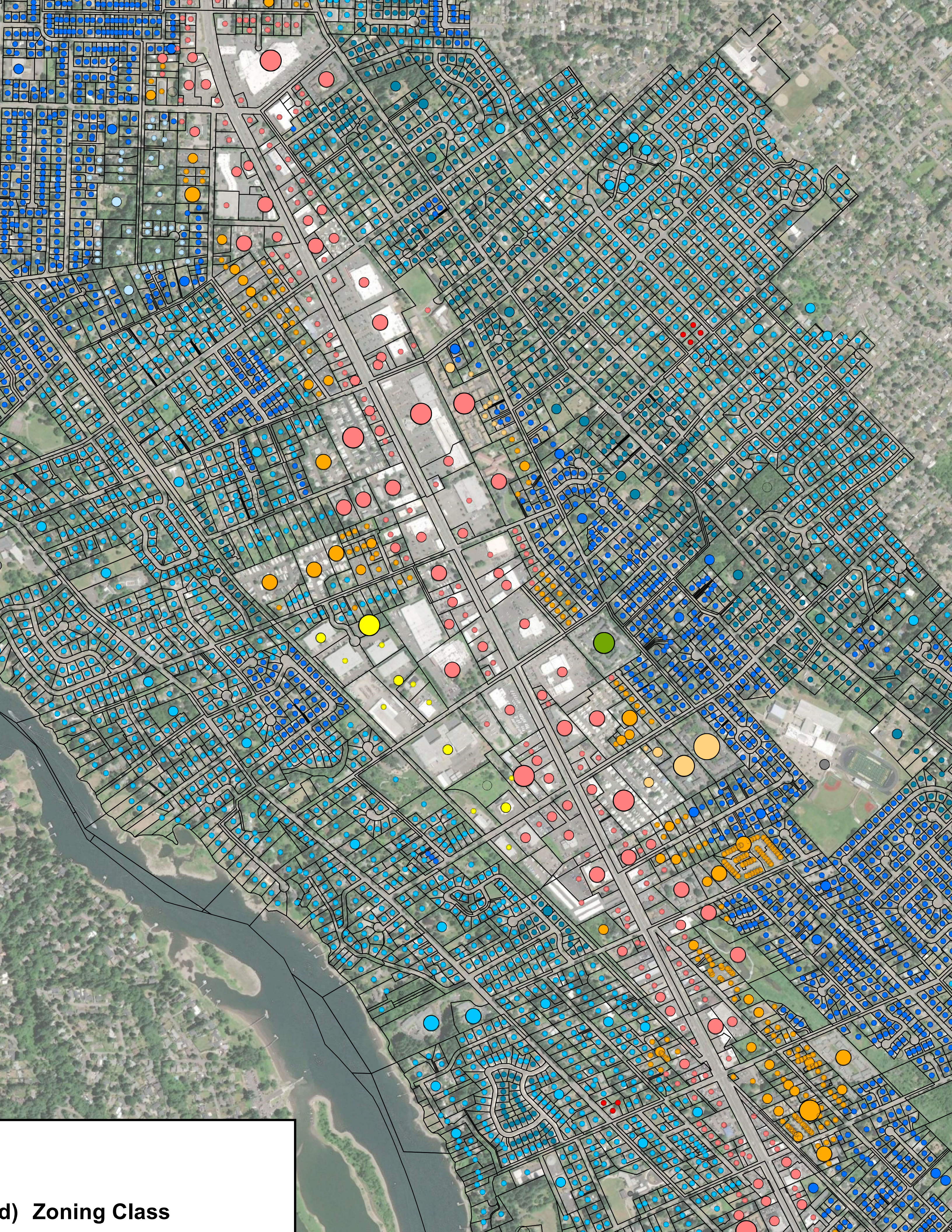
CC
CG



d) Zoning Class

Appendix C Buildable Lands Inventory

MEMORANDUM

Buildable Lands Inventory - Final Draft

Oak Lodge Wastewater Master Plan

DATE	January 27, 2023
TO	Scott Duren, PE, WSC
FROM	Andrew Parish, AICP, and Matt Hastie, AICP, MIG | APG
CC	

INTRODUCTION

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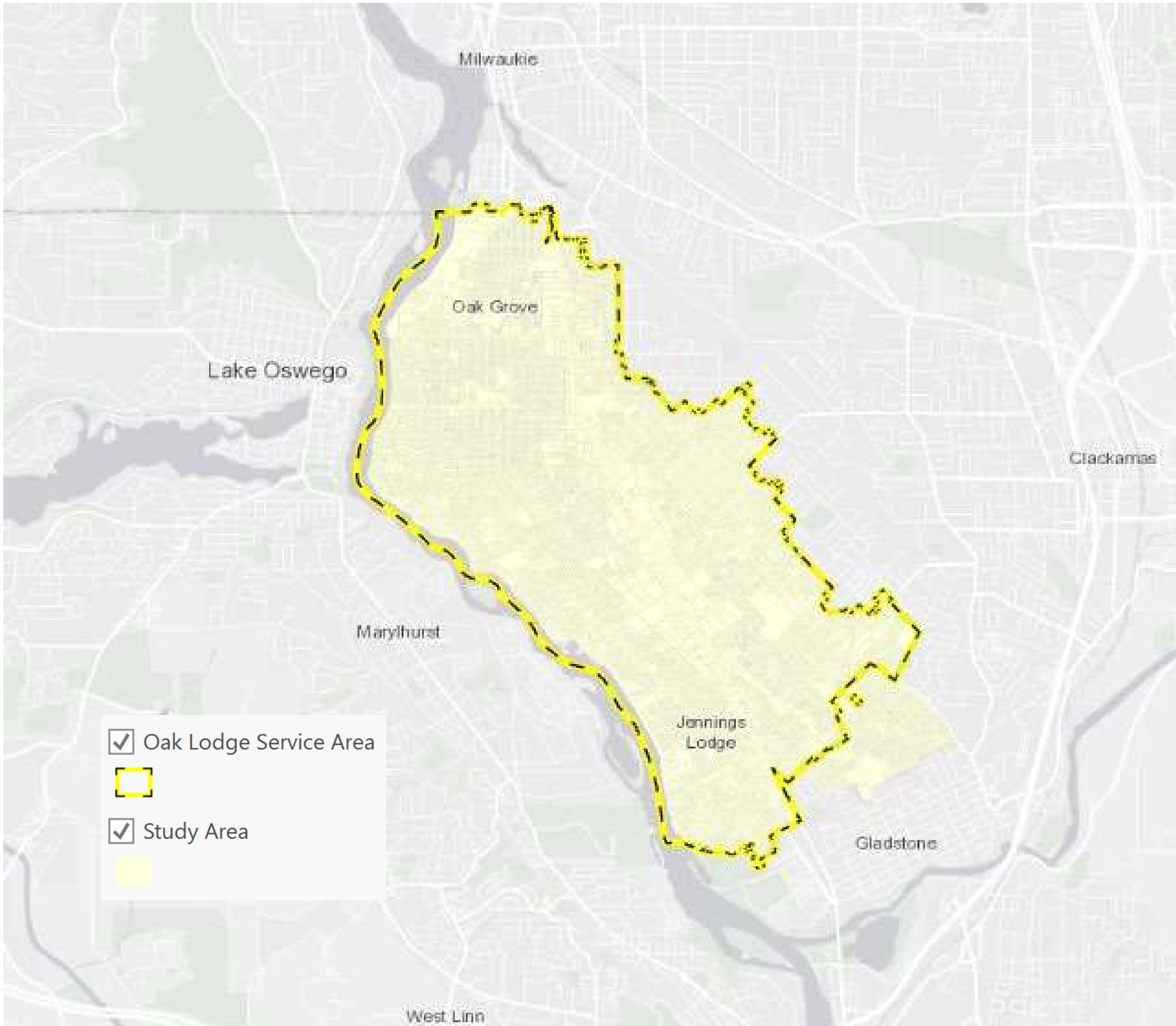
The components of this memorandum are as follows:

- Source Data
- Step 1: Environmental Constraints
- Step 2: Definition of Residential Land
- Step 3: Development Status
- Step 4: Acreage and Capacity
- Summary and Next Steps

Figure 1. Oak Lodge Service Area and Additional Study Area (Gladstone)



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OAR 660-024-0050

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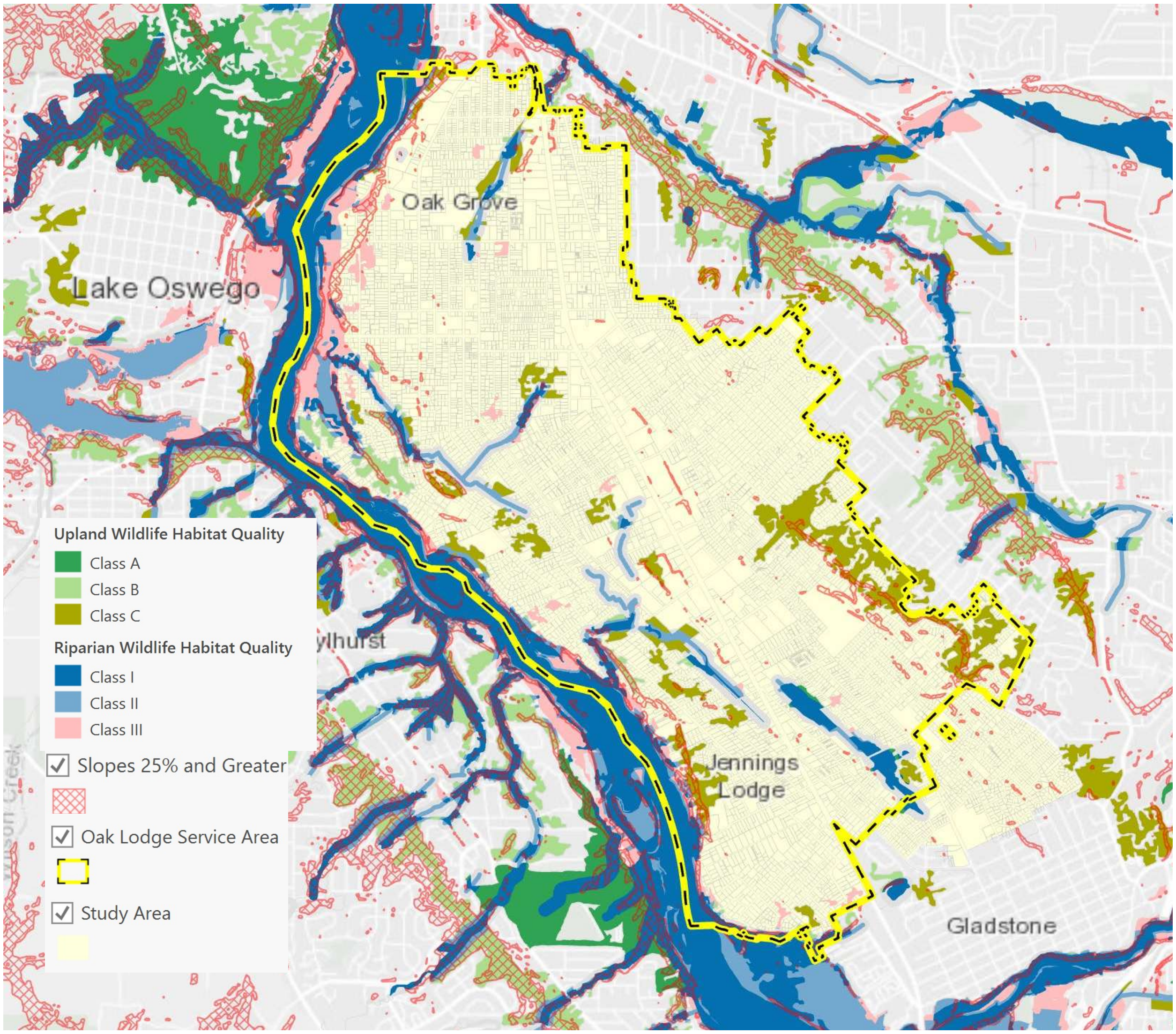

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Land within the study area is categorized by zoning/comprehensive plan designation. Generalized zoning from RLIS is shown in the figure below. The study area is predominantly residential, with a commercial corridor along Highway 99, and a small commercial/employment node in Oak Grove. Residential and employment land are treated differently in Step 3, and other land (such as parks and schools) are considered unavailable for future development.

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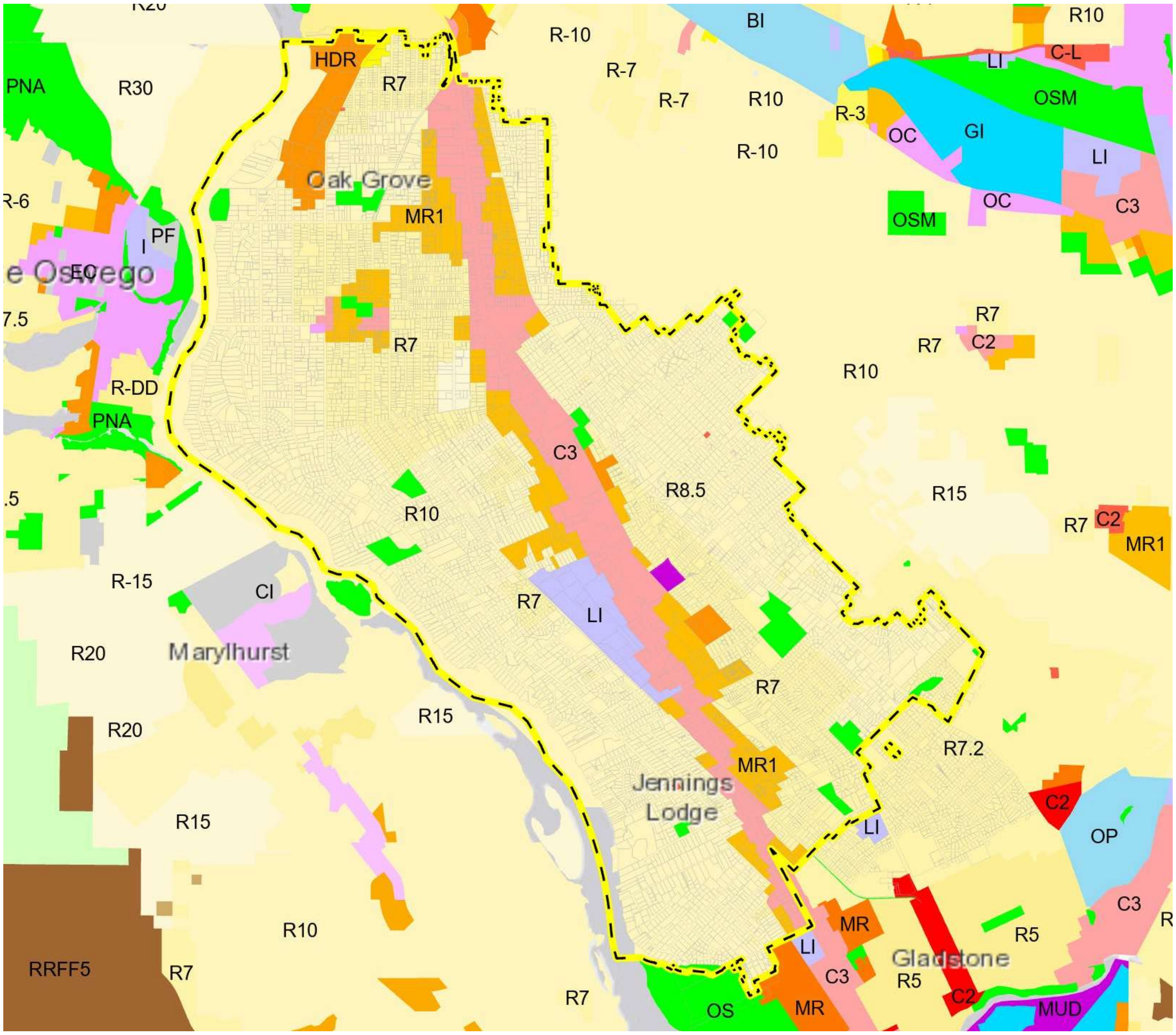

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Residential Land includes taxlots with the following zones.

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The following “development status” rules are applied to residential land in the study area:

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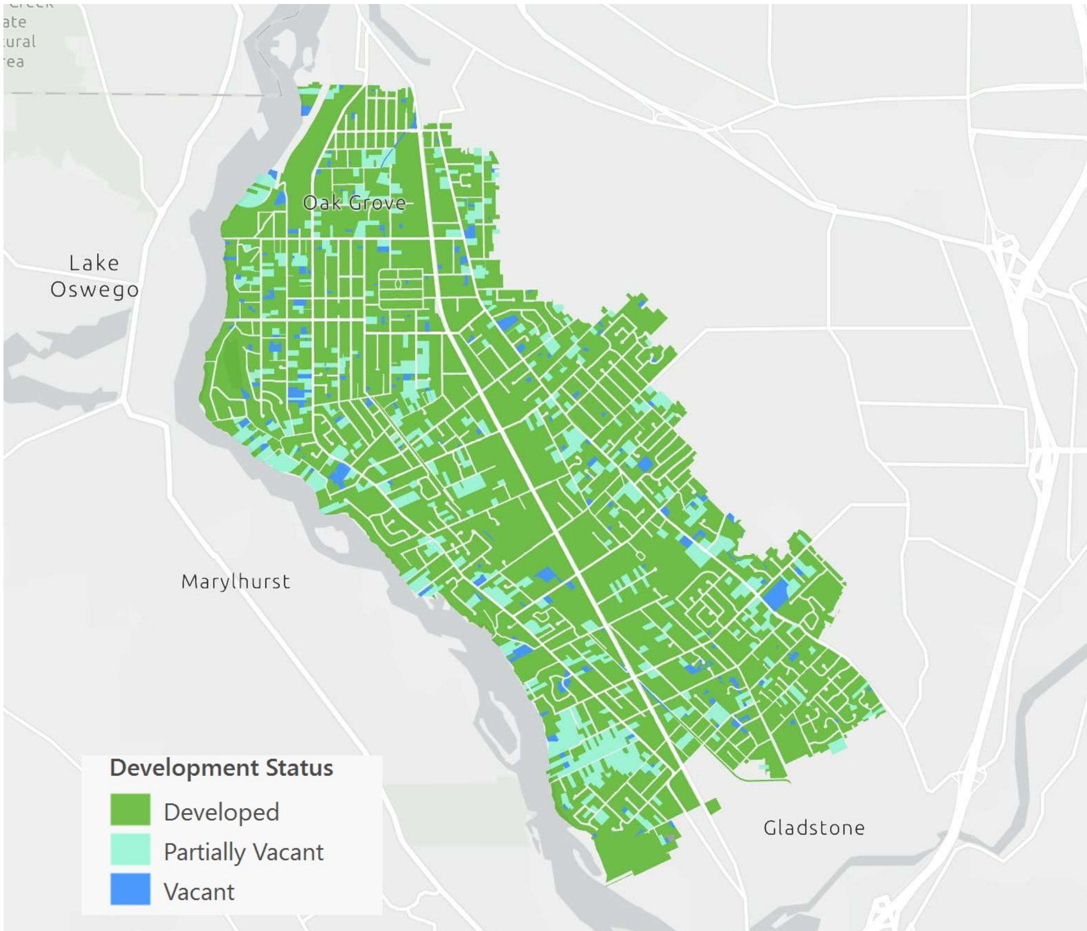

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STEP 4: CALCULATE ACREAGE AND CAPACITY

Gross developable acreage is converted to net acres to account for future rights of way and other needed infrastructure. The 2018 Metro Buildable Lands Inventory[1] uses the following method, which this BLI follows:

- Tax lots under 3/8 acre assume 0% set aside for future streets
- Tax lots between 3/8 acre and 1 acre assume a 10% set aside for future streets
- Tax lots greater than an acre assume an 18.5% set aside for future streets
- Industrial (IND) zoning assumes a 10% set aside regardless of size.

Capacity on net acreage within the study area is calculated using density assumptions based on Clackamas County's development code. The general assumptions are provided in Table 1, and special cases are discussed thereafter.

Table 1. Residential Zones and Density Assumptions

Zone	Residential Density Range	Notes
Residential Zones		
R-20	1 unit/16,000 sf	
R-2	1 unit/2,000 sf	
R-3	1 unit/3,000 sf	
R-5	1 unit/5,000 sf	
R-7	1 unit/5,600 sf	
R-7.2	1 unit/5,600 sf	Gladstone designation
R-8.5	1 unit/6800 sf	
R-10	1 unit/8,000 sf	
MR-1	1 unit/3630 sf	
SHD	1 unit/726 sf	
HDR	1 unit/1742 sf	

[1] https://www.oregonmetro.gov/sites/default/files/2018/07/03/UGR_Appendix2_Buildable_Lands_Inventory.pdf

Zone	Residential Density Range	Notes
Employment Zones		
C2	No residential uses assumed	Potential for redevelopment of employment-zoned parcels into housing at multifamily densities. See Table 5.
C3	No residential uses assumed	
LI	No residential uses assumed	
OC	No residential uses assumed	
NC	No residential uses assumed	
Other Zones		
OS	No residential uses	Open space
OSM	No residential uses	Open space

Residential Capacity

The following table shows the estimated capacity of the vacant and partially vacant land in the study area. Units are forecast using the County's current density calculations, though upcoming changes to the development code related to middle housing will alter what is allowed somewhat (see later section of this memorandum). Highlights are as follows:

- **Vacant Lots.** There are 227 vacant residential lots in the study area, totaling 91 acres. 63 of those acres are outside of natural resource areas and steep slopes.
  - About 300 units are expected on these sites though some development could be middle housing, potentially resulting in additional units
  - Almost half are on R10 land
  - Almost half are on land in the R-7-8 range

- **Partially Vacant Lots.** There are 475 "partially vacant" residential lots that have a home but enough vacant acreage to support subdivision.
  - Similar distribution of zones as vacant land – the R10 zone accounts for about half of the capacity of partially vacant lots.
  - There is capacity for roughly 1,050 units across all zones

Table 2. Capacity of Study Area Residential Land

Develop-ment Status	*Zone*	*Number of Tax Lots*	*Gross Acres*	*Constrained Acres*	*Vacant Acres*	*Net Developable Acreage*	*Unit Capacity*
Developed Land (All Zones)		**7,733**	**2,098.1**	**247.3**	**0**	**0**	**0**
Partially Vacant	HDR	1	1.6	1.4	0.0	0.0	0
	MR1	30	21.6	1.5	12.5	11.1	118
	R10	297	272.1	57.3	14.5	121.4	531
	R20	9	13.6	5.7	5.6	4.7	8
	R7	66	50.9	2.6	31.7	27.5	183
	R7.2	14	11.4	0.4	7.5	6.5	44
	R8.5	52	51.2	9.2	29.0	24.6	134
Total Partially Vacant		**469**	**422.2**	**78.2**	**226.8**	**195.9**	**1,018**
Vacant	HDR	2	3.1	1.7	1.5	1.2	30
	MR1	12	4.1	0.0	4.1	3.8	38
	R10	100	46.2	19.2	27.0	24.7	93
	R20	3	1.4	1.1	0.4	0.3	0
	R7	60	17.2	3.1	14.1	13.0	72
	R7.2	13	3.0	0.2	2.8	2.7	14
	R8.5	36	15.8	2.7	13.0	11.8	61
Total Vacant		**226**	**90.8**	**28.0**	**62.8**	**57.5**	**308**
Total		**8,428**	**2,611.2**	**353.9**	**290.0**	**258.6**	**1,326**

Non-residential capacity

Nearly all employment land in the study area is categorized as “Developed.” There are 11 vacant taxlots totaling about 5 acres, split between Light Industrial and Commercial zoning. No residential capacity is assumed in these zones.

Table 3. Capacity of Study Area Employment Land

Development Status	Zone	Number of Tax Lots	Gross Acres	Constrained Acres	Vacant Acres	Net Developable Acreage
Developed	C3	281	240.2	6.3	0.0	0
	LI	27	61.1	8.3	0.0	0
Total Developed		**308**	**301.3**	**14.6**	**0.0**	**0.0**
Vacant	C3	8	2.9	0.4	2.5	2.3
	LI	3	4.1	1.7	2.4	2.0
Total Vacant		**11**	**6.9**	**2.1**	**4.9**	**4.3**
Total		**319**	**308.2**	**16.7**	**4.9**	**4.3**

Redevelopment and Middle Housing Assumptions

The 2018 Metro BLI uses a "strike price" threshold to identify properties that are more likely to redevelop. This "Strike price" is a dollar amount per square foot of combined building and land value, under which it is assumed that the property could be redeveloped into something providing greater value for the property owner. For suburban areas, this price ranges between $10 and $15/sf depending on zoning.

Examining the study area, this screen results in 150 properties at $10/sf strike price and 203 properties at $15/sf that may be more likely to see redevelopment during the planning horizon. The following table summarizes the study area tax lots at the more aggressive $15/sf price. The majority of these potential redevelopment units are on land zoned MR1, and several are manufactured home parks that may be difficult to redevelop and may not see a greater number of residents after development than live there currently.

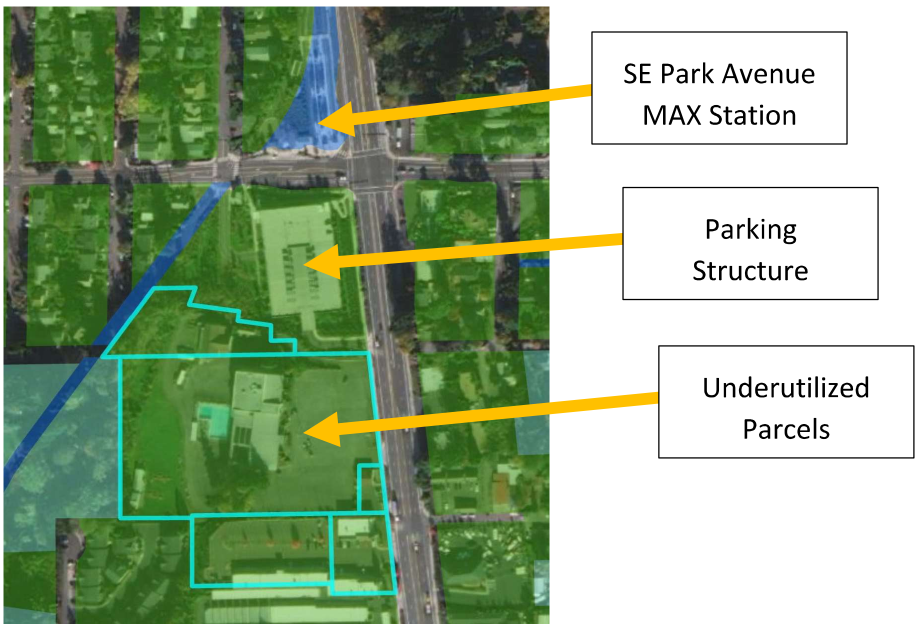
Table 4. Taxlots Identified at a $15 Strike Price for potential Redevelopment

Zone	Gross Acres	Constrained Acreage	Unit Capacity
C3	5.2	0.1	0.0
HDR	1.0	0.3	14
LI	3.2	0.8	0
MR1	13.8	0.6	149
R10	33.9	18.9	47
R20	2.8	0.9	3
R7	5.8	0.2	32
R7.2	1.2	0.0	5
R8.5	4.2	0.7	14
Grand Total	**71.1**	**22.4**	**264**

Additional Redevelopment Assumptions

Discussion with County staff has suggested some additional opportunity for redevelopment to occur in the vicinity of the Park Avenue Max Station and along the commercial corridors of the study area. The County is considering changes to zoning maximums to allow up to 60 units/acre near the transit station. There are several sites in the vicinity that meet the definition of "Developed" but would be possible to redevelop at higher densities to form a transit-oriented hub near the station. This could potentially result in several hundred new units in the area – the sites highlighted below total about 10 acres outside of Title 13 areas.

Figure 5. Park Avenue Station Vicinity



Middle Housing

Part of the impetus for this BLI work is to consider the impacts of Oregon's recent legislation allowing "middle housing" (such as duplexes, triplexes, quadplexes, cottage clusters, and accessory dwelling units) in residential areas statewide. Clackamas County is currently updating its land use regulations to address this legislation by allowing greater housing variety in urban unincorporated areas where infrastructure is available.[2]

[2] https://www.clackamas.us/planning/hb2001

State statute and rules generally limit jurisdictions to an assumption of a 3% increase in density in greenfield settings and a 1% increase in infill situations (i.e. lots under ½ acre in size) when calculating the additional development intensity due to the state's middle housing rules.[3] This BLI provides a range of growth options that may exceed these limits, though higher assumptions cannot be the basis of certain land use decisions, including urban growth boundary expansions, without additional findings (OAR 660-046-0330(4)).

Table 5. Potential Additional Residential Capacity due to Middle Housing

LAND TYPE	NUMBER OF TAXLOTS	NET DEVELOP-ABLE ACRES	RESIDENTIAL UNITS WITH TYPICAL ASSUMPTIONS (SEE TABLES 2 & 3)	NET ADDITIONAL UNITS	NOTES
Vacant Land	226	57	308	10-100	Only 24 lots are greater than .5 acres – so this is predominantly "infill." If we assume a fairly aggressive increase in capacity of 25% due to new middle housing, we'd see the potential for about 400 new units rather than the current 300.
Partially Vacant Land	469	196	1,018	25-250	About ¼ of these lots are greater than half an acre, indicating potentially greater opportunity for new middle housing development. If we assume a fairly aggressive increase in capacity of 25% due to new middle housing, we'd see about 1300 new units rather than the current 1,018.
Additional Subdivision, ADUs, other Infill on Developed Lots	7,733	-	-	541	It is difficult to estimate the likely transition of developed residences into new middle housing – uptake will likely differ significantly in different parts of the Metro region. If 5% of developed taxlots with existing homes

[3] https://oregon.public.law/rules/oar_660-046-0330

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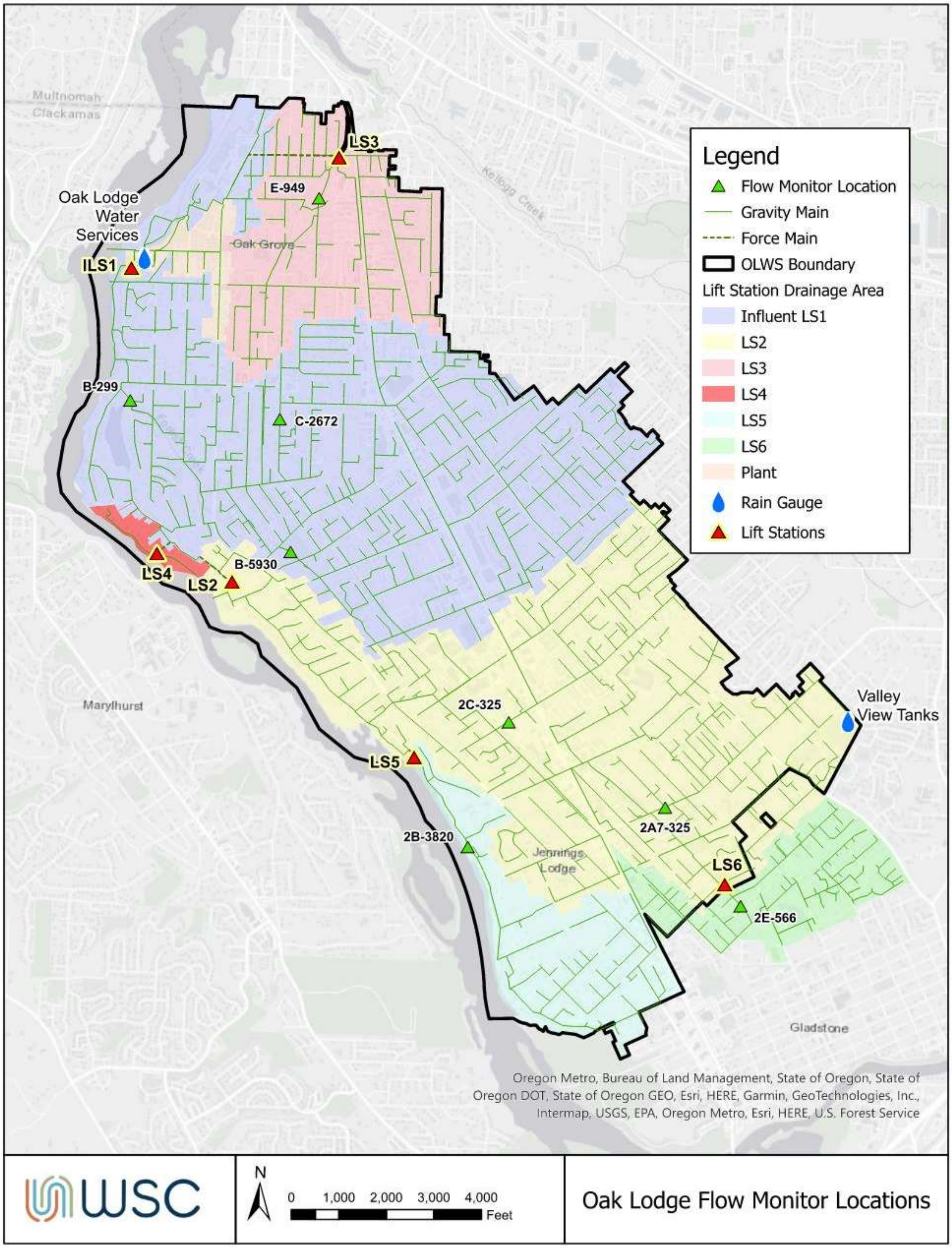
					in the study area were to redevelop, adding on average 1.5 additional units (to account for mostly duplexes, but some 3-4 plex and cluster developments), an additional 541 units would be added to the study area.
Commercial Redevelopment	5 (SE Park Avenue area)	10 (SE Park Avenue Area) 10-20 (Elsewhere along corridor)	-	400 (SE Park Avenue Area) 400-800 (Elsewhere along corridor)	Redevelopment of under-utilized lots near the SE Park Avenue Transit Station seems likely, and long-term retail trends may lead to redevelopment of some commercial properties in the study area at multifamily densities.
TOTAL	8,435	258.6	1,326	Up to 2,091 additional units, for a total of 3,417 Units	This figure represents a significant amount of infill and redevelopment in the study area. Redevelopment of underutilized commercial properties account for the largest component of this growth.

SUMMARY AND NEXT STEPS

The findings of this BLI will inform infrastructure planning work for Oak Lodge Water Services.

Appendix D Flow Meter Locations



Oak Lodge Flow Monitor Locations

Appendix F Buildable Lands Inventory

F

MEMORANDUM

Buildable Lands Inventory - Final Draft

Oak Lodge Wastewater Master Plan

DATE	January 27, 2023
TO	Scott Duren, PE, WSC
FROM	Andrew Parish, AICP, and Matt Hastie, AICP, MIG | APG
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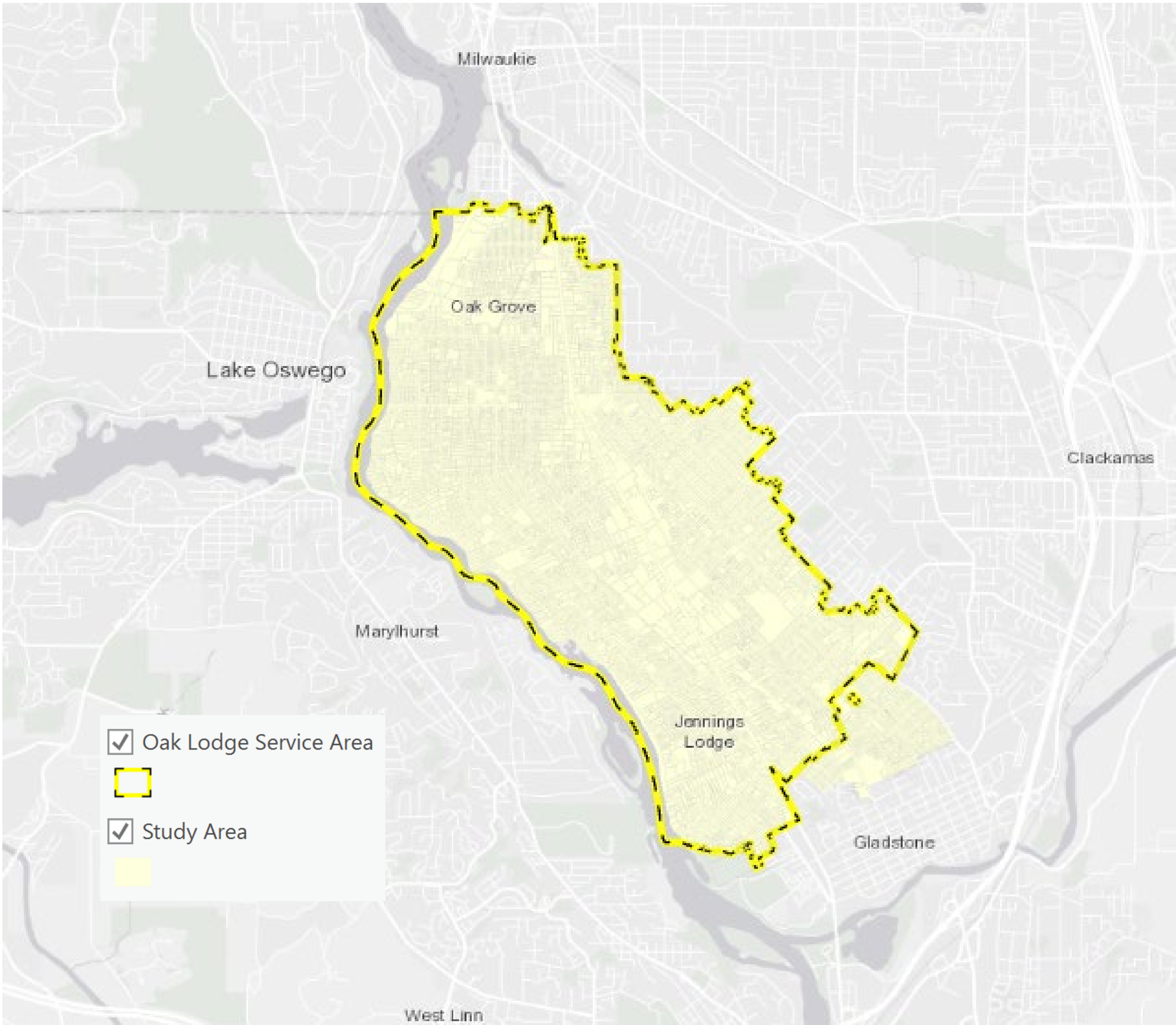

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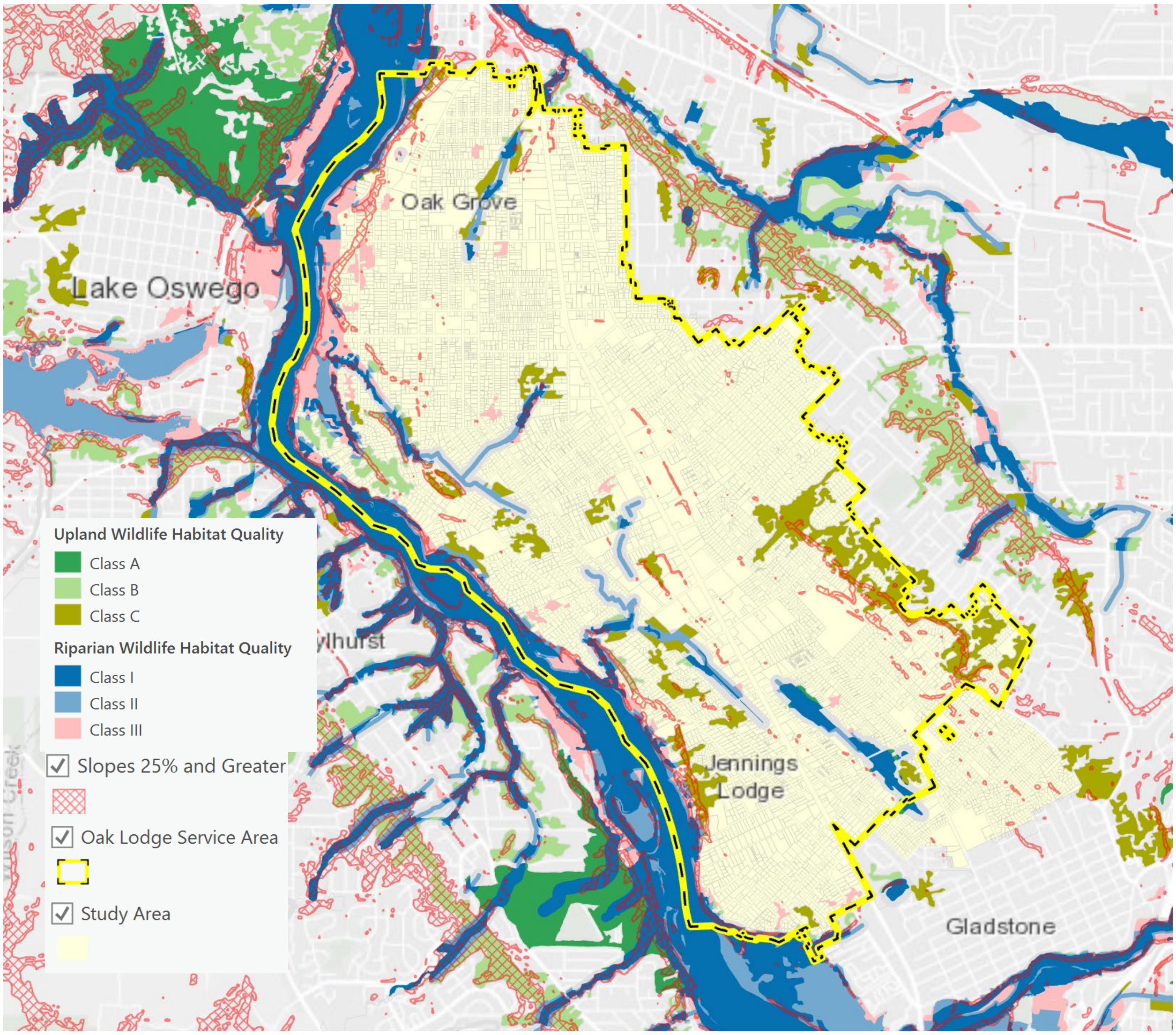

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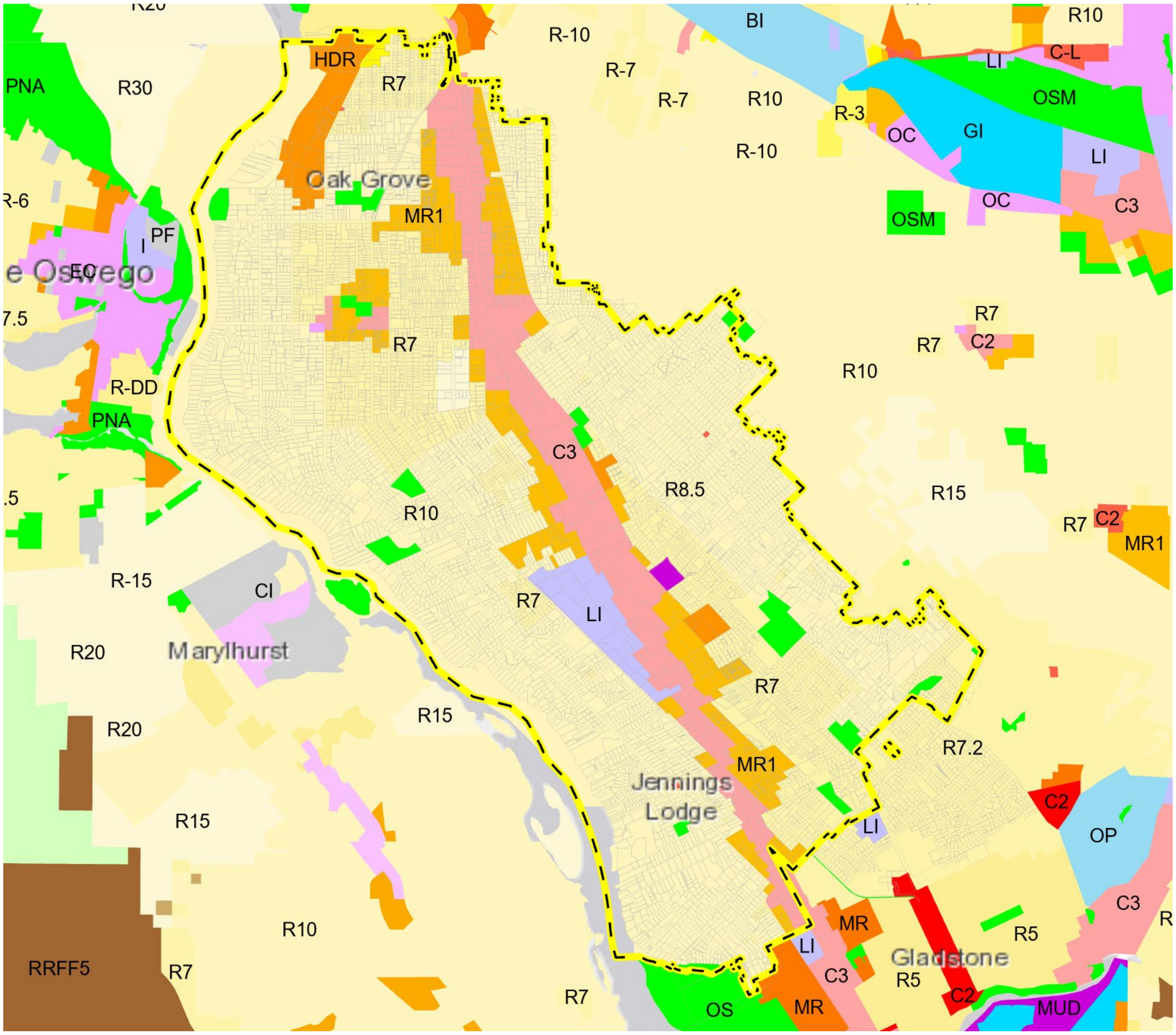

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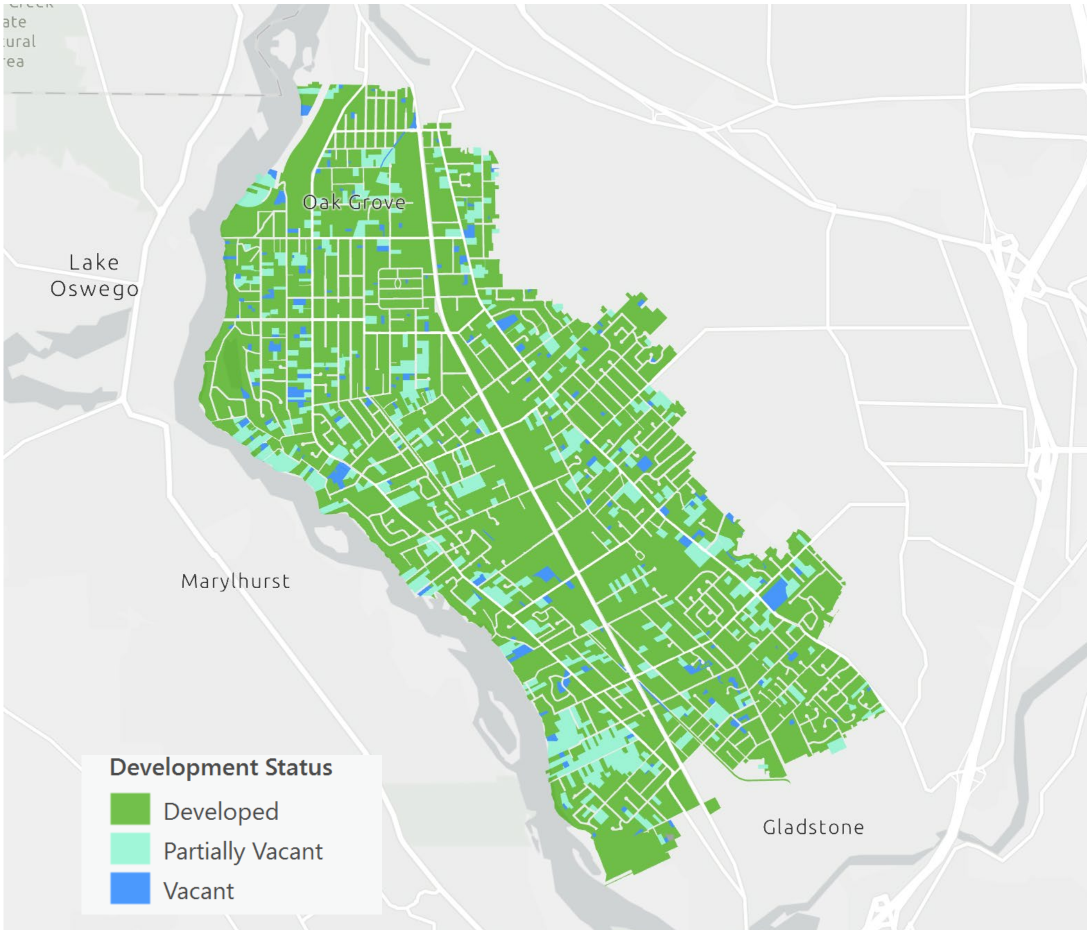

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Gross developable acreage is converted to net acres to account for future rights of way and other needed infrastructure. The 2018 Metro Buildable Lands Inventory[1] uses the following method, which this BLI follows:

- Tax lots under 3/8 acre assume 0% set aside for future streets
- Tax lots between 3/8 acre and 1 acre assume a 10% set aside for future streets
- Tax lots greater than an acre assume an 18.5% set aside for future streets
- Industrial (IND) zoning assumes a 10% set aside regardless of size.

Capacity on net acreage within the study area is calculated using density assumptions based on Clackamas County's development code. The general assumptions are provided in Table 1, and special cases are discussed thereafter.

Table 1. Residential Zones and Density Assumptions

Zone	Residential Density Range	Notes
Residential Zones		
R-20	1 unit/16,000 sf	
R-2	1 unit/2,000 sf	
R-3	1 unit/3,000 sf	
R-5	1 unit/5,000 sf	
R-7	1 unit/5,600 sf	
R-7.2	1 unit/5,600 sf	Gladstone designation
R-8.5	1 unit/6800 sf	
R-10	1 unit/8,000 sf	
MR-1	1 unit/3630 sf	
SHD	1 unit/726 sf	
HDR	1 unit/1742 sf	

[1] https://www.oregonmetro.gov/sites/default/files/2018/07/03/UGR_Appendix2_Buildable_Lands_Inventory.pdf

Zone	Residential Density Range	Notes
Employment Zones		
C2	No residential uses assumed	Potential for redevelopment of employment-zoned parcels into housing at multifamily densities. See Table 5.
C3	No residential uses assumed	
LI	No residential uses assumed	
OC	No residential uses assumed	
NC	No residential uses assumed	
Other Zones		
OS	No residential uses	Open space
OSM	No residential uses	Open space

Residential Capacity

The following table shows the estimated capacity of the vacant and partially vacant land in the study area. Units are forecast using the County's current density calculations, though upcoming changes to the development code related to middle housing will alter what is allowed somewhat (see later section of this memorandum). Highlights are as follows:

- **Vacant Lots.** There are 227 vacant residential lots in the study area, totaling 91 acres. 63 of those acres are outside of natural resource areas and steep slopes.
    - About 300 units are expected on these sites though some development could be middle housing, potentially resulting in additional units
    - Almost half are on R10 land
    - Almost half are on land in the R-7-8 range

- **Partially Vacant Lots.** There are 475 "partially vacant" residential lots that have a home but enough vacant acreage to support subdivision.
    - Similar distribution of zones as vacant land – the R10 zone accounts for about half of the capacity of partially vacant lots.
    - There is capacity for roughly 1,050 units across all zones

Table 2. Capacity of Study Area Residential Land

Develop-ment Status	*Zone*	*Number of Tax Lots*	*Gross Acres*	*Constrained Acres*	*Vacant Acres*	*Net Developable Acreage*	*Unit Capacity*
Developed Land (All Zones)		**7,733**	**2,098.1**	**247.3**	**0**	**0**	**0**
Partially Vacant	HDR	1	1.6	1.4	0.0	0.0	0
	MR1	30	21.6	1.5	12.5	11.1	118
	R10	297	272.1	57.3	14.5	121.4	531
	R20	9	13.6	5.7	5.6	4.7	8
	R7	66	50.9	2.6	31.7	27.5	183
	R7.2	14	11.4	0.4	7.5	6.5	44
	R8.5	52	51.2	9.2	29.0	24.6	134
Total Partially Vacant		**469**	**422.2**	**78.2**	**226.8**	**195.9**	**1,018**
Vacant	HDR	2	3.1	1.7	1.5	1.2	30
	MR1	12	4.1	0.0	4.1	3.8	38
	R10	100	46.2	19.2	27.0	24.7	93
	R20	3	1.4	1.1	0.4	0.3	0
	R7	60	17.2	3.1	14.1	13.0	72
	R7.2	13	3.0	0.2	2.8	2.7	14
	R8.5	36	15.8	2.7	13.0	11.8	61
Total Vacant		**226**	**90.8**	**28.0**	**62.8**	**57.5**	**308**
Total		**8,428**	**2,611.2**	**353.9**	**290.0**	**258.6**	**1,326**

Non-residential capacity

Nearly all employment land in the study area is categorized as “Developed.” There are 11 vacant taxlots totaling about 5 acres, split between Light Industrial and Commercial zoning. No residential capacity is assumed in these zones.

Table 3. Capacity of Study Area Employment Land

Development Status	Zone	Number of Tax Lots	Gross Acres	Constrained Acres	Vacant Acres	Net Developable Acreage
Developed	C3	281	240.2	6.3	0.0	0
	LI	27	61.1	8.3	0.0	0
Total Developed		**308**	**301.3**	**14.6**	**0.0**	**0.0**
Vacant	C3	8	2.9	0.4	2.5	2.3
	LI	3	4.1	1.7	2.4	2.0
Total Vacant		**11**	**6.9**	**2.1**	**4.9**	**4.3**
Total		**319**	**308.2**	**16.7**	**4.9**	**4.3**

Redevelopment and Middle Housing Assumptions

The 2018 Metro BLI uses a "strike price" threshold to identify properties that are more likely to redevelop. This "Strike price" is a dollar amount per square foot of combined building and land value, under which it is assumed that the property could be redeveloped into something providing greater value for the property owner. For suburban areas, this price ranges between $10 and $15/sf depending on zoning.

Examining the study area, this screen results in 150 properties at $10/sf strike price and 203 properties at $15/sf that may be more likely to see redevelopment during the planning horizon. The following table summarizes the study area tax lots at the more aggressive $15/sf price. The majority of these potential redevelopment units are on land zoned MR1, and several are manufactured home parks that may be difficult to redevelop and may not see a greater number of residents after development than live there currently.

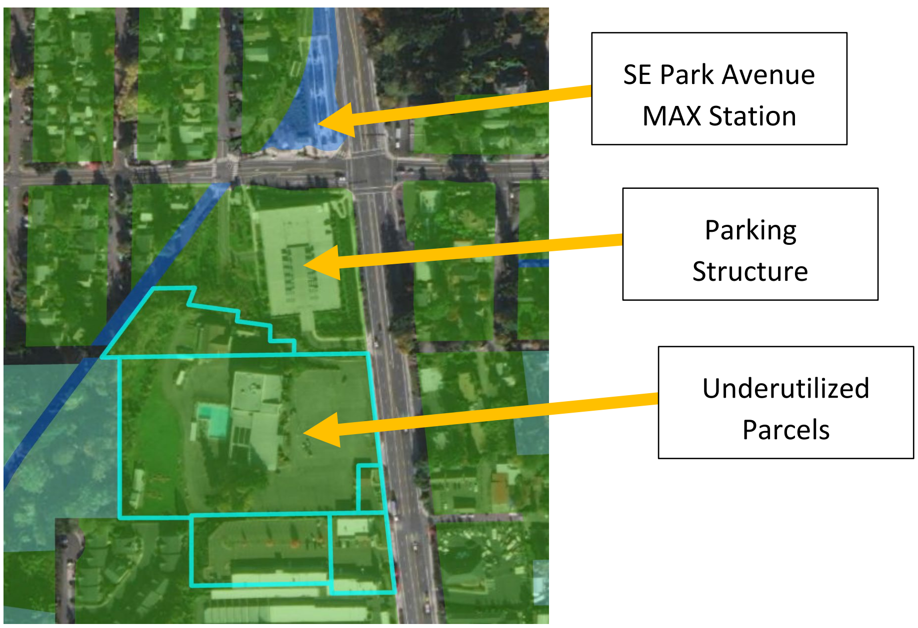
Table 4. Taxlots Identified at a $15 Strike Price for potential Redevelopment

Zone	Gross Acres	Constrained Acreage	Unit Capacity
C3	5.2	0.1	0.0
HDR	1.0	0.3	14
LI	3.2	0.8	0
MR1	13.8	0.6	149
R10	33.9	18.9	47
R20	2.8	0.9	3
R7	5.8	0.2	32
R7.2	1.2	0.0	5
R8.5	4.2	0.7	14
Grand Total	**71.1**	**22.4**	**264**

Additional Redevelopment Assumptions

Discussion with County staff has suggested some additional opportunity for redevelopment to occur in the vicinity of the Park Avenue Max Station and along the commercial corridors of the study area. The County is considering changes to zoning maximums to allow up to 60 units/acre near the transit station. There are several sites in the vicinity that meet the definition of "Developed" but would be possible to redevelop at higher densities to form a transit-oriented hub near the station. This could potentially result in several hundred new units in the area – the sites highlighted below total about 10 acres outside of Title 13 areas.

Figure 5. Park Avenue Station Vicinity



Middle Housing

Part of the impetus for this BLI work is to consider the impacts of Oregon's recent legislation allowing "middle housing" (such as duplexes, triplexes, quadplexes, cottage clusters, and accessory dwelling units) in residential areas statewide. Clackamas County is currently updating its land use regulations to address this legislation by allowing greater housing variety in urban unincorporated areas where infrastructure is available.[2]

[2] https://www.clackamas.us/planning/hb2001

State statute and rules generally limit jurisdictions to an assumption of a 3% increase in density in greenfield settings and a 1% increase in infill situations (i.e. lots under ½ acre in size) when calculating the additional development intensity due to the state's middle housing rules.[3] This BLI provides a range of growth options that may exceed these limits, though higher assumptions cannot be the basis of certain land use decisions, including urban growth boundary expansions, without additional findings (OAR 660-046-0330(4)).

Table 5. Potential Additional Residential Capacity due to Middle Housing

LAND TYPE	NUMBER OF TAXLOTS	NET DEVELOP -ABLE ACRES	RESIDENTIAL UNITS WITH TYPICAL ASSUMPTIONS (SEE TABLES 2 & 3)	NET ADDITIONAL UNITS	NOTES
Vacant Land	226	57	308	10-100	Only 24 lots are greater than .5 acres – so this is predominantly "infill." If we assume a fairly aggressive increase in capacity of 25% due to new middle housing, we'd see the potential for about 400 new units rather than the current 300.
Partially Vacant Land	469	196	1,018	25-250	About ¼ of these lots are greater than half an acre, indicating potentially greater opportunity for new middle housing development. If we assume a fairly aggressive increase in capacity of 25% due to new middle housing, we'd see about 1300 new units rather than the current 1,018.
Additional Subdivision, ADUs, other Infill on Developed Lots	7,733	-	-	541	It is difficult to estimate the likely transition of developed residences into new middle housing – uptake will likely differ significantly in different parts of the Metro region. If 5% of developed taxlots with existing homes

[3] https://oregon.public.law/rules/oar_660-046-0330

LAND TYPE	NUMBER OF TAXLOTS	NET DEVELOP -ABLE ACRES	RESIDENTIAL UNITS WITH TYPICAL ASSUMPTIONS (SEE TABLES 2 & 3)	NET ADDITIONAL UNITS	NOTES
					in the study area were to redevelop, adding on average 1.5 additional units (to account for mostly duplexes, but some 3-4 plex and cluster developments), an additional 541 units would be added to the study area.
Commercial Redevelopm ent	5 (SE Park Avenue area)	10 (SE Park Avenue Area) 10-20 (Elsewhe re along corridor)	-	400 (SE Park Avenue Area) 400-800 (Elsewhere along corridor)	Redevelopment of under-utilized lots near the SE Park Avenue Transit Station seems likely, and long-term retail trends may lead to redevelopment of some commercial properties in the study area at multifamily densities.
TOTAL	8,435	258.6	1,326	Up to 2,091 additional units, for a total of 3,417 Units	This figure represents a significant amount of infill and redevelopment in the study area. Redevelopment of underutilized commercial properties account for the largest component of this growth.

SUMMARY AND NEXT STEPS

The findings of this BLI will inform infrastructure planning work for Oak Lodge Water Services.

Appendix G   Flow Monitoring TM

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Technical Memo

Date:	1/18/2023
To:	Brad Albert, PE
CC:	Jeff Page; Haakon Ogbeide, PE
Prepared By:	Adam Donald, PE
Reviewed By:	Scott Duren, PE
Project:	Wastewater Master Plan
Subject:	Flow Monitoring

Water Systems Consulting (WSC) contracted with SFE Global (SFE) to perform flow monitoring services for the preparation of Oak Lodge Water Services' (OLWS) Wastewater Master Plan. The following technical memorandum (TM) provides a summary of the flow monitoring performed, an analysis of the data, and a summary of the results.

1.0 Overview

WSC's subconsultant SFE deployed flow monitors within OLWS' collection system from December 18, 2021 through February 28, 2022. Flow meters were placed in eight locations to capture large portions of the collection system. A map of the flow meter locations is shown in Figure 1-1.

The goal of the flow monitoring was to understand the collection system's response to rainfall, provide a data set for calibrating the hydraulic model to wet weather conditions, and identify areas within the collection system experiencing high levels of rainfall dependent inflow and infiltration (RDII). When possible, meters were placed in manholes with the influent pipe aligned with the effluent pipe, with no substantial internal vertical drop, only one influent pipe coming into the manhole, and in locations far enough upstream from lift stations to avoid backwater influencing the readings to obtain hydraulic conditions that are conducive to meter accuracy. Monitoring locations also require approximately 1-inch of minimum water depth in the pipe to allow the meters to collect a reading, so locations also needed to have a sufficiently large upstream collection area that would produce the minimum flows.

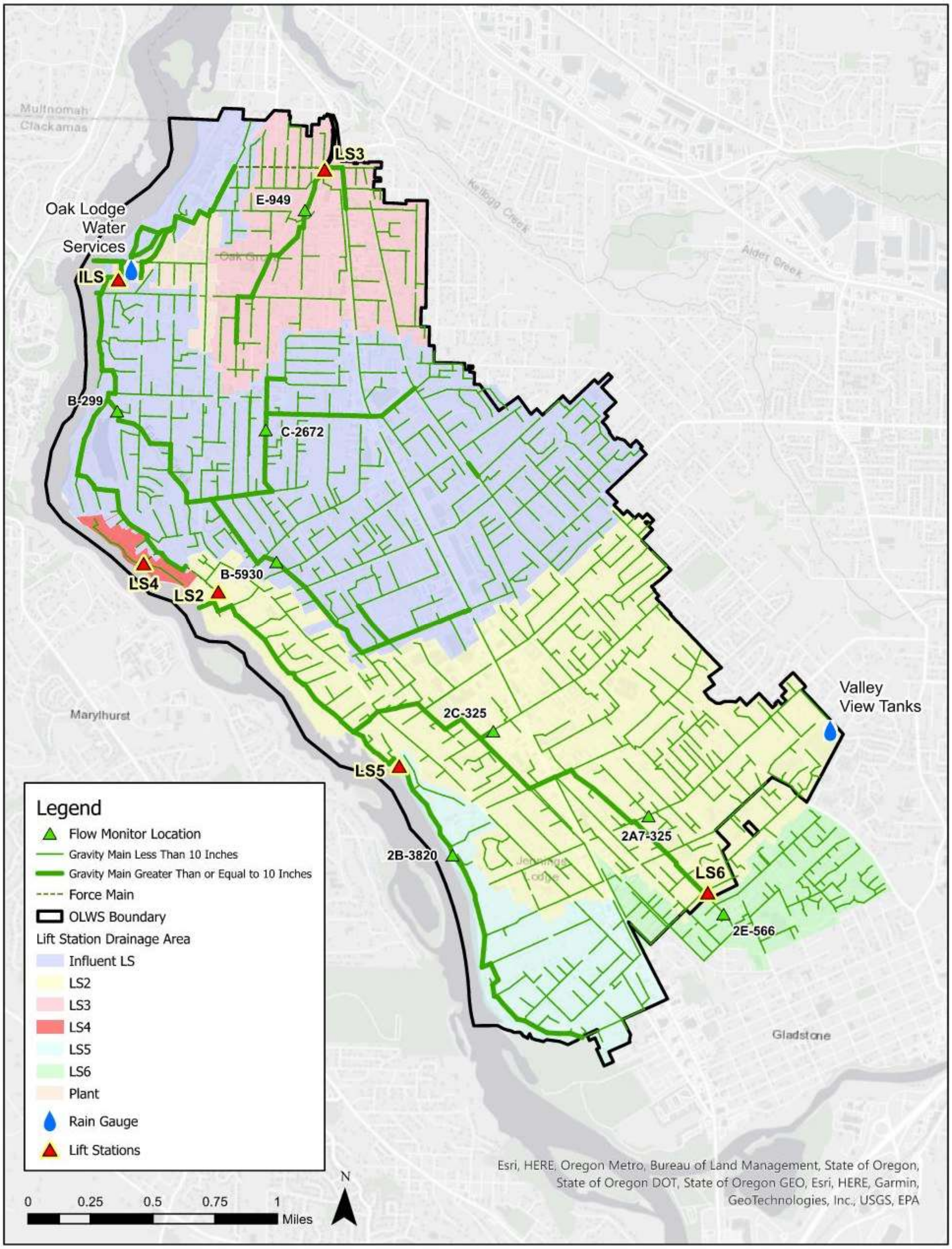


Figure 1-1: Flow Monitoring Map

2.0 Methods and Procedures

SFE Global provided and installed the flow monitors and rain gauges used to collect water surface depth and velocity within each monitoring manhole location and precipitation rates and volumes. A site walk was performed with the SFE Global installation crew, and OLWS staff to confirm the final flow monitoring loctions based on the recommendations from the flow monitoring plan (Appendix A). During this site walk, SFE Global evaluated each manhole to take measurements, determine style of flow meter required, determine traffic control requirements, and mark the manholes to avoid any confusion on installation day.

Flow monitors were installed by SFE Global's installation crew on December 18, 2021. Installation consisted of standard confined space entry procedures, including the use of a tripod to lower the crew into the manhole to install the flow meter within the trough. Most of the flow monitoring sites selected were located outside of the right of way, eliminating the need for traffic control.

ISCO 2150 flow monitors were selected for each location. These monitors use an area velocity (AV) module with a pressure transducer to determine flow level and an AV sensor to determine velocity within the pipe. The AV module unit then calculates the flow rate and total flow data based on these measurements. A transmitter was installed within each manhole that wirelessly transmits this data to a cloud-based server. A local copy of the data is stored within the AV module in the event that the data transmission fails. Figure 2-1 shows the final configuration of the installed flow meter assembly as well as a sketch for where the sensors were installed. In locations where significant ragging or sedimentation was anticipated, the sensor was installed in an "offset" position just above the flowline of the pipe. In these locations additional calibration was performed during installation to adjust readings to account for the offset. The flow meter at manhole 2B-3820 required the use of a weir to accurately measure flow due to elevated water levels. Descriptions of each installation are provided in Appendix B.

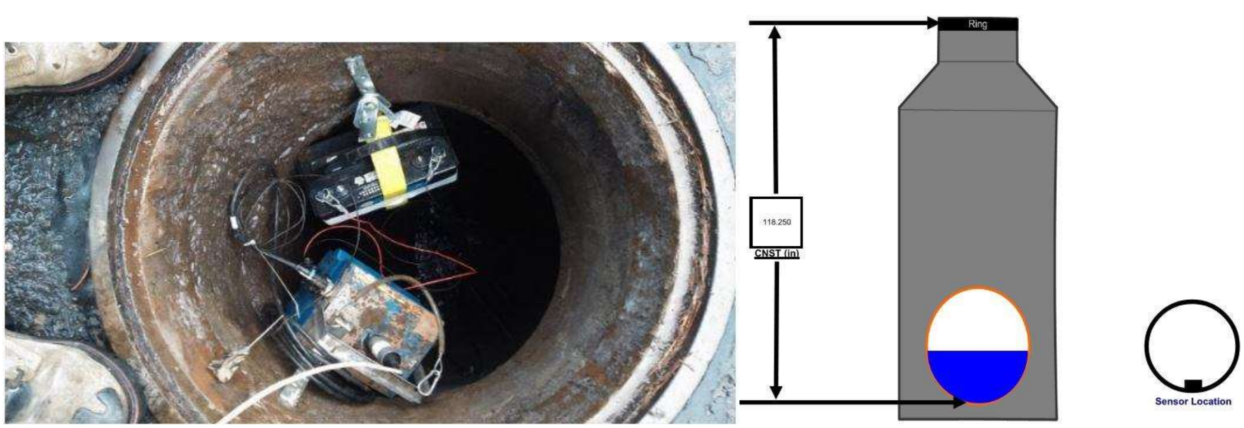


Figure 2-1: Installed Flow Monitor

3.0 Scatter Plot Analysis

3.1 Overview

Scatter plots are an industry best practice used to analyze the quality of flow monitor data and evaluate collection system performance. Based on the shape of the plot, the scatter plot can indicate whether the meters are reading accurately and whether backwater or sanitary sewer overflows are occurring at the metering manhole. These plots are created by plotting the velocity and depth readings from the flow meters and analyzing the results relative to the pipe curve created using the Manning Equation (Equation 1) to understand if the readings align with anticipated performance.

$$v = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where: v = flow velocity, ft/s

n = Manning roughness coefficient

R = hydraulic radius, ft

S = slope of the energy gradient

Equation 1: The Manning Equation

To determine the pipe curve, the Manning Equation is further simplified as shown in Equation 2. The hydraulic radius is dependent upon the flow depth so a pipe curve can be developed by solving for the velocities at a variety of flow depths and plotting this on the scatter plot to compare against the actual flow depth. A sample pipe curve is shown in Figure 3-1.

$$v = 1.486 C R^{\frac{2}{3}}$$

Where: v = flow velocity, ft/s

C = hydraulic coefficient = $\frac{1}{n} S^{\frac{1}{2}}$

R = hydraulic radius, ft

Equation 2: The Manning Equation Using the Hydraulic Coefficient

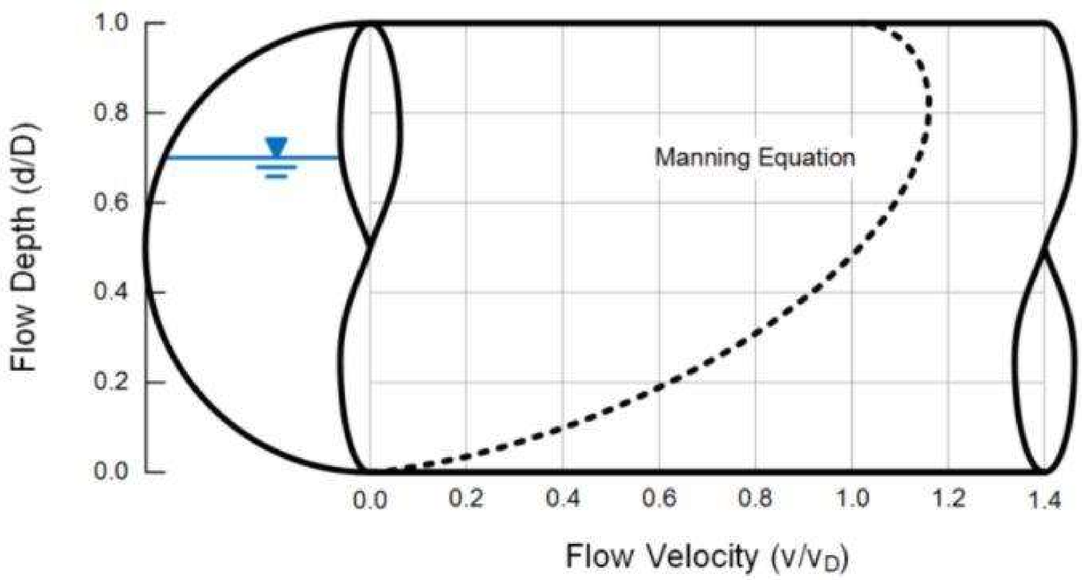


Figure 3-1: Manning Equation Pipe Curve (1)

There are three common methods used for developing a pipe curve that fits the data: the Design Method, the Lanfear-Coll Method, and the Stevens-Schutzbach Method. A brief overview is provided in the following subsections. The best fitting pipe curve should be used as indicative of the level of accuracy of the data. The closer the values are to the curve, the more accurate the data set is. Precision is determined by how close individual readings are to one another. Precise data has little spread amongst the data points while non-precise data is spread out.

3.1.1 Design Method

The Design Method assumes uniform flow within the pipe and calculates the hydraulic coefficient (C) by plugging in the slope of the pipe and Manning's roughness coefficient for the pipe material based on as-built records. (1) The curve is then developed by solving for velocity at a range of depths within the pipe equal to or less than the diameter and plotting the velocity versus the depth. When flow monitoring data points fit the Design Method pipe curve well, it indicates the as-built information for the slope and material are accurate. Due to the nature of the equation, a Design Method pipe curve will always pass through the origin (0,0) and is only valid for when the flow monitor depth reading is less than or equal to the diameter of the pipe.

3.1.2 Lanfear-Coll Method

The Lanfear-Coll Method is similar to the Design Method in that it assumes uniform flow, but the hydraulic coefficient (C) is calculated by applying a curve fitting technique to the flow monitoring data. (1) Under this method, the value for C is calculated by maximizing the coefficient of determination (R^2 value) when fitting the Manning's Equation to the data. The coefficient of determination is the proportion of total variation between the calculated results and the measured results, and a higher value indicates a curve with less variation from the observed results. This allows the hydraulic coefficient to be calculated when the slope and material of the pipe are not known. If the Lanfear-Coll pipe curve is a better fit to the data than the Design Method pipe curve, then the data for the pipe slope and/or Manning's roughness coefficient is not accurate in the as-builts. Similar to the Design Method, the Lanfear-Coll pipe curve will always pass through the origin (0,0) and is only valid for when the flow monitor depth reading is less than or equal to the diameter of the pipe.

3.1.3 Stevens-Schutzbach Method

The Stevens-Schutzbach Method uses an iterative curve fitting technique to apply the Manning Equation to the flow monitoring data. (1) Unlike the Design Method and the Lanfear-Coll Method, the Stevens Schutzbach Method applies to both uniform and non-uniform flow conditions, which means the curve is not restrained to passing through the origin (0,0). This method accounts for non-uniform flow conditions resulting from downstream obstructions that result in the slope of the energy gradient being less than the pipe slope. Downstream obstructions can be caused from offset joints, silt, debris or other physical obstructions within the pipe. To determine the hydraulic coefficient (C), an equivalent depth is used in calculations and is defined as the difference between the measured depth at the flow meter and the magnitude of the downstream obstruction. The magnitude of the downstream obstruction is iterated until the coefficient of determination (R^2 value) is maximized for the curve.

3.2 Flow Meter at Manhole 2A7-325

Manhole 2A7-325 is located in the upper eastern portion of the Lift Station 2 basin. The scatter plot for the flow meter at Manhole 2A7-325 is shown in Figure 3-2. The level and velocity readings resulted in a pattern that did not align with any of the pipe curves. The Stevens-Schutzbach pipe curve fit the data the best but only had an R^2 value of 0.41 indicating a poor overall fit. There appear to be two factors at play in the data. First, when the velocity and level data were plotted over time, there was a significant shift from January 14, 2022 through January 15, 2022, which resulted in high level readings at a low velocity. The meter readings were likely impacted by ragging during this time period. The readings returned to previous levels after this time. Additionally, the scatterplot indicates that the velocity varies significantly for a constant level, which indicates a problem with the velocity sensor. Since the flow is directly proportional to the velocity reading, a faulty velocity reading results in unreliable flow measurements. With this understanding, the data for this meter should be disregarded and not used for calibration of the model.

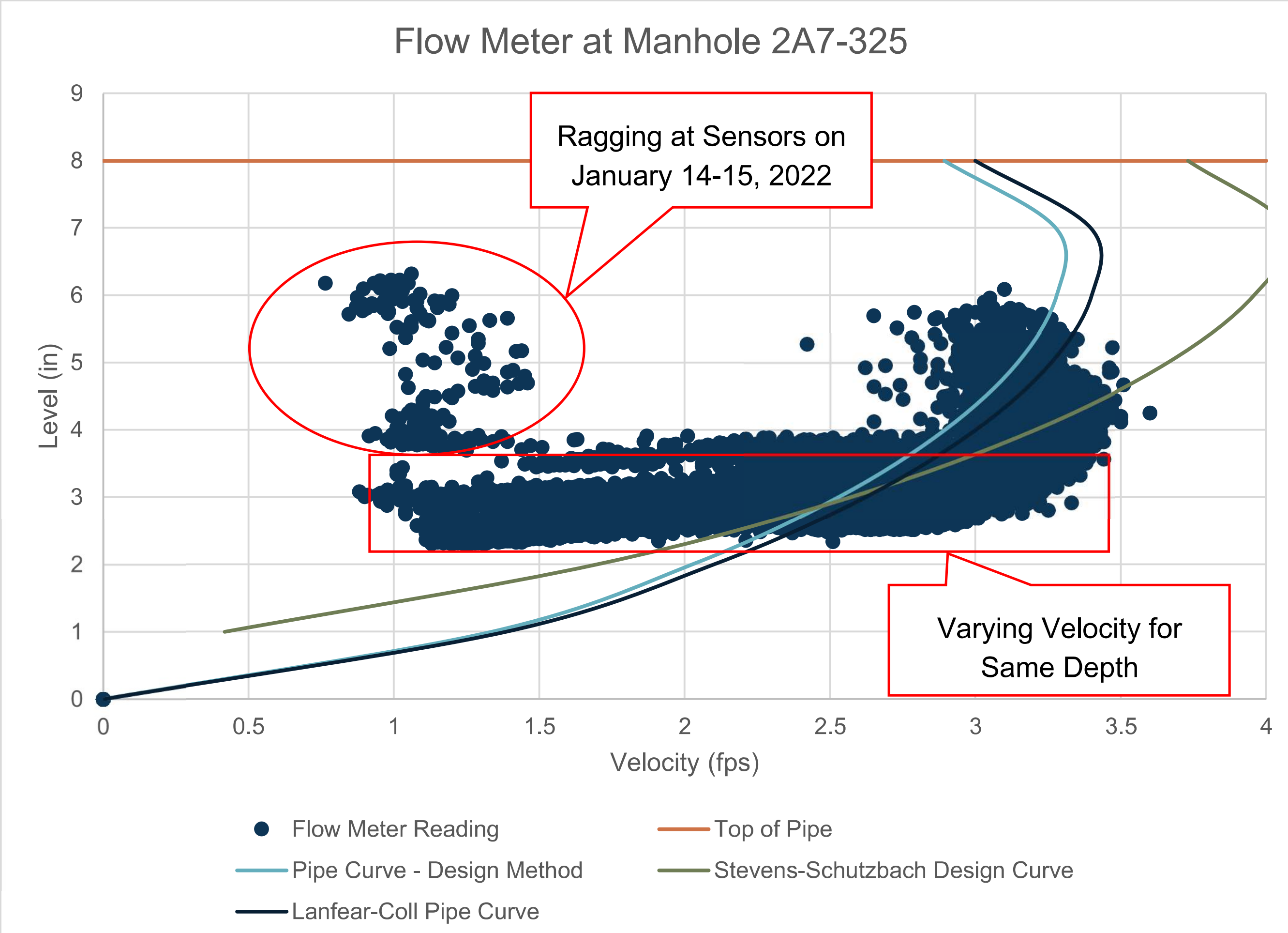


Figure 3-2: Scatterplot for Flow Meter at Manhole 2A7-325

3.3 Flow Meter at Manhole 2B-3820

Manhole 2B-3820 is located in the Lift Station 5 basin. The meter at Manhole 2B-3820 utilized a custom compound weir due to the high levels of flow within the pipe to get an accurate flow reading. When the weir is used, the meters do not measure velocity, so a scatterplot of velocity versus depth was not possible. This data is assumed to be satisfactory for use in calibrating the hydraulic model.

3.4 Flow Meter at Manhole 2C-325

Manhole 2C-325 is located in the Lift Station 2 basin and picks up flow from an upper portion of the basin to the north and east of McLoughlin Blvd. The scatter plot for the flow meter at Manhole 2C-325 is shown in Figure 3-2. The readings from the flow meter resulted in values shifted significantly to the right of what was predicted by the Design Method, indicating the pipe slope and/or Manning's roughness coefficient in the as-builts and model are not representative of the conditions in the field. Both the Lanfear-Coll Method and Stevens-Schutzbach Method produced similar curves indicating that there were little to no obstructions downstream of this location during the flow monitoring period. However, the R^2 value of the curves are low and indicate poor correlation with observed data. The scatter plot seems to indicate a drifting level sensor as the level measured drifts over a wide range without seeing a corresponding change in velocity. Given the drifting level data, this flow meter's data quality is not good and should not be used in calibrating the hydraulic model.

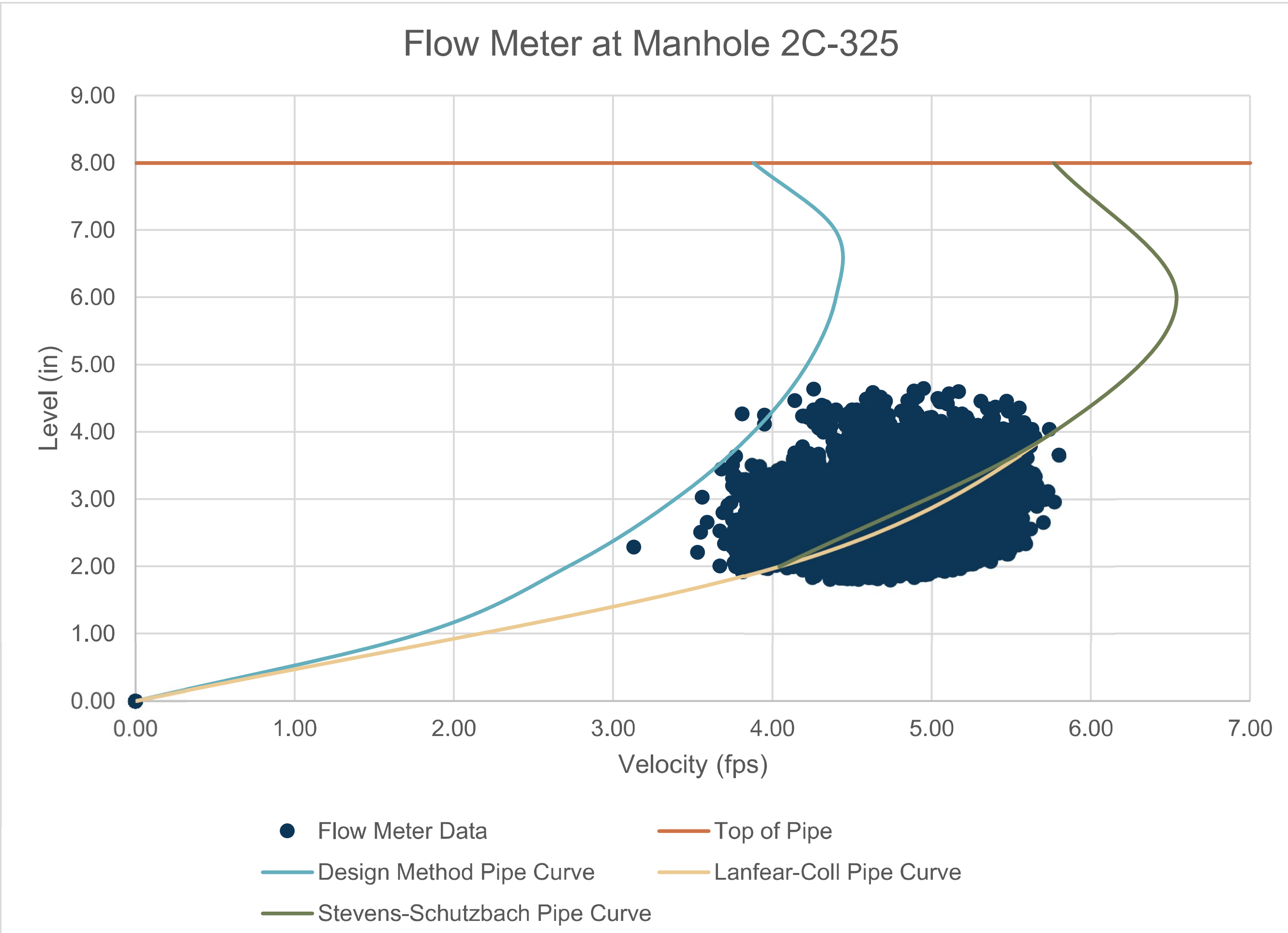


Figure 3-3: Scatterplot for Flow Meter at Manhole 2C-325

3.5 Flow Meter at Manhole 2E-566

Manhole 2E-566 is located in the Lift Station 6 basin and picks up flow from the portion of the City of Gladstone's collection system that connects to OLWS' system. The scatter plot for the flow meter at Manhole 2E-566 is shown in Figure 3-4 and Figure 3-5. For this data set, the Stevens-Schutzbach pipe curve was equivalent to the Lanfear-Coll pipe curve. Neither these curves nor the design curve provided a great fit to the observed data. Manhole 2E-566 is located two manholes upstream of Lift Station 6. There appears to be two distinct patterns at lower flow levels that generally follow the shape of the pipe curve – one on the bottom right and one above and to the left (circled in red). The direction of this shift indicates that the data is following iso-Q (equal flow) lines and could possibly be impacted by flows at Lift Station 6. Given the appropriate shape of the scatter plot in these two distinct zones, the data is suitable for calibrating the hydraulic model. The velocity vs level data points plotted above the pipe diameter of 8 inches indicate that the manhole is surcharging frequently and is likely influenced by wastewater elevations within the Lift Station 6 wet well.

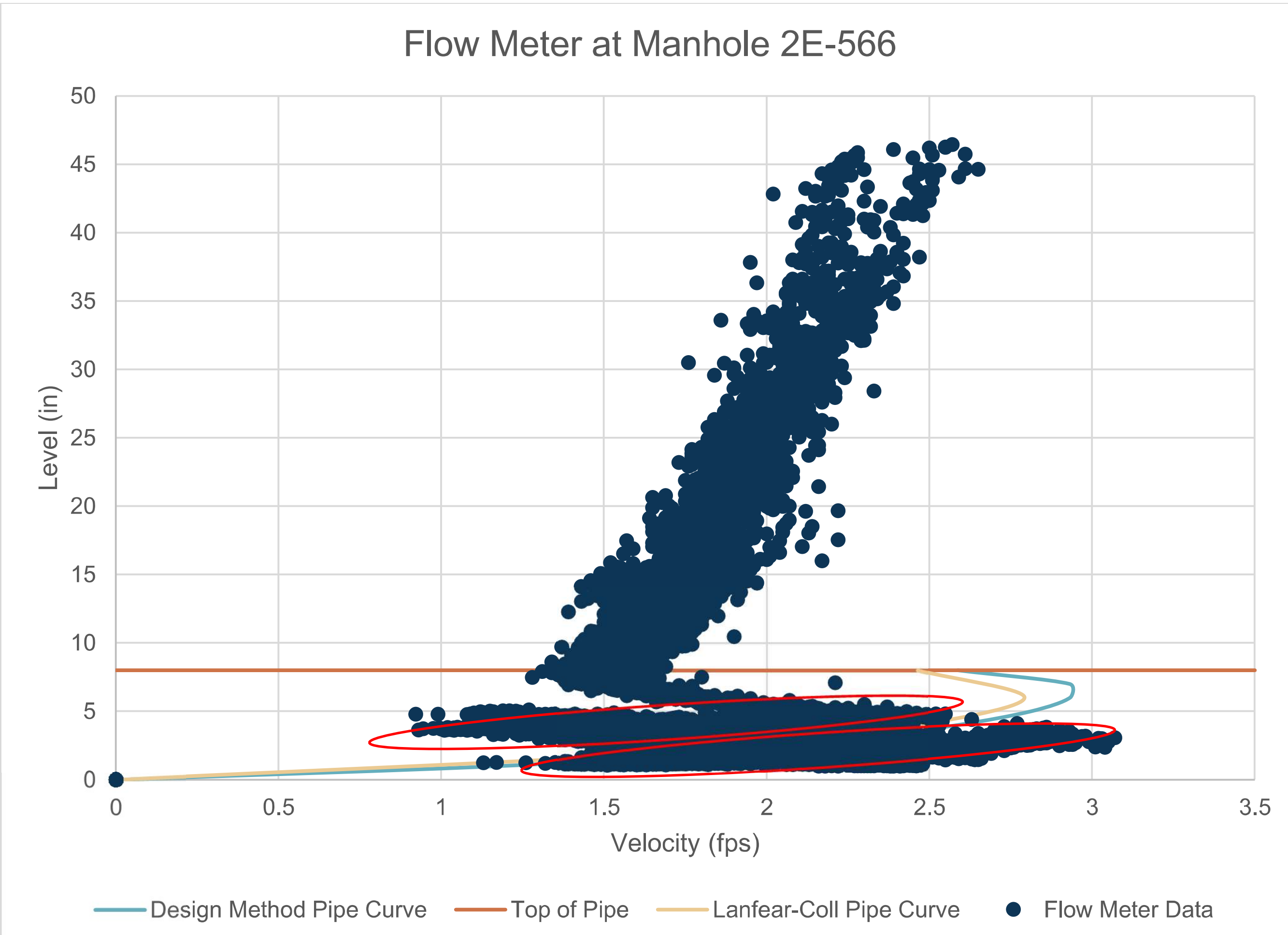


Figure 3-4: Scatterplot for Flow Meter at Manhole 2E-566

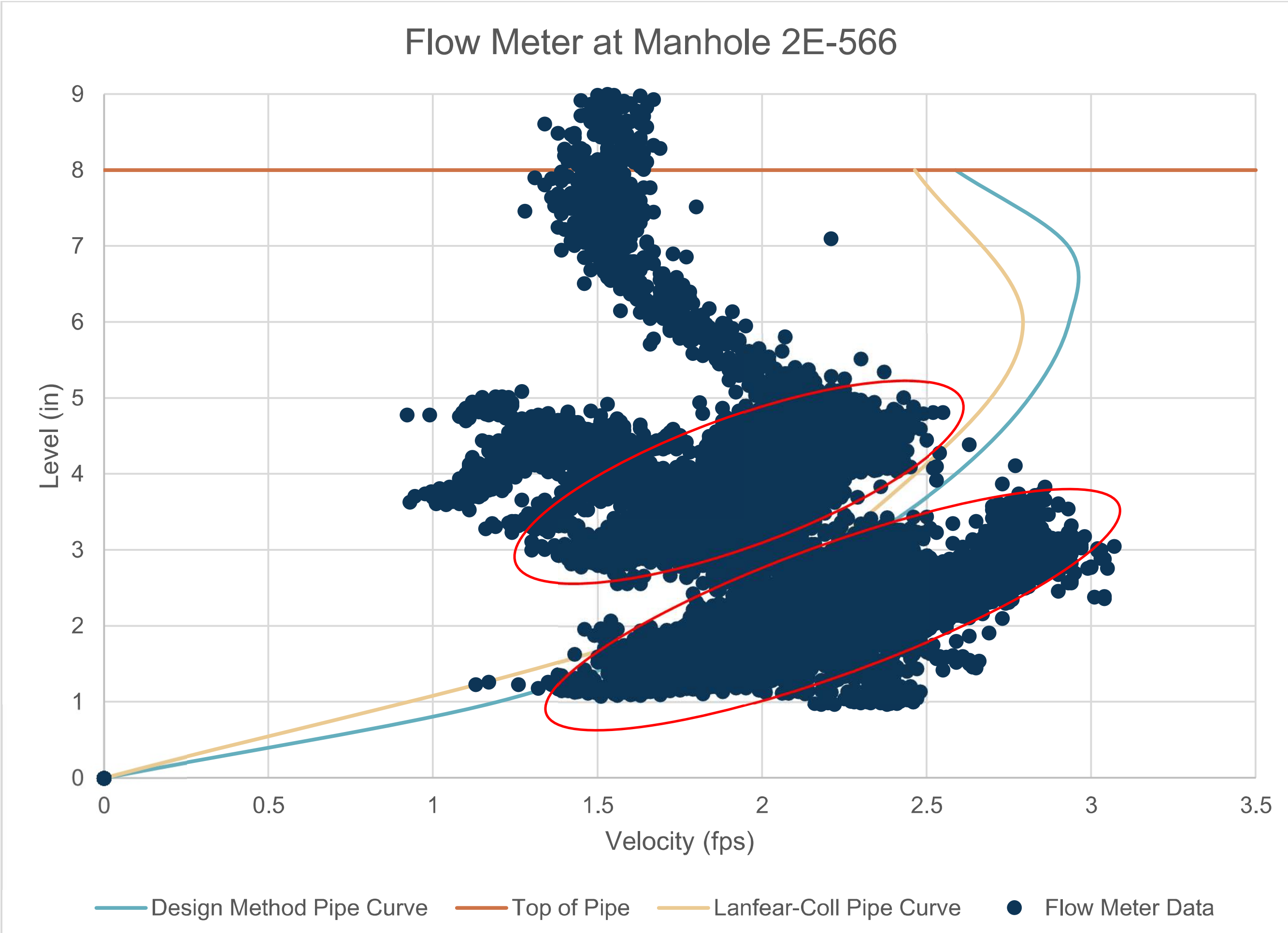


Figure 3-5: Scatterplot for Flow Meter at Manhole 2E-566 at Lower Flow Levels

3.6 Flow Meter at Manhole B-299

Manhole B-299 is located in the Influent Lift Station basin and captures a relatively large portion of the total area of the basin. The scatter plot for the flow meter at Manhole B-299 is shown in Figure 3-6. All three pipe curve methods fit the data well, with the Stevens-Schutzbach Method providing the best fit (R^2 equal to 0.91). To optimize the fit, a downstream obstruction factor of 1.5 inches was used to subtract from the measured depth. Since this is an 18-inch diameter main, this level of obstruction is minor and could be attributed to sediment buildup or a potential sag downstream. During heavy rain periods, this flow meter measured levels significantly above the top of the pipe indicating significant surcharging. Since the velocity-depth relationship moved up and to the right (level increases and so does flow), the sewer is experiencing orifice flow conditions. Orifice flow conditions indicate that free flow conditions are present downstream of the flow monitor past the restriction. Overall, this flow meter's data is satisfactory for use in calibrating the hydraulic model.

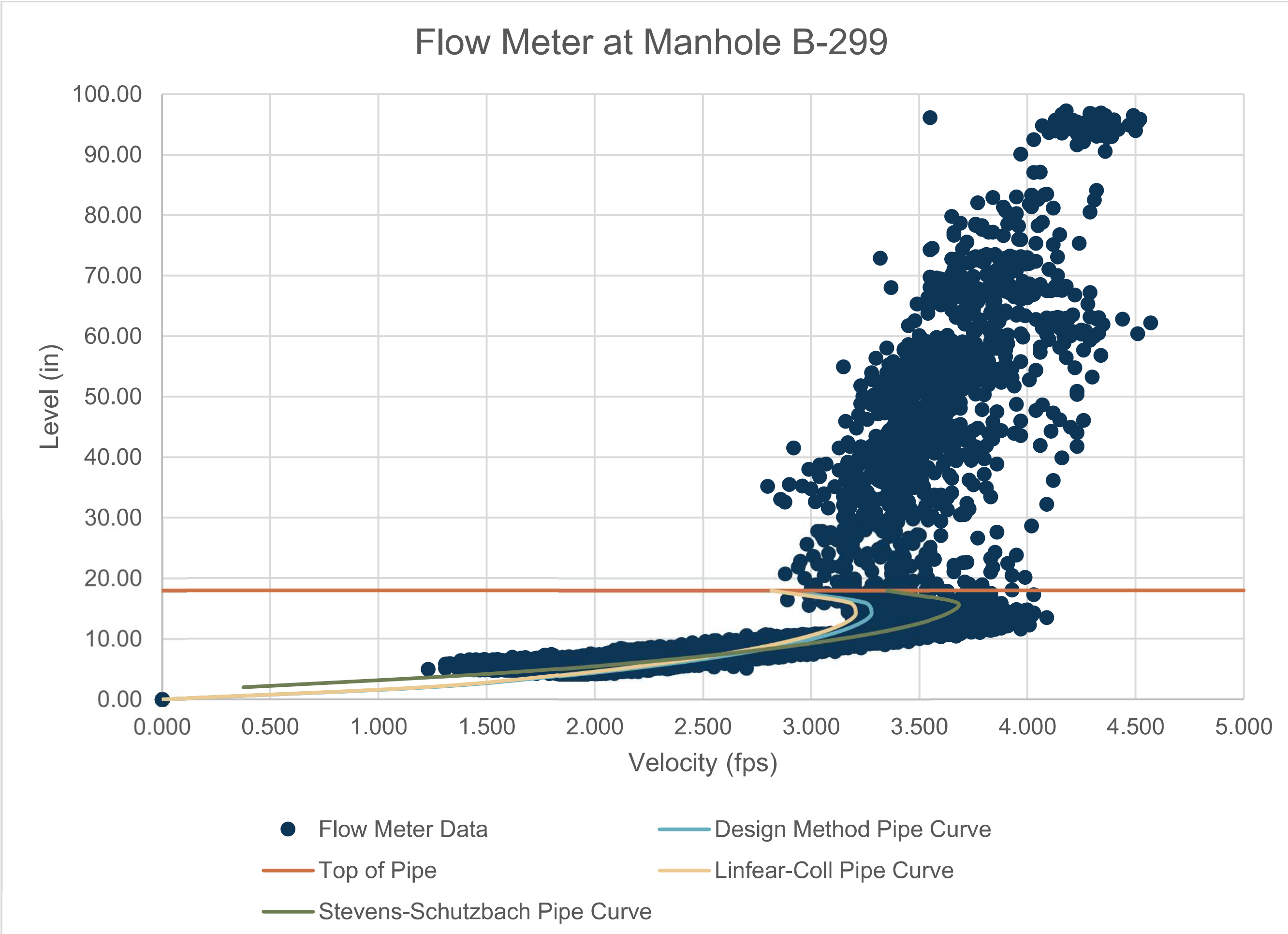


Figure 3-6: Scatterplot for Flow Meter at Manhole B-299

3.7 Flow Meter at Manhole B-5930

Manhole B-5930 is located in the Influent Lift Station basin and captures the southeastern portion of the basin. The scatter plot for the flow meter at Manhole B-5930 is shown in Figure 3-7. The Design Method pipe curve slightly underpredicted the level reading for a given velocity, indicating that the Manning's coefficient and/or the slope used was not accurate. However, the Lanfear-Coll and Steven-Schutzbach pipe curves both fit the data well, with the Steven-Schutzbach pipe curve having the best overall fit (R^2 value of 0.86). The Steven-Schutzbach pipe curve was optimized using a downstream obstruction value of 0.65 inches, which indicates relatively minor obstructions downstream of the meter given that this is a 15-inch diameter pipe. Based on the strong correlation of the data to the pipe curve, the readings can be considered accurate. The precision for the meter is generally strong with data points located close together, however the precision seems to decrease at higher velocities and higher level readings. Overall, this flow meter's data is satisfactory for use in calibrating the hydraulic model. The flow meter stopped collecting and transmitting data on December 22, 2021, and SFE Global was able to inspect the meter and resume data collection on January 8, 2022. Unfortunately, the gap in data included one of the largest storm events during the flow monitoring period, but the data includes several smaller storms that will support model calibration.

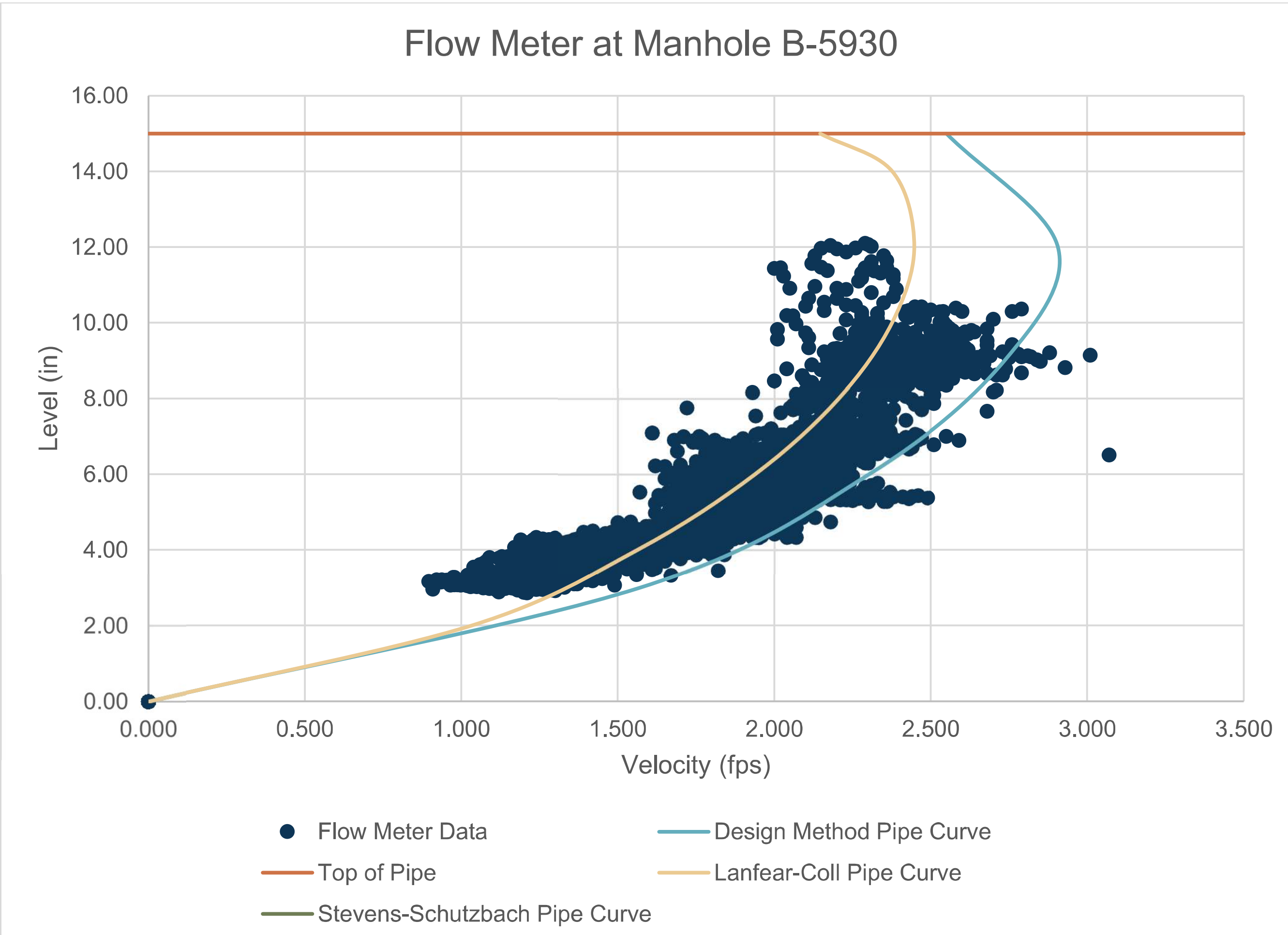


Figure 3-7: Scatterplot for Flow Meter at Manhole B-5930

3.8 Flow Meter at Manhole C-2672

Manhole C-2672 is located in the Influent Lift Station basin and captures the northeast portion of the basin. The scatter plot for the flow meter at Manhole C-2672 is shown in Figure 3-8. The Design Method pipe curve provided the worst overall fit, indicating the slope and/or Manning's roughness coefficient from the as-builts were not accurate. The Stevens-Schutzbach pipe curve provided the best overall fit using a downstream obstruction value of 1.5 inches to achieve an R^2 value of 0.69. The fit of the pipe curve is fairly good for velocities up to 3.25 feet per second. After this velocity reading, the observed data continues to indicate velocity increasing while the level seems to stabilize around 10 inches. Based on the Manning's Equation, the velocity should show an inflection point around a level of 10 inches and begin to reduce as the pipe continues to fill. This potentially indicates the level sensor's accuracy was diminished at higher levels for this particular sensor. While the higher velocities seem to be a poor fit, overall, the data had a decent R^2 fit, indicating moderate accuracy. Precision at this meter was low with levels ranging 4 inches for a given velocity reading. Based on the overall scatterplot pattern, it is not recommended this flow meter be used calibrating the hydraulic model.

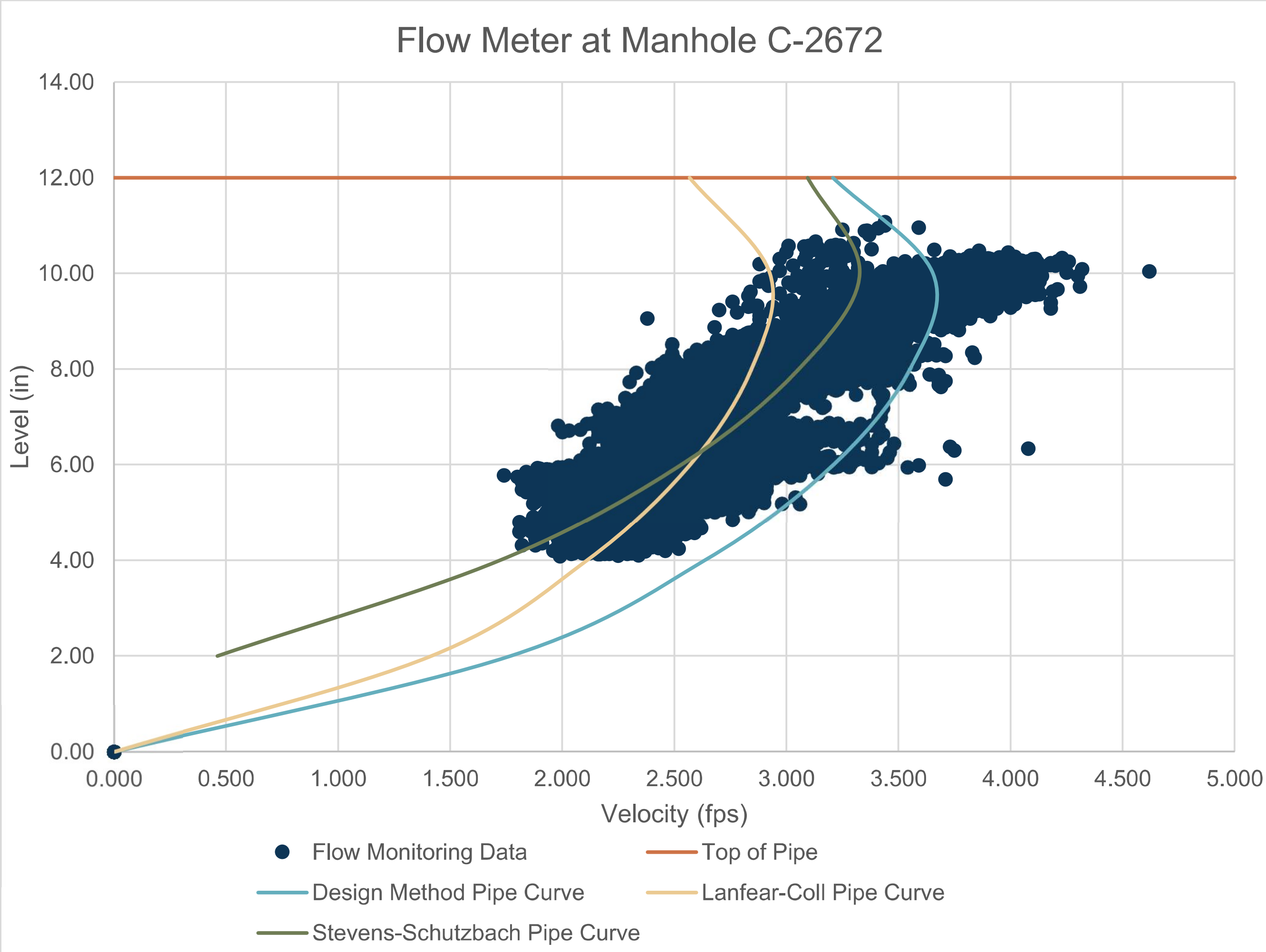


Figure 3-8: Scatterplot for Flow Meter at Manhole C-2672

3.9 Flow Meter at Manhole E-949

Manhole E-949 is located in the Lift Station 3 basin. The scatter plot for the flow meter at Manhole E-949 is shown in Figure 3-9. The Design Method pipe curve is shifted significantly to the right of the data indicating the Manning's roughness coefficient and/or the pipe slope from the as-builts is not correct. The Lanfear-Coll pipe curve provides a better fit (R^2 value of 0.619), but the fit is not optimized because the curve must fit though the origin. The Stevens-Schutzbach pipe curve provided the best fit by using a downstream obstruction value of 1.5 inches to achieve an R^2 value of 0.76. This R^2 value indicates a moderate level of accuracy in the data. The overall precision of the data is good with values being generally close together for a given velocity. Overall, this data is satisfactory for use in calibrating the hydraulic model.

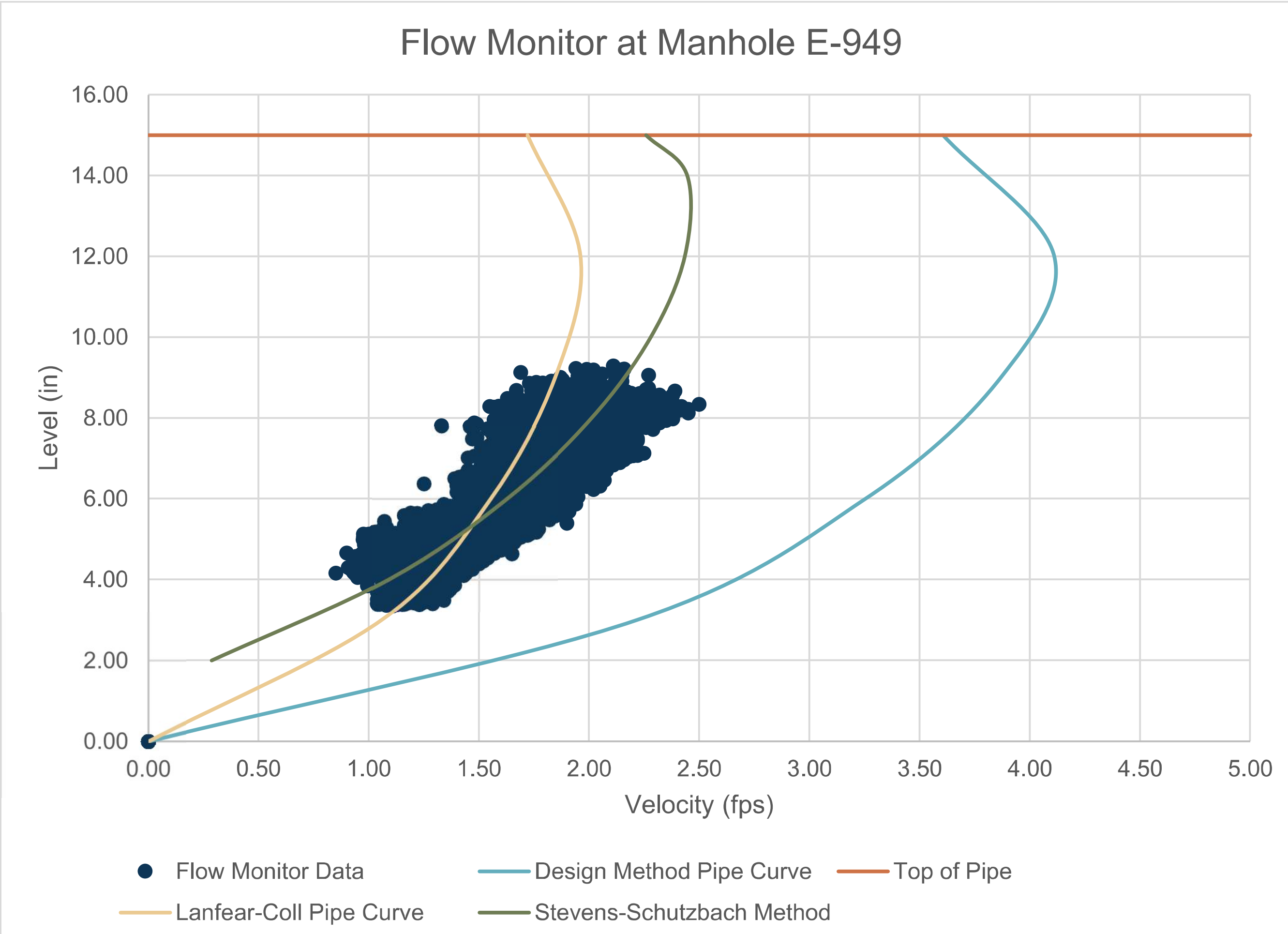


Figure 3-9: Scatterplot for Flow Monitor at Manhole E-949

3.10 Flow Data Summary

The following table provides a summary of which flow meters will be used for calibrating the hydraulic model. Overall, five of the eight meters captured flow data suitable for model calibration.

Table 3-1: Flow Meter Calibration Summary

Flow Meter	Used for Model Calibration
2A7-325	No
2B-3820	Yes
2C-325	No
B-299	Yes
B-5930	Yes
C-2672	No
E-949	Yes

4.0 Flow Data Analysis

4.1 Overview

Plots of the flow measured at each of the flow meters are included in Appendix C. The following subsections identify dry weather flow, groundwater infiltration, and peak wet weather flow based on the flow monitoring data.

4.2 Dry Weather Flow

For the purposes of developing and calibrating the model, average dry weather flow was determined by evaluating the average flow at OLWS' Influent Lift Station from July 8, 2021 through July 28, 2021, as this period was determined to be most representative of dry weather conditions with no active rain during this time and no rain within the 14 days prior to this period. Flow monitors were not deployed during the summer months so the flow monitoring data could not be used to determine the average dry weather flow in the collection system.

4.3 Determination of Groundwater Infiltration

To determine the impacts of groundwater infiltration (GWI), the winter flow monitoring data was evaluated to determine the average flow under no rain conditions and compared with the average dry weather flow. During the winter months, the soils are often saturated due to an elevated groundwater table so that even when it has not been raining, flows within the collection system are higher than those observed during the summer months.

For the purposes of this master plan, average dry weather flow was only determined at the Influent Lift Station while flow metering data was collected at eight locations throughout the collection system. To estimate average dry weather flow at the locations with flow meters, the calibrated hydraulic model was run under dry weather conditions and the flows extracted from these locations. GWI was then determined for the flow metering subbasin by subtracting the average dry weather flow model output from the average flow measured under dry conditions during the wintering monitoring period, which was determined to be January 23, 2022 – January 29, 2022. The flow meters whose data was not determined to be suitable for calibration were omitted from the GWI analysis as these data sets did not produce reliable numbers. A summary of the results is shown in Table 4-1.

Table 4-1: Estimated GWI

Flow Meter Location	Modeled ADWF (gpd)	Winter Dry Weather Flow (gpd)	Flow Meter Basin GWI (gpd)
2A7-325	60,832	Omitted from GWI Analysis	
2B-3820	89,747	181,583	91,836
2C-325	146,424	Omitted from GWI Analysis	
2E-566	83,599	120,460	36,861
B-299	518,456	725,020	206,564
B-5930	227,905	278,928	51,023
C-2672	168,451	Omitted from GWI Analysis	
E-949	104,941	246,801	141,860

4.4 Wet Weather Flow

To estimate peak wet weather flow, the average hourly flow rate was determined for each hour on each day. The highest average hourly flow rate was designated as the peak hour flow. Peaking factors were estimated by dividing the peak hour flow by the modeled ADWF. A summary of these values is presented in Table 4-2. It should be noted that the peak hour flow for meter B-5930 did not occur during the largest storm during the metering period due to the metering failing to collect data during that storm. The actual peak hour flow was likely higher.

Table 4-2: Peak Wet Weather Flow

Flow Meter Location	Modeled ADWF (gpd)	Peak Hour Flow (gpd)	Peaking Factor	Occurrence of Peak Flow
2A7-325	60,832	Omitted from Analysis		
2B-3820	89,747	1,053,661	11.7	1/3/22 at 4 am
2C-325	146,424	Omitted from Analysis		
2E-566	83,599	588,784	7.0	12/22/22 at 8 am
B-299	518,456	5,132,466	9.9	1/3/22 at 7 am
B-5930	227,905	1,591,863	7.0	12/18/22 at 11 pm
C-2672	168,451	Omitted from Analysis		
E-949	104,941	1,062,624	10.1	1/3/22 at 11 am

5.0 Rainstorm Analysis

Rainfall data was collected by two rain gauges on opposite sides of OLWS' service area throughout the duration of flow monitoring. Rain Gauge 1 was located at the OLWS Wastewater Treatment Plant and Rain Gauge 2 was located at the OLWS Valley View Tank site. A summary of the largest rainstorms captured is presented in Table 5-1. For the purposes of modeling RDII, the data used for wet weather calibration of the model should ideally include a series of storms that stress the collection system so that the soil is saturated. According to ADS Environmental, "system stressing events are typically more than one inch of rainfall in a 24-hour period."(2) The rain gauges and flow meters captured two storms that meets these criteria. The storm from January 2, 2022 – January 3, 2022 will be used for calibrating the model to wet weather conditions due to it having the largest quantity of rain. In addition to receiving over 1 inch of rain in 24 hours, this storm also had the second largest peak rain intensity and was preceded by smaller storms that allowed for antecedent soil saturation conditions. All of these provide valuable data for developing the wet weather response unit hydrographs within the hydraulic model.

Table 5-1: Top 5 Rain Event (24 Hour) by Total Rain During Wet Weather Monitoring

Period	Total Rain (inches)	Peak Rain Intensity (inches/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

6.0 Conclusion

Overall, the flow metering effort successfully captured flow data for eight locations within OLWS' collection system. Based on an analysis of the metering data using the Manning's Equation and scatter plots, only five of these locations were deemed to have valid data for model calibration. One of these five locations (B-5930) did not have flow data logged during the peak rainstorm that will be used for calibrating the hydraulic model. However, this meter did collect flows during the second largest rainstorm (February 27-28, 2022), which will allow it to be incorporated into the model calibration process. These five locations with good data are sufficient for accurately calibrating the hydraulic model.

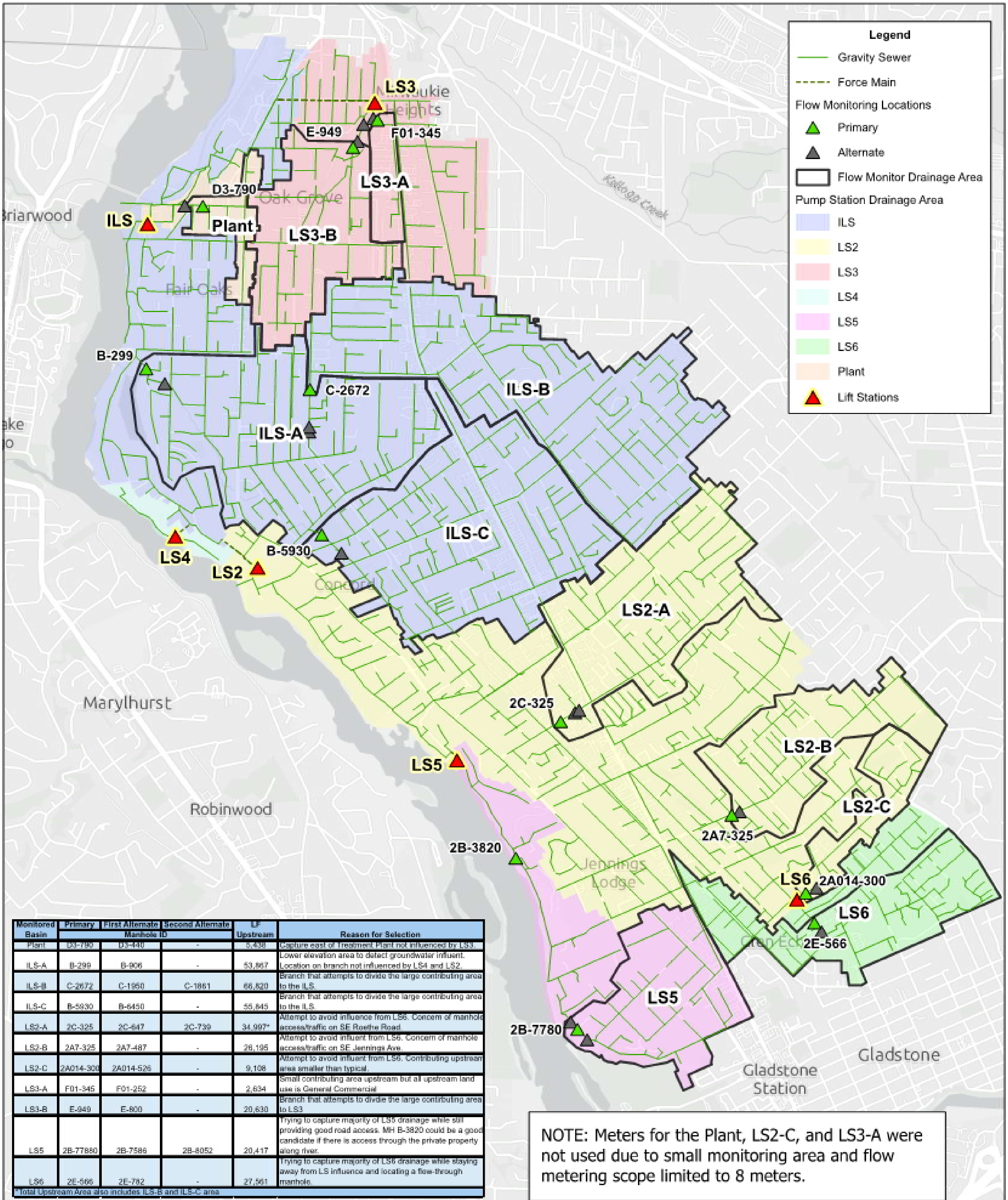
The five locations with good data quality were used to estimate ground water infiltration within each flow metering basin as well as peak wet weather flow. A rainstorm analysis was used to determine the largest intensity storm captured for use in calibrating the model. The analysis determined that the storm from January 2, 2022 through January 3, 2022 will provide the best results.

7.0 References

1. **Kevin L. Enfinger, P.E. and Hal R. Kimbrough, Ph.D.** *Scattergraph Principles and Practice: A Comparison of Various Applications of the Manning Equation.* San Diego, CA : American Society of Civil Engineers, 2004.

2. *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.** Huntington Beach, CA : Water Environment Federation, 2005, Vols. Collection Systems 2005 - Sustaining Aging Infrastructure: System, Workforce, and Funding.

Appendix A Flow Meter Plan



Monitored Basin	Primary	First Alternate	Second Alternate	LF Upstream	Reason for Selection
	Manhole ID				
Plant	D3-790	D3-440	-	5,438	Capture east of Treatment Plant not influenced by LS3.
ILS-A	B-299	B-906	-	53,867	Lower elevation area to detect groundwater influent. Location on branch not influenced by LS4 and LS2.
ILS-B	C-2672	C-1950	C-1861	66,820	Branch that attempts to divide the large contributing area to the ILS.
ILS-C	B-5930	B-6450	-	55,845	Branch that attempts to divide the large contributing area to the ILS.
LS2-A	2C-325	2C-647	2C-739	34,997*	Attempt to avoid influence from LS6. Concern of manhole access/traffic on SE Roethe Road.
LS2-B	2A7-325	2A7-487	-	28,195	Attempt to avoid influent from LS6. Concern of manhole access/traffic on SE Jennings Ave.
LS2-C	2A014-300	2A014-526	-	9,108	Attempt to avoid influent from LS6. Contributing upstream area smaller than typical.
LS3-A	F01-345	F01-252	-	2,634	Small contributing area upstream but all upstream land use is General Commercial
LS3-B	E-949	E-800	-	20,630	Branch that attempts to divdie the large contributing area to LS3
LS5	2B-77880	2B-7586	2B-8052	20,417	Trying to capture majority of LS5 drainage while still providing good road access. MH B-3820 could be a good candidate if there is access through the private property along river.
LS6	2E-566	2E-782	-	27,561	Trying to capture majority of LS6 drainage while staying away from LS influence and locating a flow-through manhole.

*Total Upstream Area also includes ILS-B and ILS-C area

NOTE: Meters for the Plant, LS2-C, and LS3-A were not used due to small monitoring area and flow metering scope limited to 8 meters.

WSC

N

Scale: 1:28,000

0 1,000 2,000 3,000 4,000 Feet

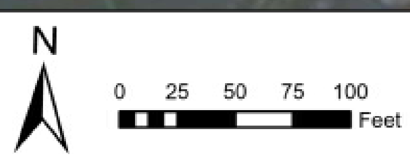
Oak Lodge Wastewater Flow Monitoring Locations
Overall Collection Basin Map

WSC

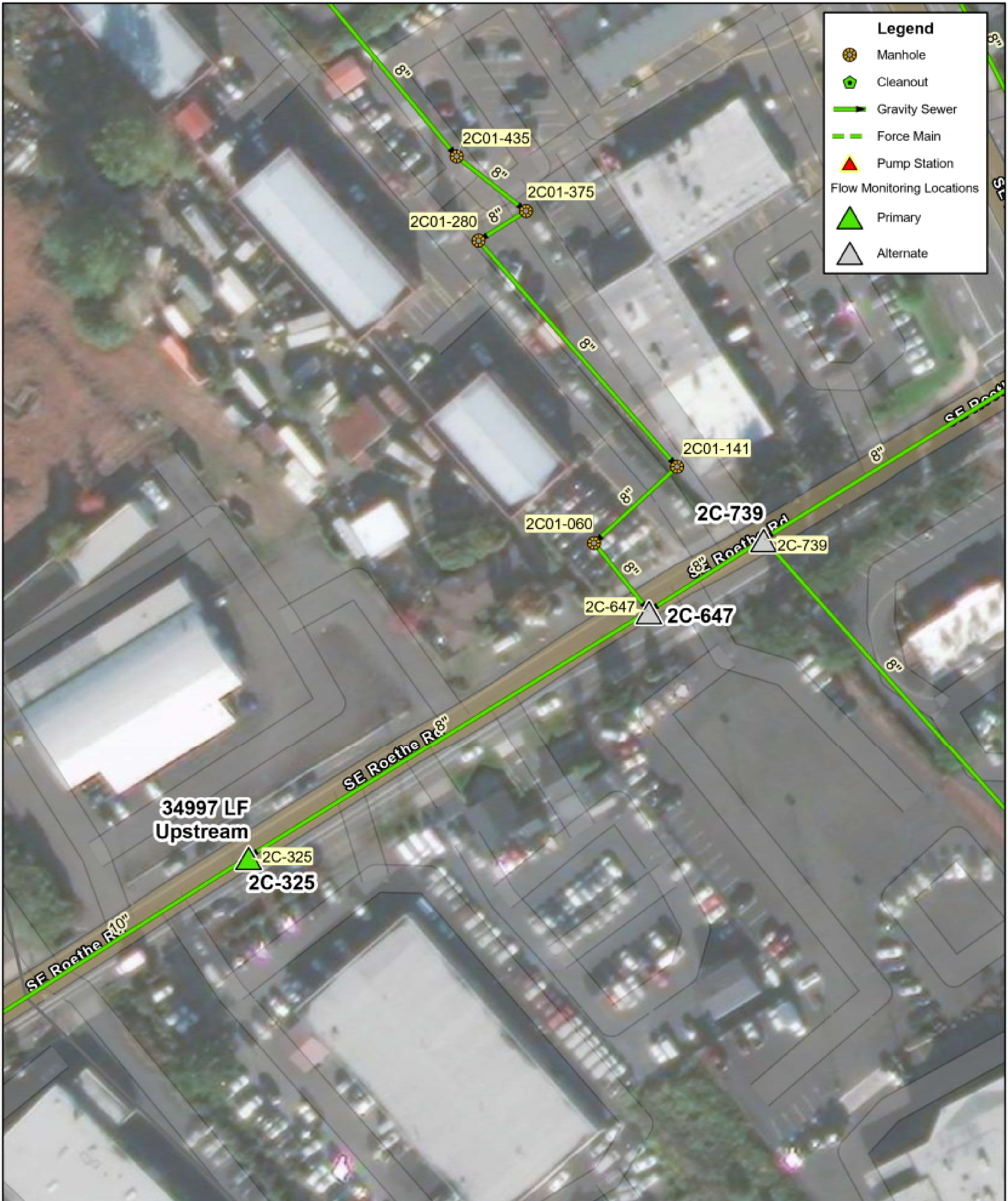
Oak Lodge Sewer Flow Monitoring Locations
ILS-A Flow Monitoring Location

N
0 30 60 90 120 Feet

Oak Lodge Sewer Flow Monitoring Locations
ILS-B Flow Monitoring Location



Oak Lodge Sewer Flow Monitoring Locations
ILS-C Flow Monitoring Location



WSC

N

0 25 50 75 100 Feet

Oak Lodge Sewer Flow Monitoring Locations
LS2-A Flow Monitoring Location

WSC

Oak Lodge Sewer Flow Monitoring Locations
LS2-B Flow Monitoring Location

Oak Lodge Sewer Flow Monitoring Locations
LS3-B Flow Monitoring Location

WSC

N

0 20 40 60 80 Feet

Oak Lodge Sewer Flow Monitoring Locations
LS5 Flow Monitoring Location

Oak Lodge Sewer Flow Monitoring Locations
LS6 Flow Monitoring Location

Appendix B Flow Meter Installations

Site Details Sheet

SFE GLOBAL

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water Services, Oak Grove, OR**	**SFE SITE #:**	**2A7-325**

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	Dec 15 2021	Feb 28 2022
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	AB207C00222	na
Wireless I.D # / Cell #:	SFE Cell	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Compression	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

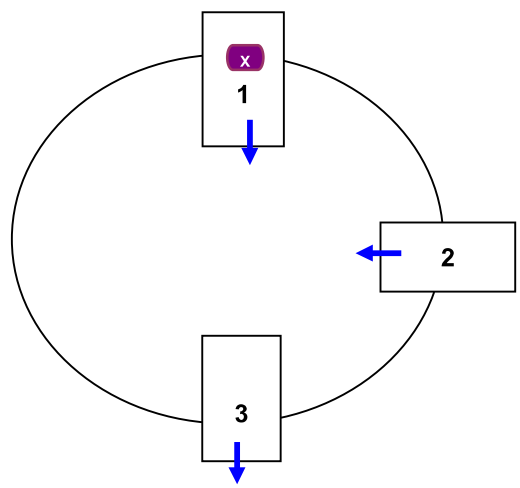
Client Site #:	2A7-325
Address (Location):	5322 SE Jennings Ave
City, State:	Milwaukie, OR
GPS (North - West):	
Landmarks:	na
Traffic Control Req's:	Full Traffic
Additional Information:	n/a

Site Profile

Invert Distance (in):	118	Access:	yes
Overall Site Condition:	residential intersection		
Pipe Size (in): #1	8	#2	8
#3	8	#4	na
Location of Sensor (which pipe?):	x	=	1
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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- -

Site Pictures

CLIENT MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	2A7-325

Notes

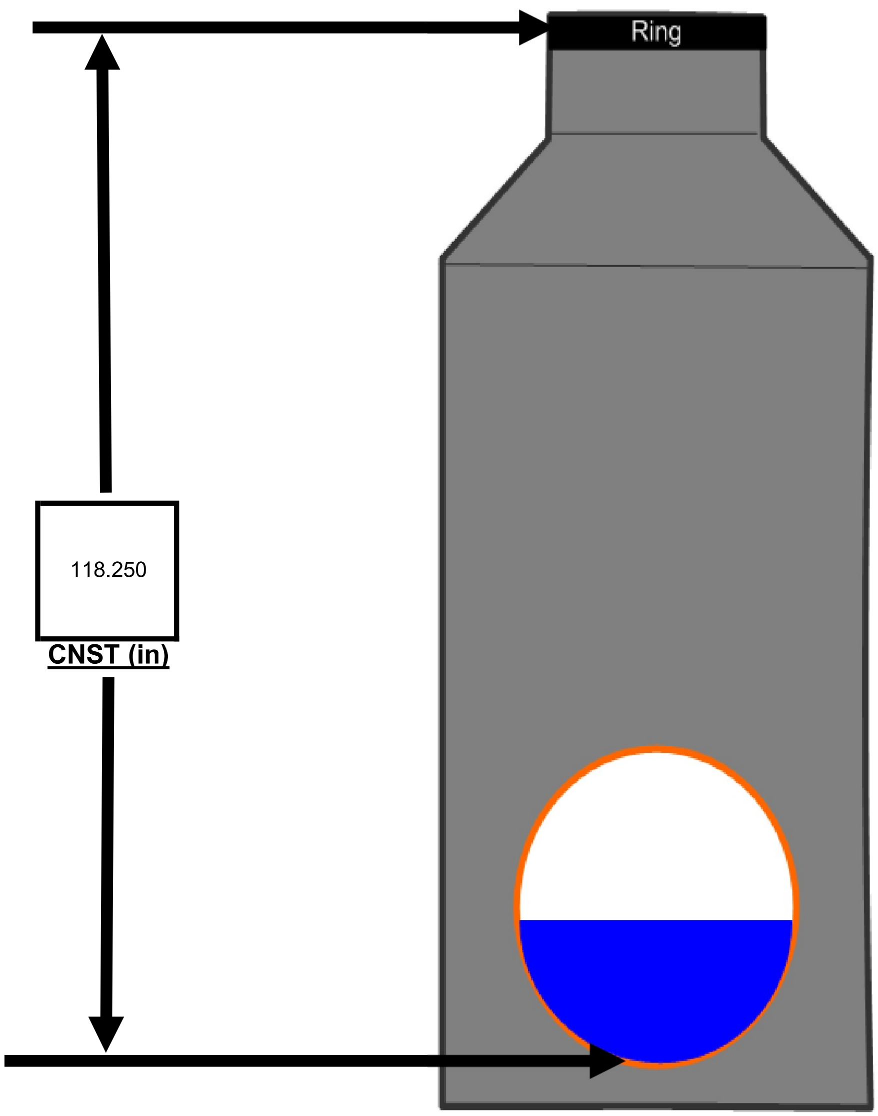
1 area
2 manhole prior to meter installation
3 manhole after sensor installation
4 meter
5
6

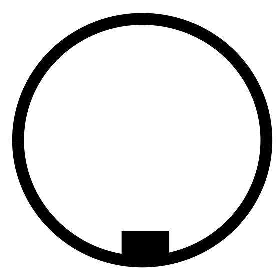
Install Sheet

CLIENT FLOW MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	2A7-325
		Technician 1:	Dylan Carvin
		Technician 2:	Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-15-21	12:04	3.3	3.1	install with 4" offset
1		12:05	3.3	3.2	
2		12:05	3.3	3.3	
3		12:05	3.3	2.2	
Average			3.3	2.9	





Sensor Location

Site Details Sheet

CLIENT MONITORING #: WSC | **SFE PROJECT #:** U026B
NAME: Oak Lodge Water Services, Oak Grove, OR | **SFE SITE #:** 2B-3820

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	Dec 17 2021	Feb 28 2022
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	BC206D00357	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	other	
Primary Device:	Weir - Custom	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

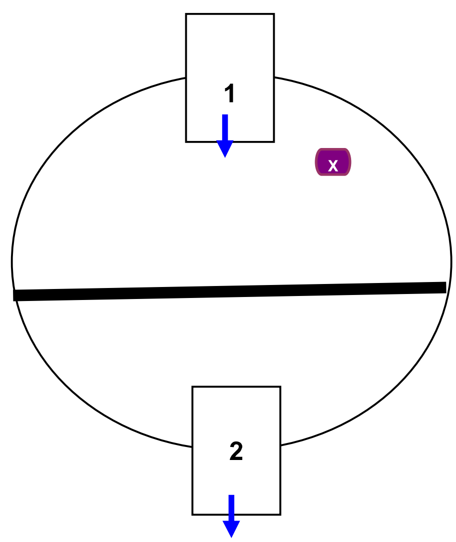
Client Site #:	2B-3820	
Address (Location):	18200 SE Willamette Dr	
City, State:	Milwaukie, OR	
GPS (North - West):	45.39083	122.623303
Landmarks:	on riverbank	
Traffic Control Req's:	Local Traffic	
Additional Information:	n/a	

Site Profile

Invert Distance (in):	73	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	12	#2	12
#3	na	#4	na
Location of Sensor (which pipe?): x =	1		
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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Site Pictures

CLIENT MONITORING #: WSC **SFE PROJECT #:** U026B
NAME: Oak Lodge Water Services, Oak Grove, OR **SFE SITE #:** 2B-3820

Notes

1 area
2 manhole prior to meter installation
3 manhole after sensor and weir installation
4 meter
5
6

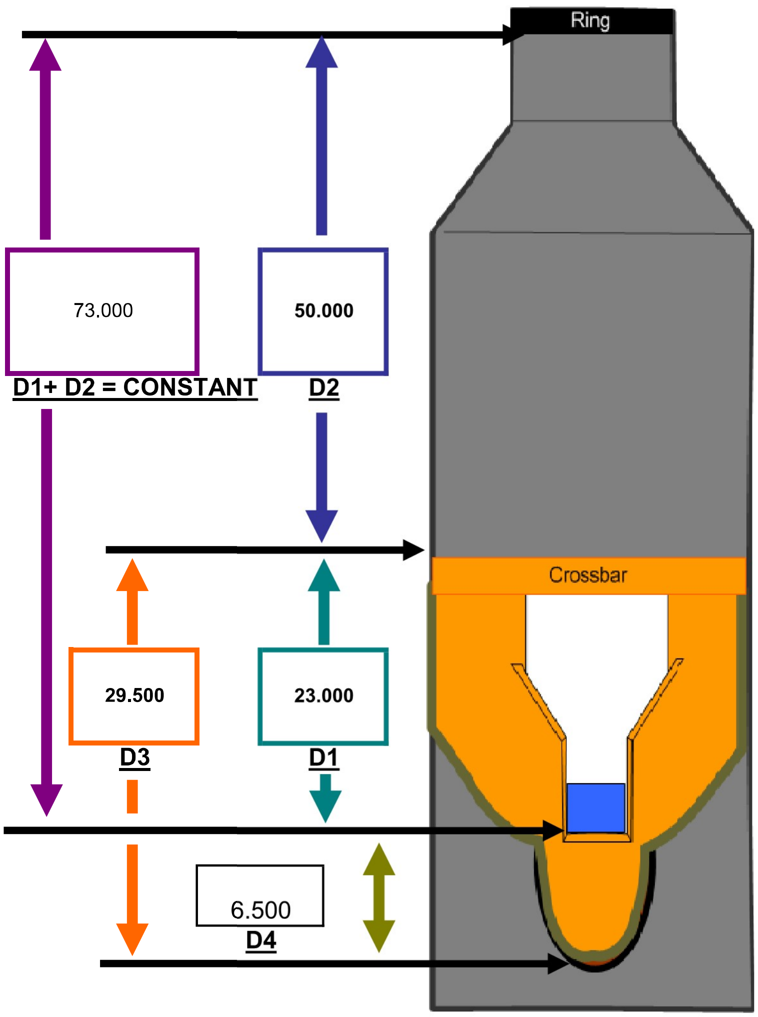
Weir Install Sheet

CLIENT FLOW MONITORING #: WSC
NAME: Oak Lodge Water Services, Oak Grove, OR

SFE PROJECT #: U026B
SFE SITE #: 2B-3820
Technician 1: Dylan Carvin
Technician 2: Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	2021-12-17	10:44	3.750	3.750	
1		10:46	3.675	4.339	
2		10:47	3.675	3.669	
3		10:48	3.500	3.600	
Average			3.650	3.840	



Weir Measurements

Weir Size (mm)
350

Raw Weir Level
3.650 (in)

CONSTANT
73.000 (in)

D1 CONSTANT
23.000 (in)

Enter Hi-lighted Numbers Only

Site Details Sheet

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water Services, Oak Grove, OR**	**SFE SITE #:**	**2C-325**

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	Dec 15 21	Feb 28 22
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	SFEAB077	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Compression	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

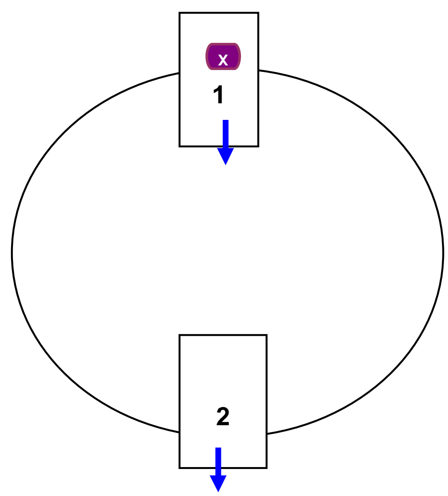
Client Site #:	2C-325	
Address (Location):	4111 SE Roethe Rd	
City, State:	Oak Grove, OR	
GPS (North - West):	45.397758	122.620897
Landmarks:	n/a	
Traffic Control Req's:	Full Traffic	
Additional Information:	n/a	

Site Profile

Invert Distance (in):	142.25	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	8	#2	8
#3	na	#4	na
Location of Sensor (which pipe?):	x	=	1
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

- incoming pipe is drop pipe, sensor inserted upstream
-
-
-
-
-

Site Pictures

CLIENT MONITORING #: **WSC** **SFE PROJECT #:** **U026B**
NAME: **Oak Lodge Water Services, Oak Grove, OR** **SFE SITE #:** **2C-325**

Notes

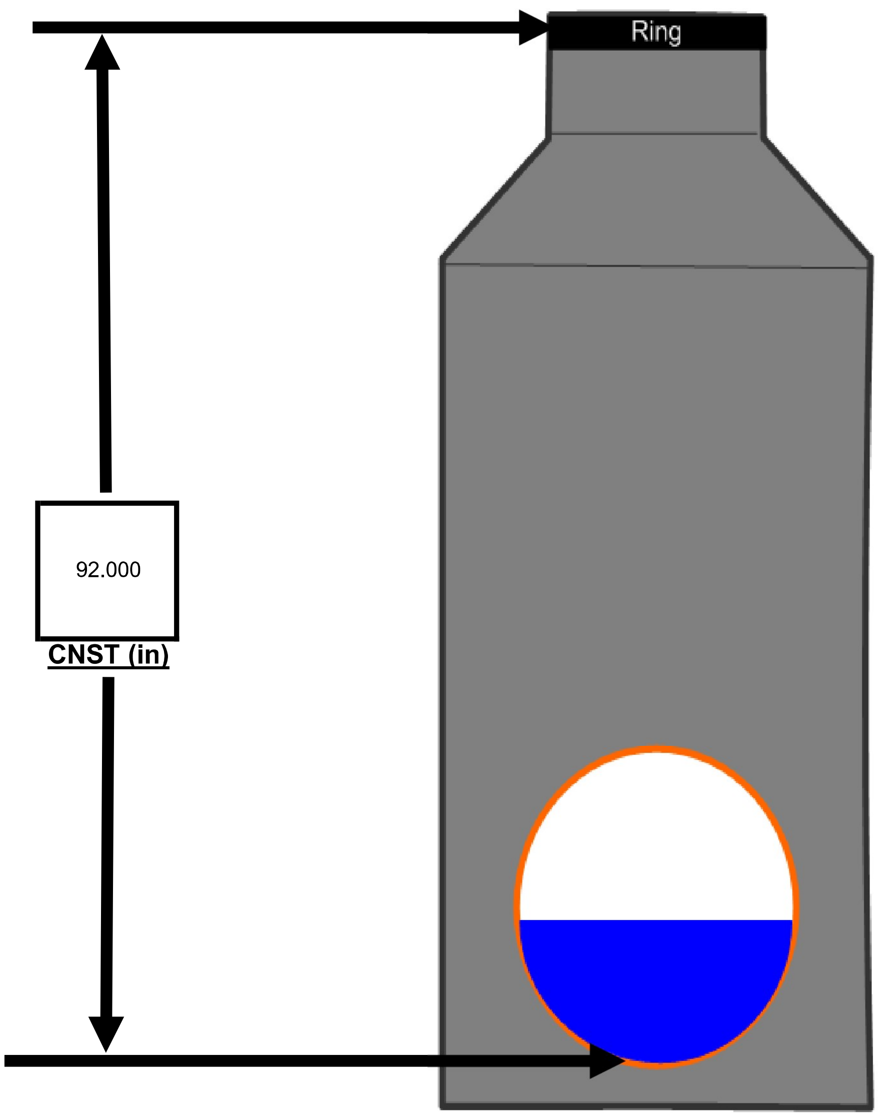
1 area
2 manhole prior to meter installation
3 manhole after sensor installation
4 meter
5
6

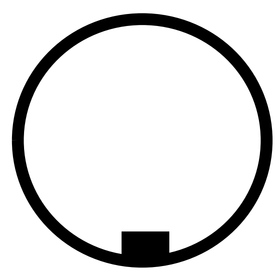
Install Sheet

CLIENT FLOW MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	2C-325
		Technician 1:	Dylan Carvin
		Technician 2:	Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-15-21	9:53	2.5	2.3	install with 4" offset
1		9:54	2.4	2.2	
2		9:54	2.4	2.2	
3		9:54	2.3	2.2	
Average			2.4	2.3	





Sensor Location

Site Details Sheet

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water Services, Oak Grove, OR**	**SFE SITE #:**	**2E-566**

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	Dec 16 21	Feb 28 22
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	AB212A01445	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Compression	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

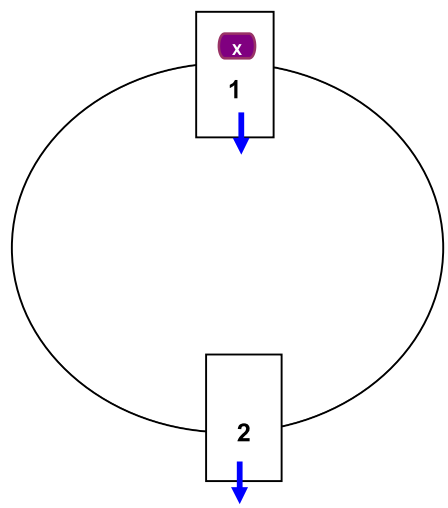
Client Site #:	2E-566	
Address (Location):	18595 Portland Ave	
City, State:	Gladstone, OR	
GPS (North - West):	45.387851	122.599929
Landmarks:	near Gladstone Public Works	
Traffic Control Req's:	Local Traffic	
Additional Information:	n/a	

Site Profile

Invert Distance (in):	207.75	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	8	#2	8
#3	na	#4	na
Location of Sensor (which pipe?):	x	=	1
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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Site Pictures

CLIENT MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	2E-566

Notes

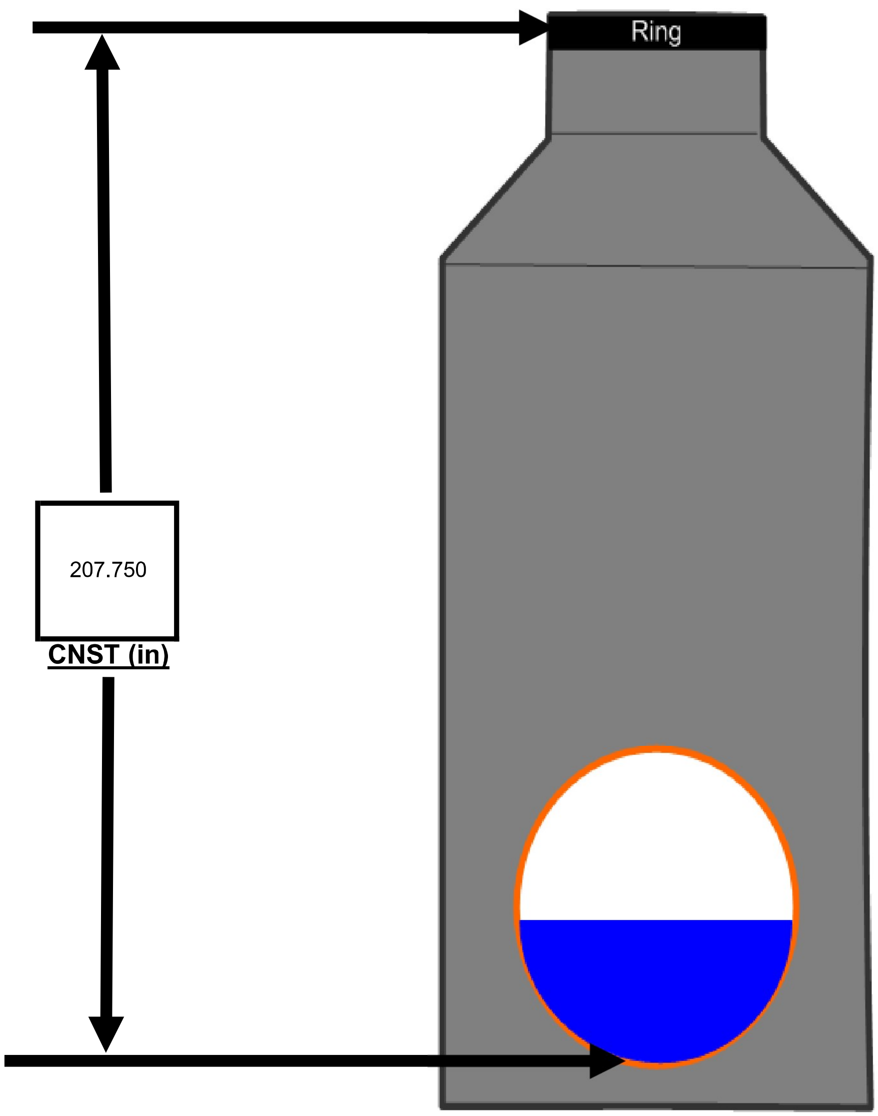
1 area
2 manhole prior to meter installation
3 manhole after sensor installation
4 meter
5
6

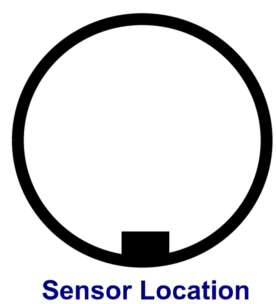
Install Sheet

CLIENT FLOW MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	2E-566
		Technician 1:	Dylan Carvin
		Technician 2:	Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-16-21	11:19	3.0	3.0	install with 4" offset
1		11:19	3.0	3.0	
2		11:20	3.0	3.0	
3		11:20	3.0	2.9	
Average			3.0	3.0	





Site Details Sheet

CLIENT MONITORING #: WSC
NAME: Oak Lodge Water Services, Oak Grove, OR
SFE PROJECT #: U026B
SFE SITE #: B-299

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	Dec 14 21	Feb 28 22
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	AB207C01382	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Hilti Band	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

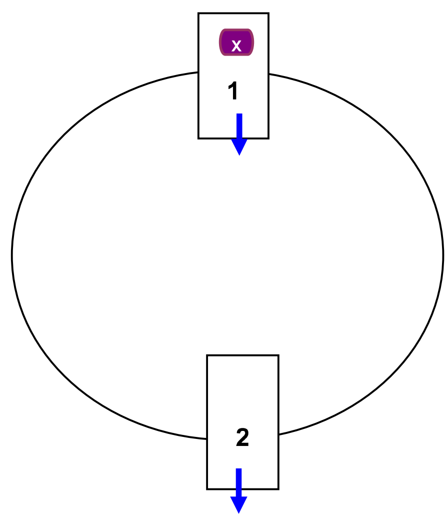
Client Site #:	B-299	
Address (Location):	980 SE Dogwood Ln	
City, State:	Milwaukie, OR	
GPS (North - West):	45.415653	122.652791
Landmarks:	na	
Traffic Control Req's:	Local Traffic	
Additional Information:	n/a	

Site Profile

Invert Distance (in):	170	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	18	#2	18
#3	na	#4	na
Location of Sensor (which pipe?): x =	1		
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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Site Pictures

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water Services, Oak Grove, OR**	**SFE SITE #:**	**B-299**

Notes

1 area
2 manhole prior to meter
3 manhole after sensor install
4 meter
5
6

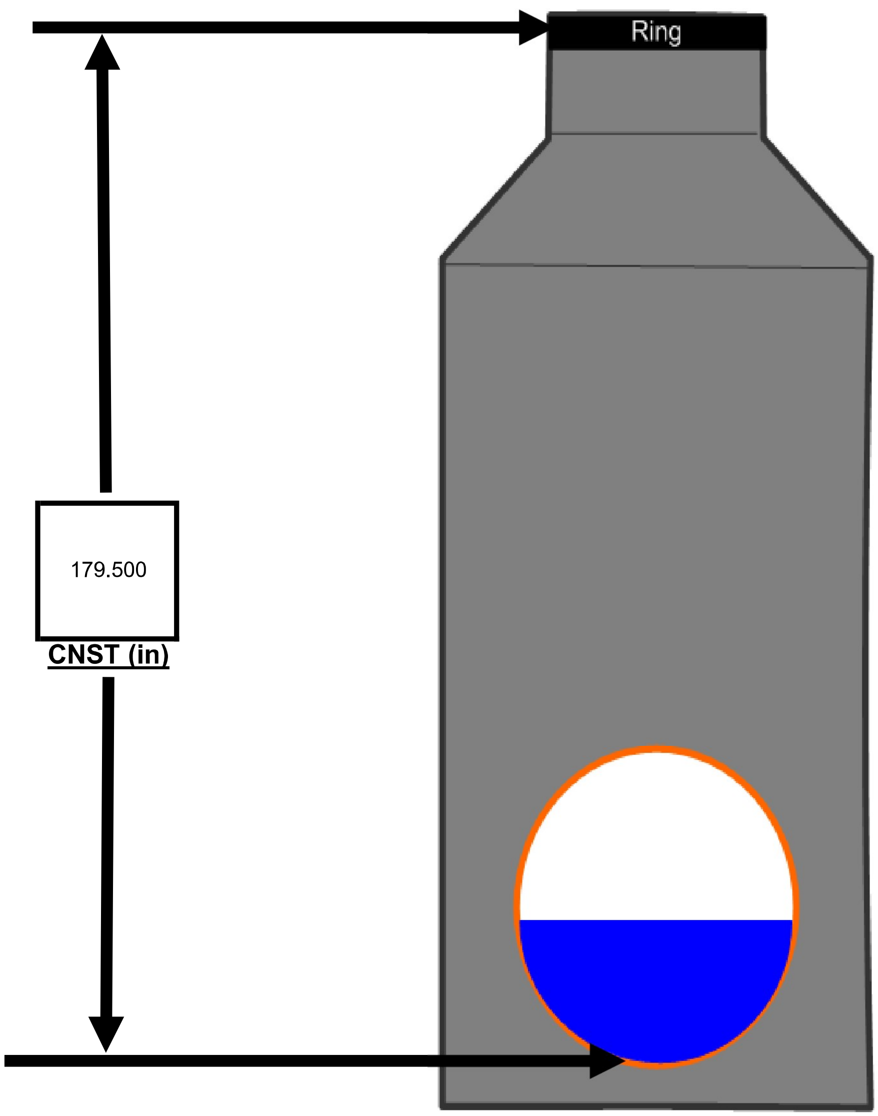
Install Sheet

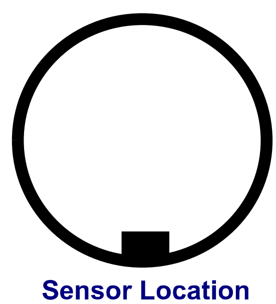
CLIENT FLOW MONITORING #: WSC
NAME: Oak Lodge Water Services, Oak Grove, OR

SFE PROJECT #: U026B
SFE SITE #: B-299
Technician 1: Dylan Carvin
Technician 2: Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-14-21	17:08	10.5	10.5	install with 4" offset
1		17:09	10.5	10.5	
2		17:09	10.5	10.5	
3		17:10	10.5	10.6	
Average			10.5	10.5	





Site Details Sheet

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water System, Oak Grove, OR**	**SFE SITE #:**	**B-5930**

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	Dec 14 2021	Feb 28 2022
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	AB207C01390	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Hilti Band	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

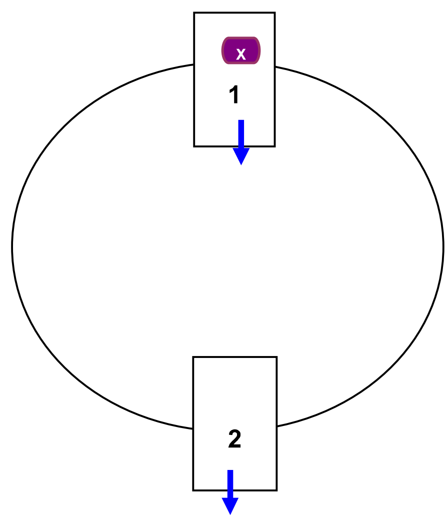
Client Site #:	B-5930
Address (Location):	2350 SE Swain Ave (Risley Park)
City, State:	Milwaukie, OR
GPS (North - West):	45.407507 122.63888
Landmarks:	Risley Park, near Tennis court
Traffic Control Req's:	Local Traffic
Additional Information:	Risley park, in bushes near tennis crt

Site Profile

Invert Distance (in):	135	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	15	#2	15
#3	na	#4	na
Location of Sensor (which pipe?):	x	=	1
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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Site Pictures

CLIENT MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water System, Oak Grove, OR	SFE SITE #:	B-5930

Notes

1	area	4	meter
2	manhole prior to meter	5	
3	manhole after sensor install	6	

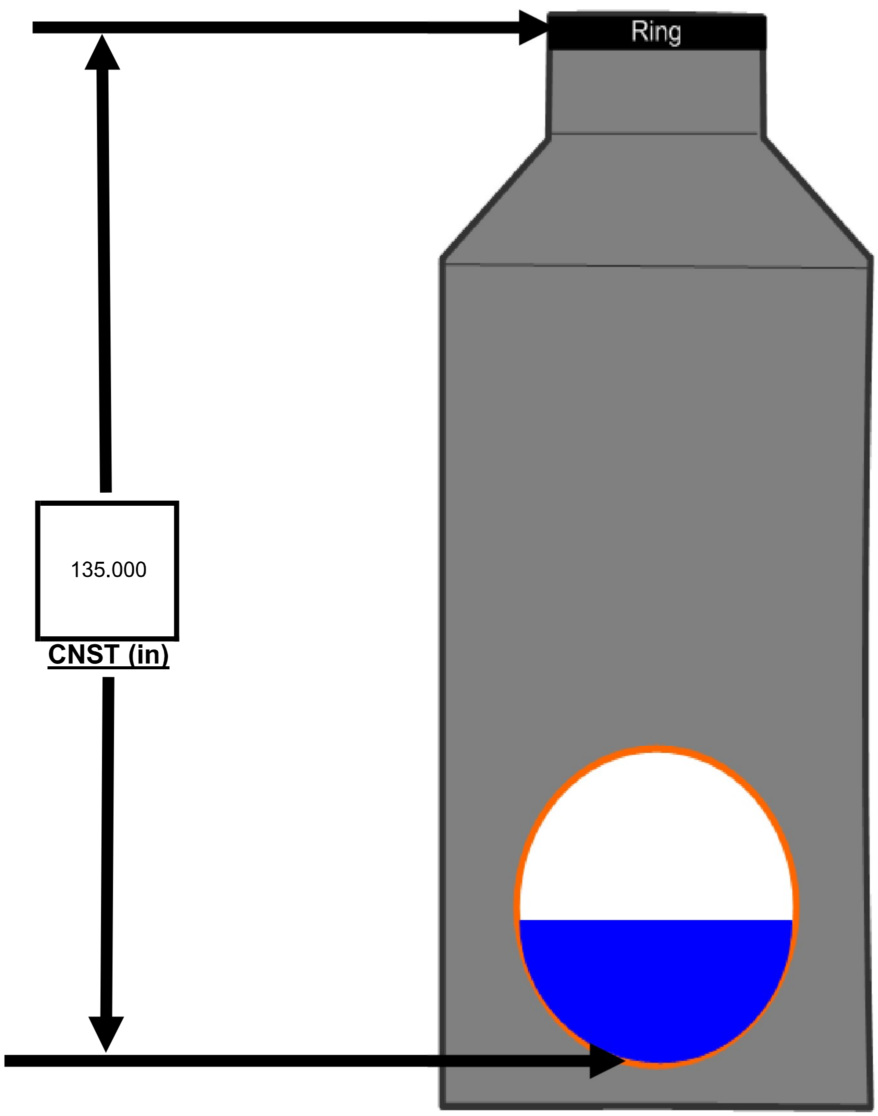
Install Sheet

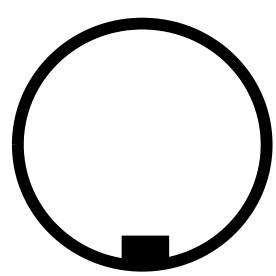
CLIENT FLOW MONITORING #: WSC
NAME: Oak Lodge Water System, Oak Grove, OR

SFE PROJECT #: U026B
SFE SITE #: B-5930
Technician 1: Jason Rowley
Technician 2: Dylan Carvin

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-14-21	14:49	6.3	6.2	install with 4" offset
1		14:50	6.3	6.2	
2		14:50	6.3	6.2	
3		14:51	6.3	6.2	
Average			6.3	6.2	





Sensor Location

Site Details Sheet

SFE GLOBAL

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water Services, Oak Grove, OR**	**SFE SITE #:**	**C-2672**

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	December 15 2021	February 28 2022
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	AB207C01400	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Compression	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

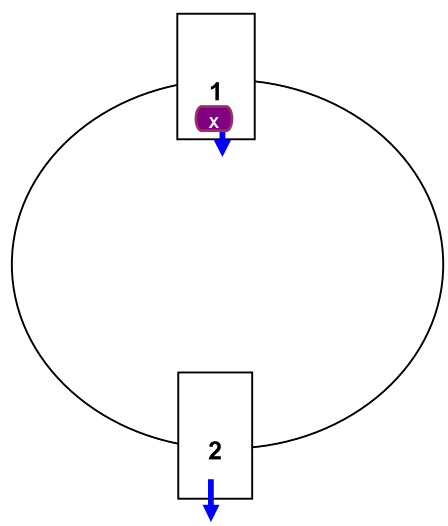
Client Site #:	B-5930
Address (Location):	14825 SE Rupert DR
City, State:	Oak Grove, OR
GPS (North - West):	45.414743 122.640811
Landmarks:	na
Traffic Control Req's:	Full Traffic
Additional Information:	n/a

Site Profile

Invert Distance (in):	89	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	12	#2	12
#3	na	#4	na
Location of Sensor (which pipe?):	x	=	1
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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Site Pictures

CLIENT MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	C-2672

Notes

1 area
2 manhole prior to meter
3 manhole with sensor
4 meter
5
6

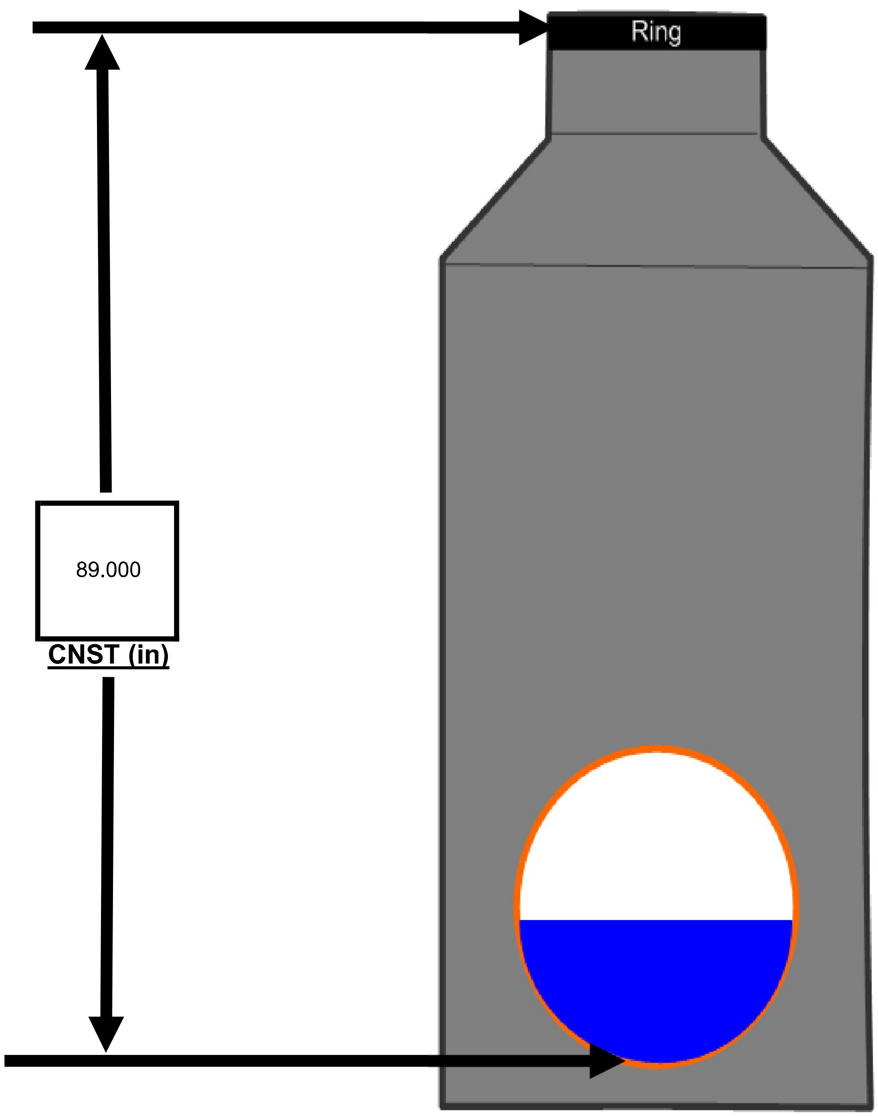
Install Sheet

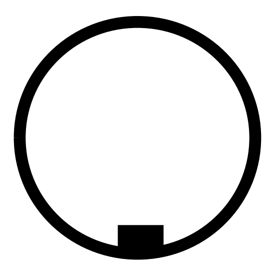
CLIENT FLOW MONITORING #: WSC
NAME: Oak Lodge Water Services, Oak Grove, OR

SFE PROJECT #: U026B
SFE SITE #: C-2672
Technician 1: Dylan Carvin
Technician 2: Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-15-21	14:19	6.5	6.5	install with 4" offset
1		14:20	6.5	6.6	
2		14:20	6.5	6.6	
3		14:20	6.5	6.7	
Average			6.5	6.6	





Site Details Sheet

CLIENT MONITORING #:	**WSC**	**SFE PROJECT #:**	**U026B**
NAME:	**Oak Lodge Water Services, Oak Grove, OR**	**SFE SITE #:**	**E-949**

Project Specific Information

Client Name:	Water Engineering Consulting
End User Name:	Oak Lodge Water Services
Project Name:	Sanitary Sewer Flow Monitoring
Client Contact:	Scott Duren
Field Contact:	Scott Duren
SFE PM Contact:	Dylan Carvin
Site Maintenance:	as required

Site Equipment

Install / Removal Date:	December 17 2021	February 28 2022
Meter Make & Model:	ISCO 2150	
Meter I.D. - #1 and #2	AB206C01493	na
Wireless I.D # / Cell #:	na	na
Level / Velocity Type:	Pressure Probe	AV Sensor
Sensor Mounting:	Hilti Band	
Primary Device:	Area Velocity	
Logging Rate / Call out:	5 minute	24hr

Site Location Information

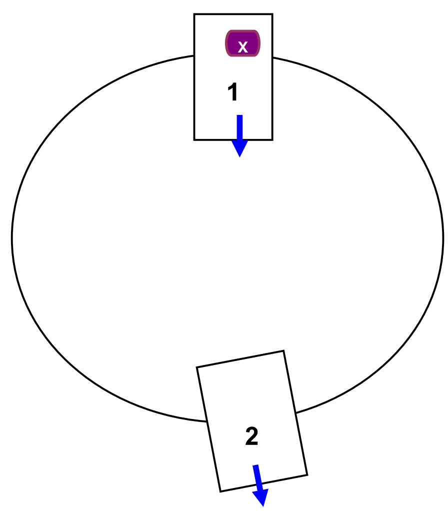
Client Site #:	E-949	
Address (Location):	13124 SE Rupert Dr	
City, State:	Oak Grove, OR	
GPS (North - West):	45.422489	122.640266
Landmarks:	n/a	
Traffic Control Req's:	Full Traffic	
Additional Information:	n/a	

Site Profile

Invert Distance (in):	142.25	Access:	yes
Overall Site Condition:	good		
Pipe Size (in): #1	15	#2	15
#3	na	#4	na
Location of Sensor (which pipe?):	x	=	1
Overall Pipe Condition:	good		
Additional Information:	na		

Map

Site Setup



Additional Notes

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Site Pictures

CLIENT MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	E-949

Notes

1 more pictures will be obtained upon next site visit
2
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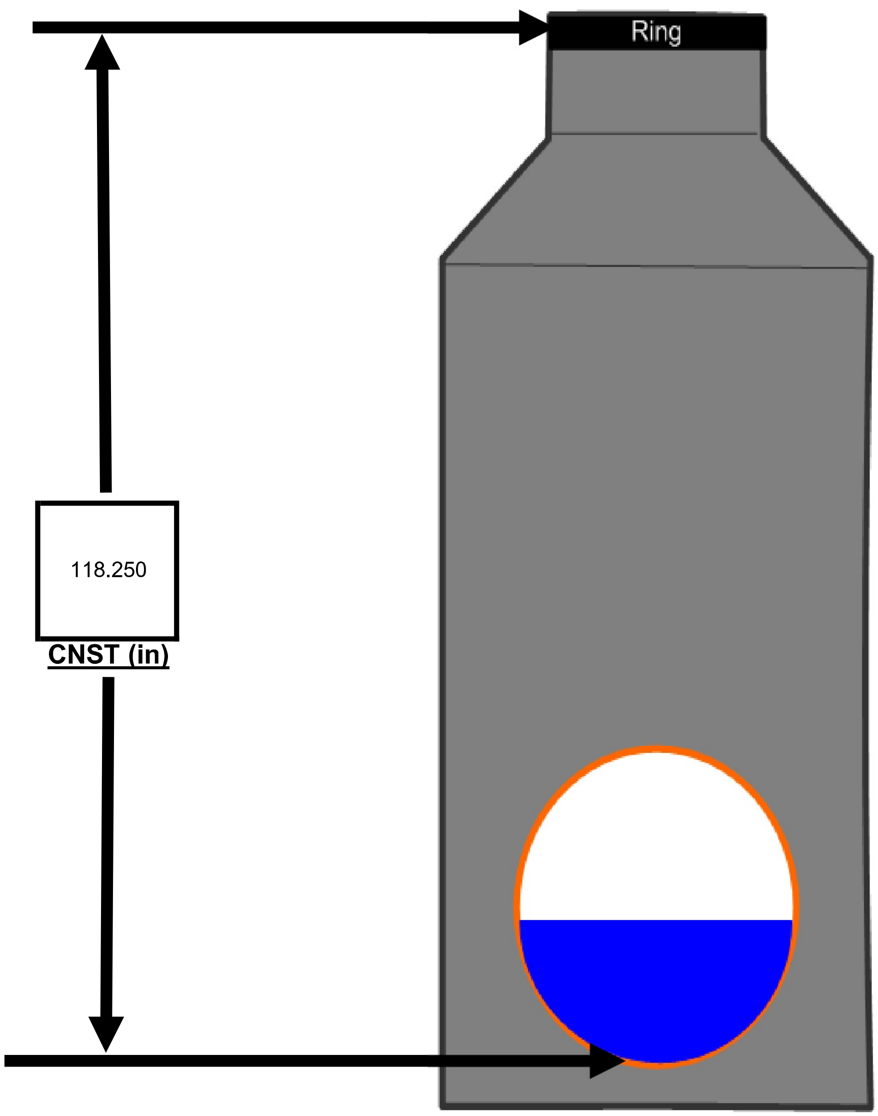
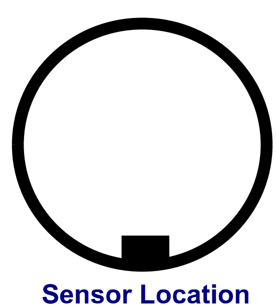
Install Sheet

CLIENT FLOW MONITORING #:	WSC	SFE PROJECT #:	U026B
NAME:	Oak Lodge Water Services, Oak Grove, OR	SFE SITE #:	E-949
		Technician 1:	Dylan Carvin
		Technician 2:	Jason Rowley

Meter Depth vs.. Field Depth Calibration / Verification

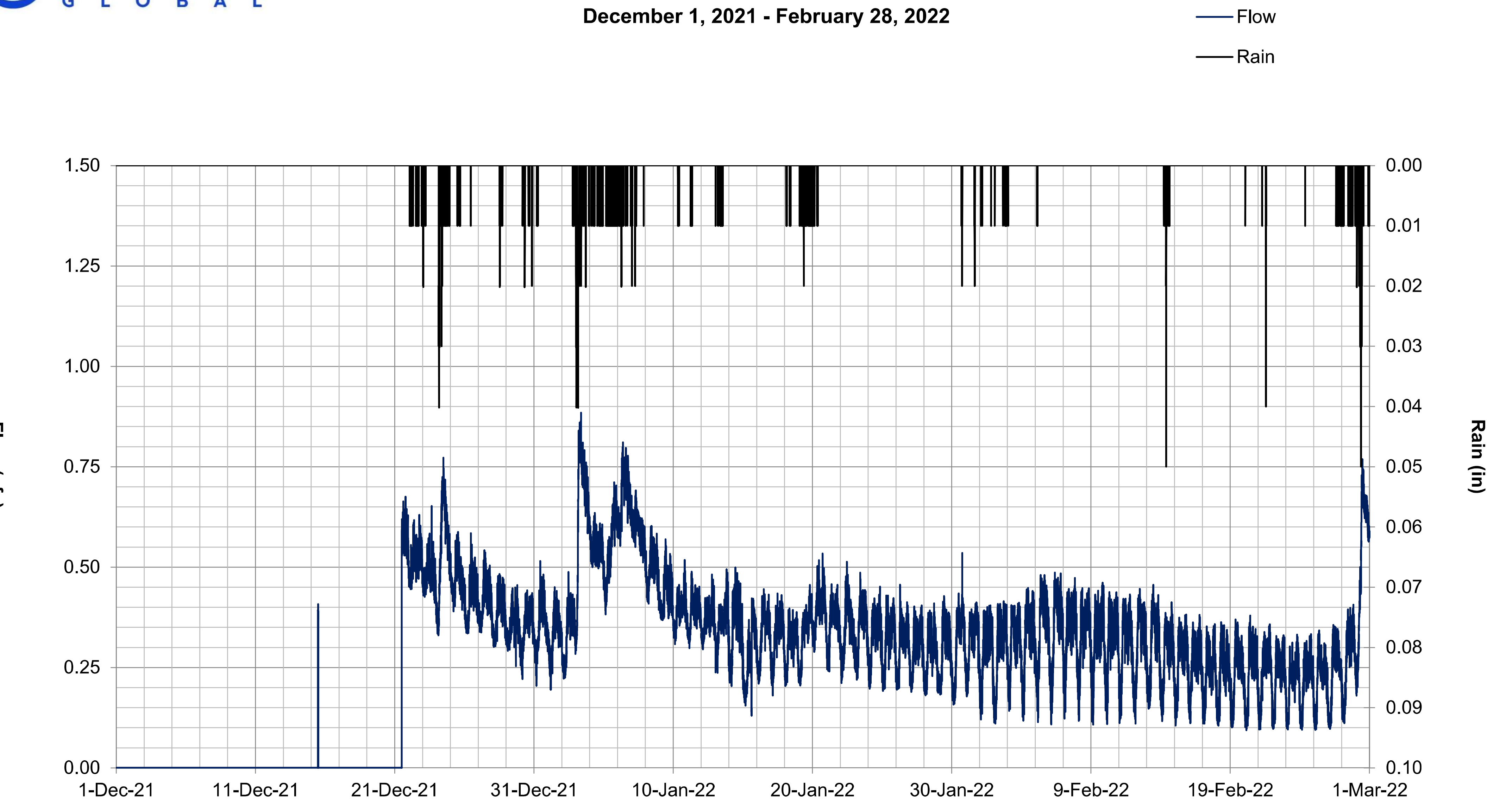
Reading Number	Date (m/d/yyyy)	Time (hh:mm)	Field Meas (in)	Meter Depth (in)	Comments (Zero Meter Level before Installation)
Initial	12-17-21	12:35	5.5	5.7	install with 4" offset
1		12:37	5.5	5.7	
2		12:38	5.5	5.7	
3		12:40	5.5	5.7	
Average			5.5	5.7	





Appendix C Flow Meter Graphs

Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #2A7-325
December 1, 2021 - February 28, 2022



Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #2B-3820
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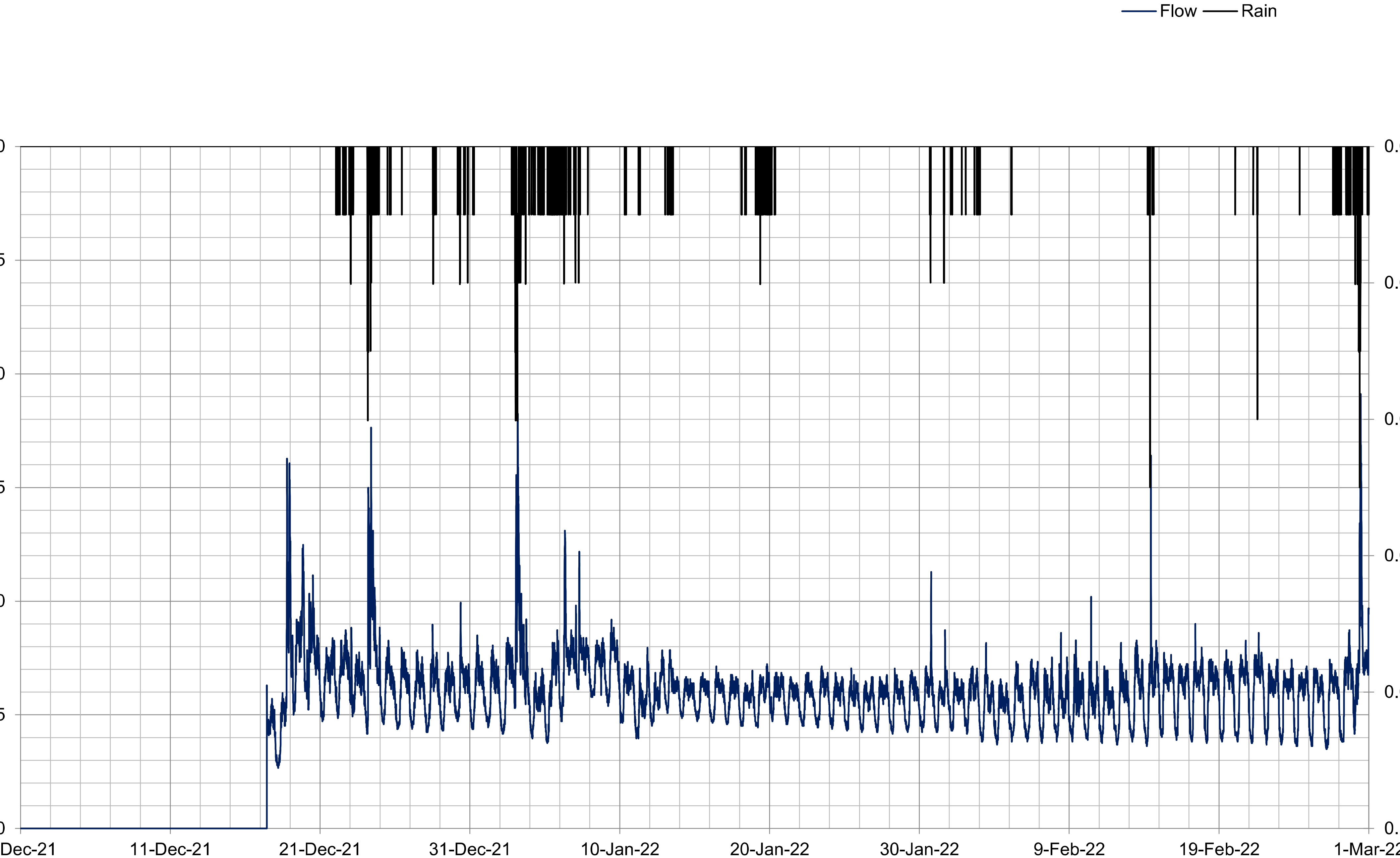
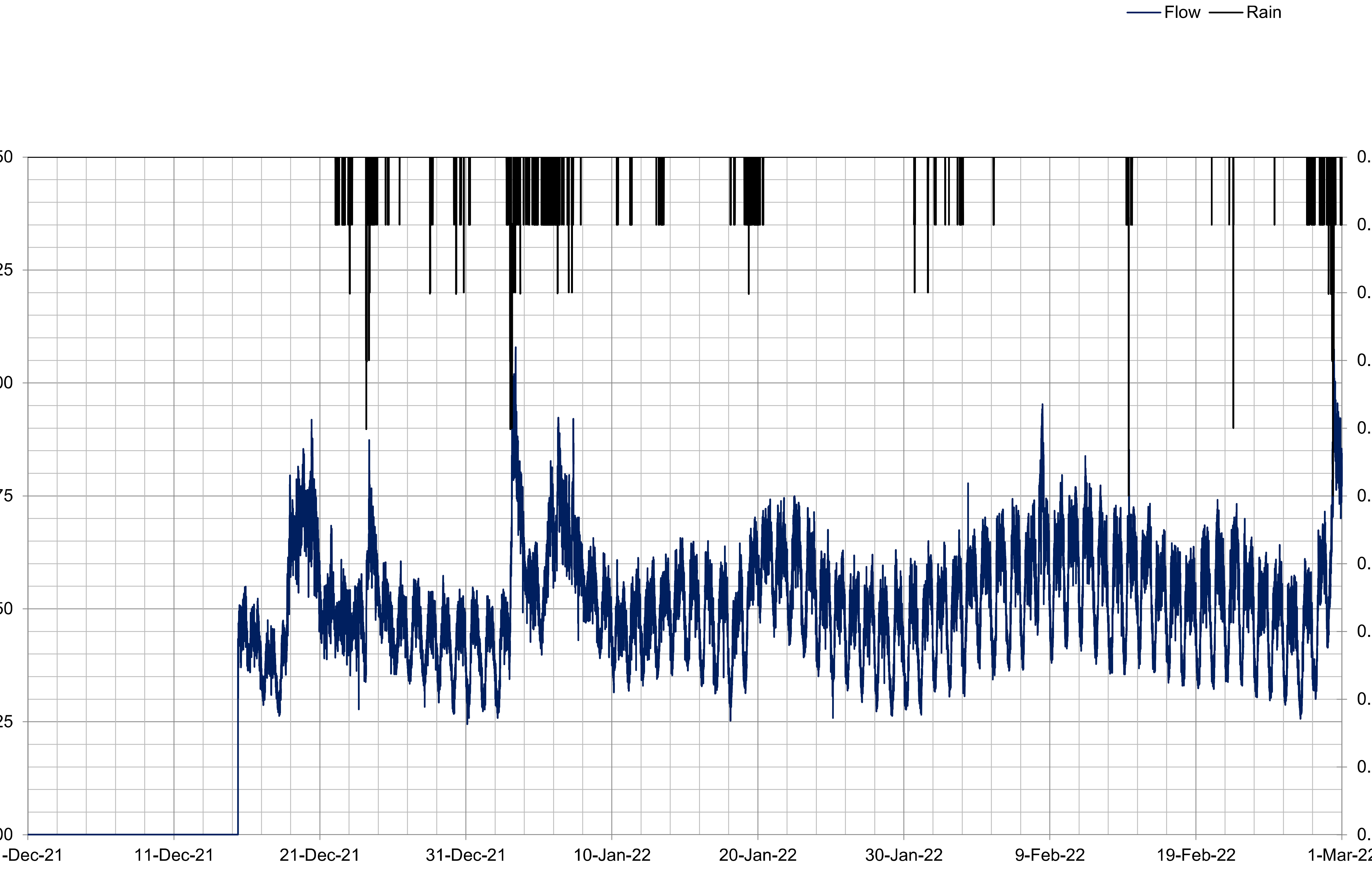
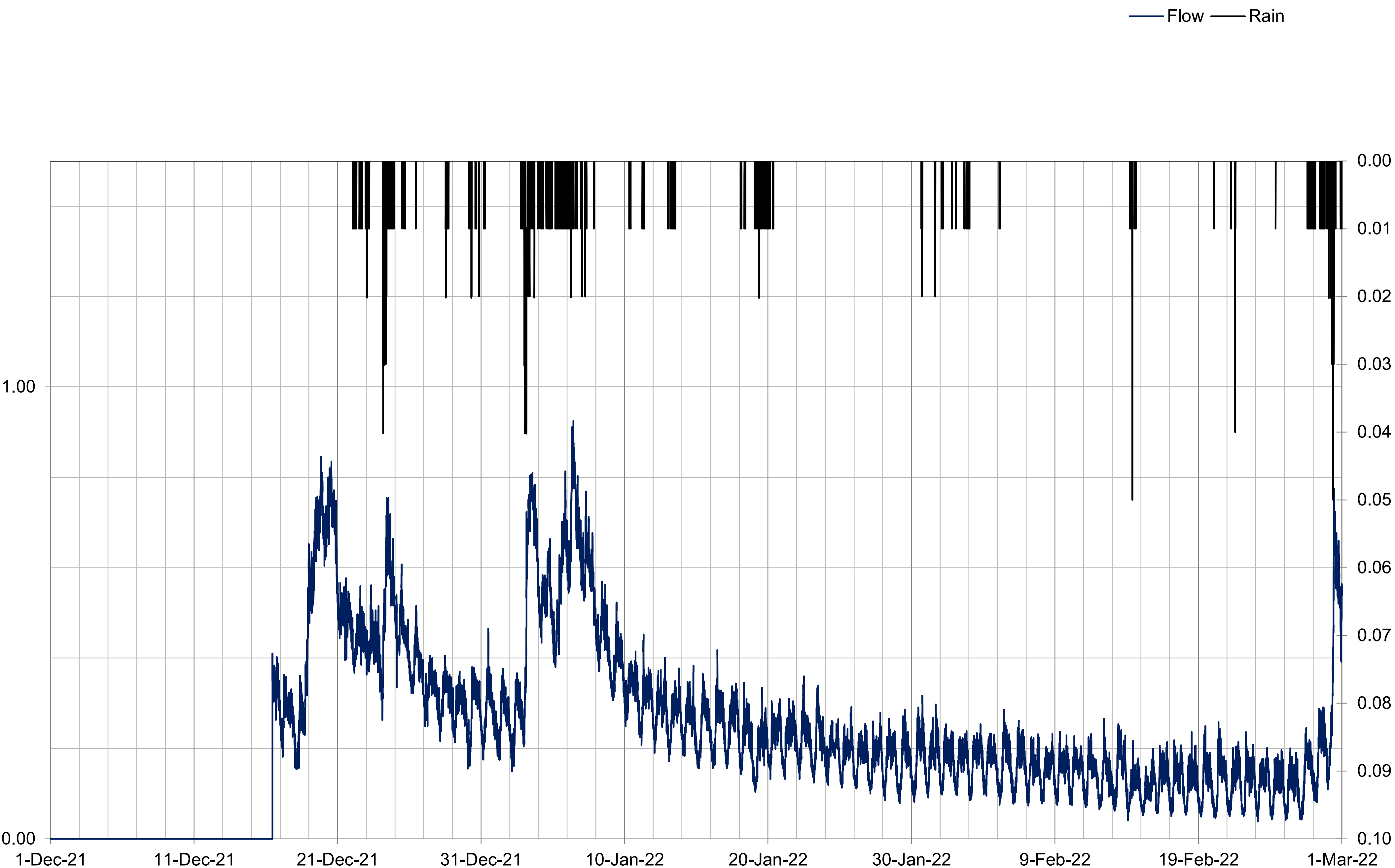


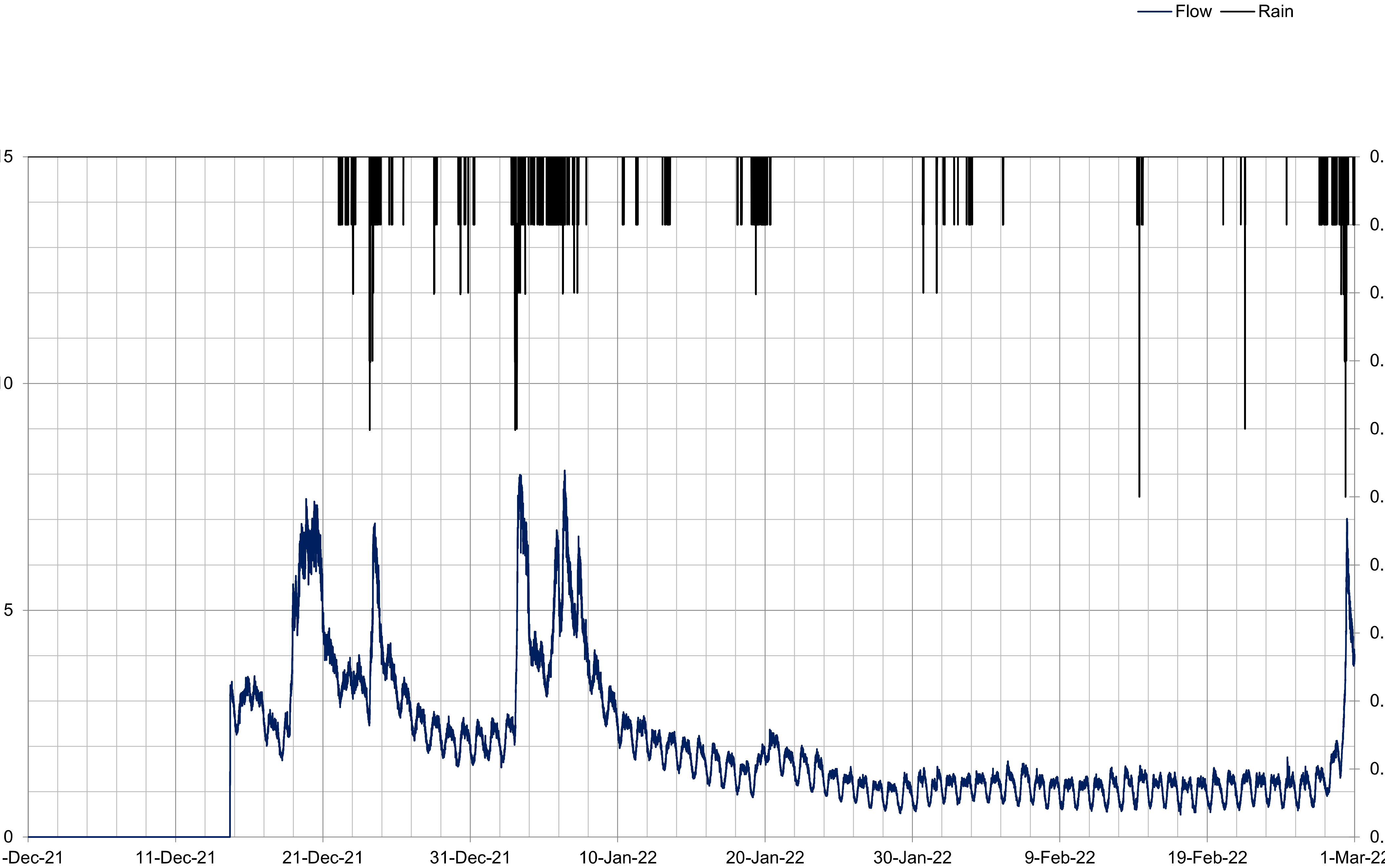
Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #2C-325
December 1, 2021 to February 28, 2022



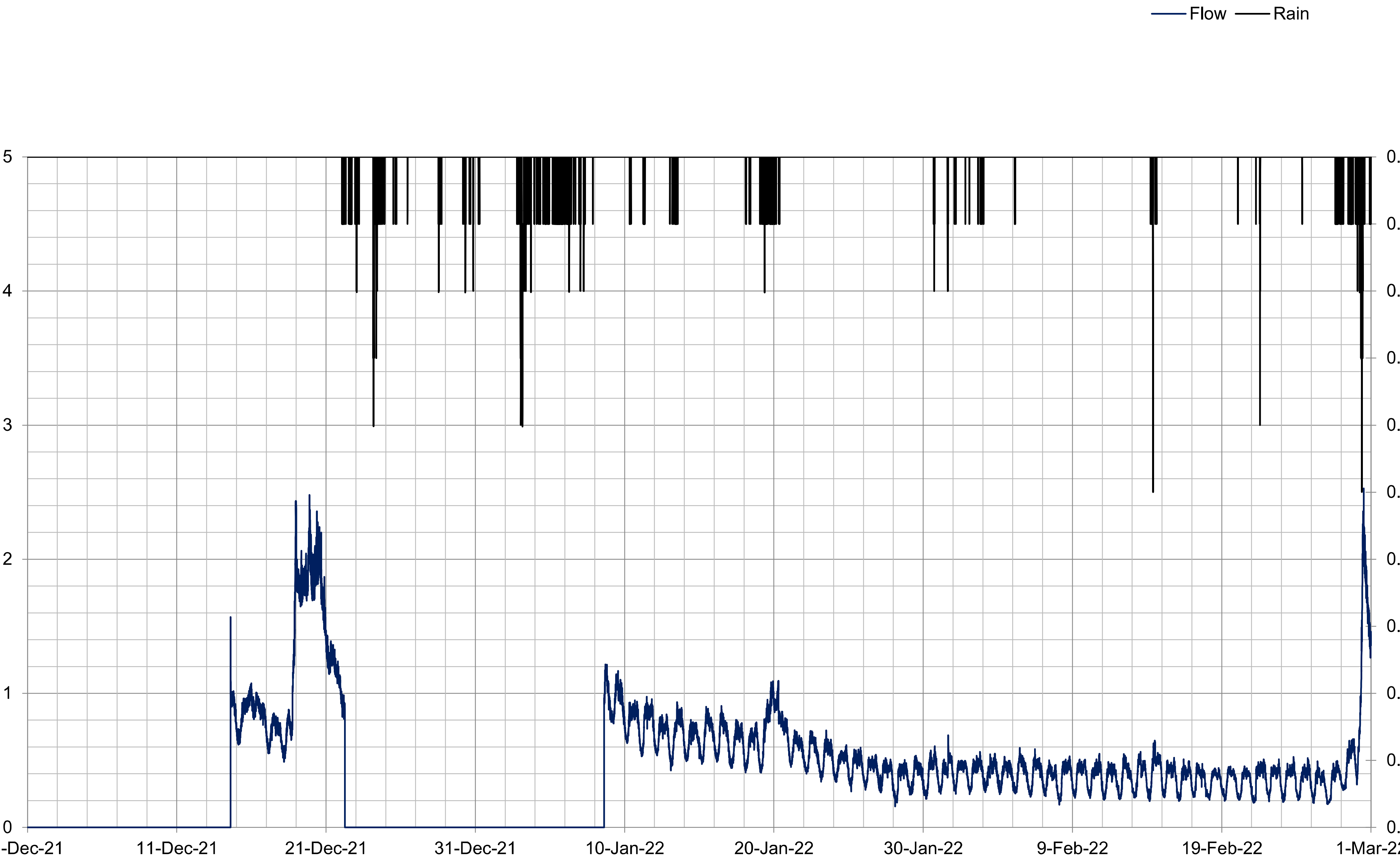
Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #2E-566
December 1, 2021 - February 28, 2022



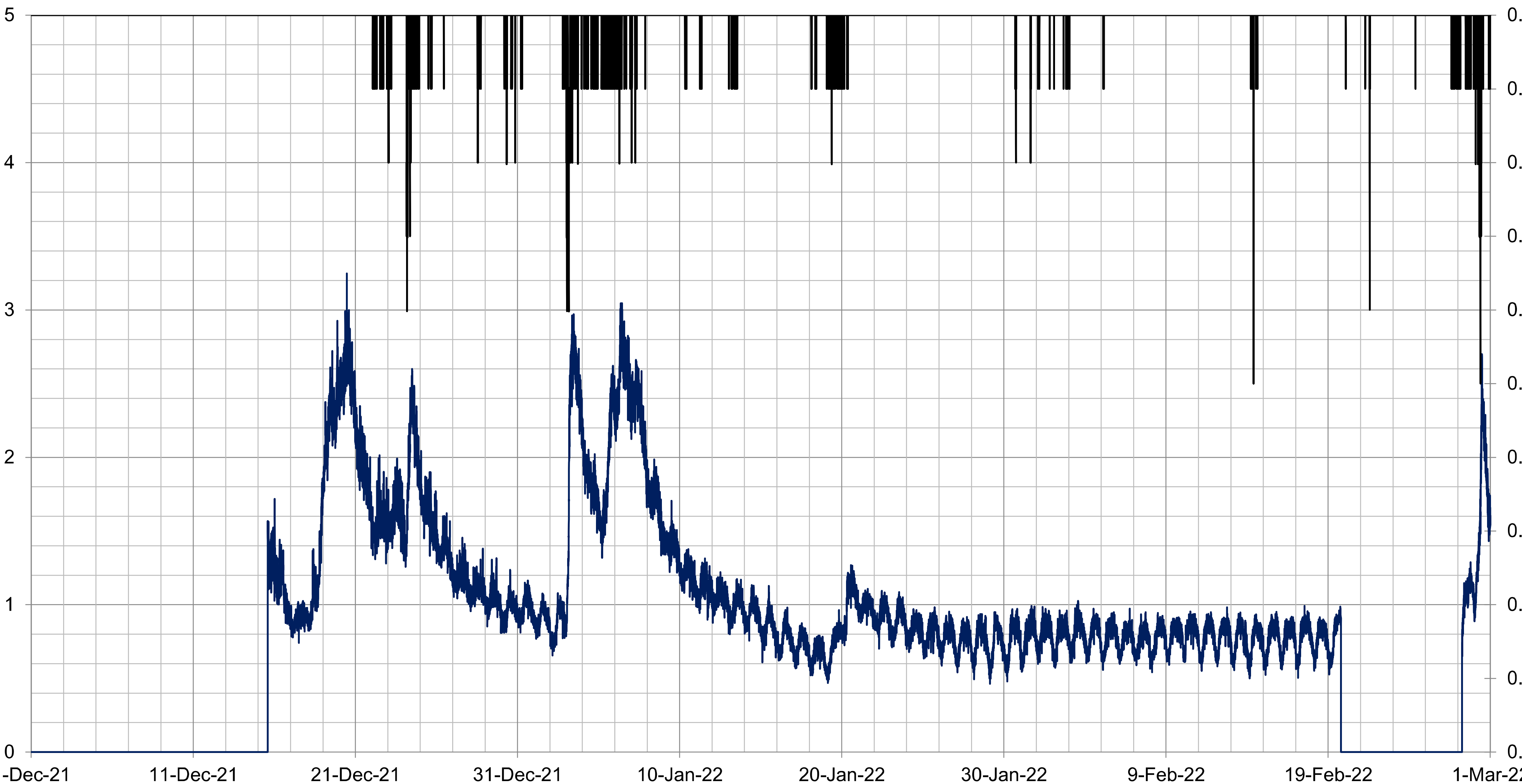
Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #B-299
December 1, 2021 - February 28, 2022



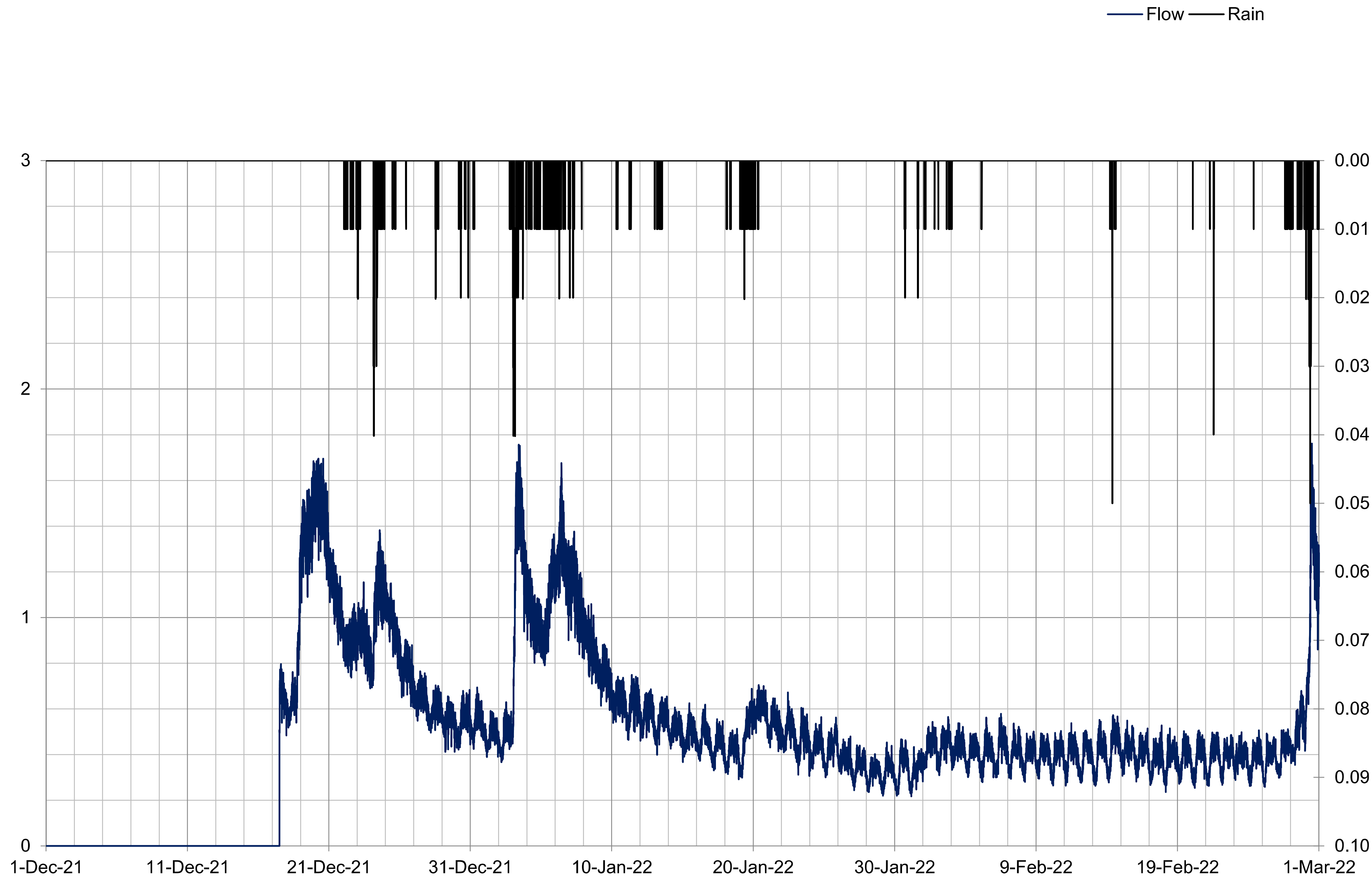
Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #B-5930
December 1, 2021 - February 28, 2022



Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #C-2672
December 1, 2021 - February 28, 2022



Oak Lodge Water Service, Oak Grove, Oregon
SFE File U026B - Site #E-949
December 1, 2021 - February 28, 2022



Appendix H Recommended Pipe Upsizing

H

The following table identifies the manhole IDs of the pipes recommended for upsizing to address capacity constraints.

Upstream Manhole	Downstream Manhole	Existing Size (in)	Upgraded Size (in)	Length (feet)
2A-8842	2A-8520	12	15	321.9
2A-8091	2A-7723	14	18	364.2
2A-8455	2A-8091	14	18	366.7
2A-246	A-13554	20	24	246.8
2A-6917	2A-6748	14	18	160.9
2A-7357	2A-6917	14	18	439.0
2A-7723	2A-7357	14	18	367.6
B-5666	B-5459	15	18	205.2
B-5244	B-5122	15	18	105.0
B-5122	B-4792	15	18	329.8
B-5930	B-5666	15	18	264.2
B-6203	B-5930	15	18	272.8
B-8274	B-8037	15	18	237.5
B-8620	B-8274	15	18	345.4
B-8984	B-8891	12	15	91.0
B-8891	B-8620	12	15	270.9
B-7789	B-7434	15	18	355.0
B-8037	B-7807	15	18	230.1
B-7807	B-7789	15	18	17.8
B-566	B-378	18	24	188.0
B-906	B-566	18	24	339.9
B-1465	B-1454	18	24	11.0
A-2552	A-2203	24	30	344.5
A-2203	A-2061	24	30	138.5
B-2650	B-2480	18	24	169.1
B-2480	B-2426	18	24	54.1
B-2426	B-2206	18	24	218.5
B-1454	B-1090	18	24	352.4
B-378	B-299	18	24	80.1

Upstream Manhole	Downstream Manhole	Existing Size (in)	Upgraded Size (in)	Length (feet)
A-13554	A-13165	21	24	389.9
A-2061	A-1863	24	30	200.2
B-2841	B-2650	18	24	191.0
B-3026	B-2841	18	24	203.6
A-10467	A-10252	21	24	214.6
B-3554	B-3446	18	24	108.0
B-3446	B-3252	18	24	194.0
B-1893	B-1465	18	24	434.8
B-3252	B-3026	18	24	205.5
A-2812	A-2677	24	30	130.6
B-2206	B-2095	18	24	111.1
A-2677	A-2552	24	30	135.7
B-2095	B-1893	18	24	202.0
A-10780	A-10467	21	24	311.1
A-3056	A-2812	21	24	240.1
B-4168	B-4131	15	18	39.0
B-6450	B-6203	15	18	247.0
B-7101	B-6752	15	18	349.0
B-7434	B-7101	15	18	335.1
A-12929	A-12819	21	24	111.0
A-11039	A-11001	21	24	38.8
A-12310	A-11830	21	24	480.3
A-12819	A-12709	21	24	108.9
A-13138	A-12929	21	24	208.0
B-4792	B-4604	15	18	188.1
A-13165	A-13138	21	24	27.7
B-6752	B-6450	15	18	301.5
B-4604	B-4462	15	18	131.4
B-4462	B-4168	15	18	294.0
A-12510	A-12310	21	24	192.1
A-12709	A-12510	21	24	199.6
A-3790	A-3586	21	27	199.1

Upstream Manhole	Downstream Manhole	Existing Size (in)	Upgraded Size (in)	Length (feet)
B-1051	B-906	18	24	145.1
A-599	A-240	24	30	366.6
A-11491	A-11039	21	24	435.0
A-240	A-000	24	30	220.2
A-10252	A-10069	21	24	184.8
A-11001	A-10780	21	24	221.0
A-11830	A-11491	21	24	336.0
C-9487	C-9196	8	10	289.3
B-4131	B-3776	15	18	352.1
A-778	A-599	24	30	604.8
A-1827	A-1479	24	30	339.0
A-1863	A-1842	24	30	16
A-1842	A-1827	24	30	10
B-299	A-2812	18	24	298.5
A-3273	A-3056	21	27	213.2
A-10069	Lift Station 2	21	24	57.5
A-1479	A-1194	24	30	283.1
A-1194	A-778	24	30	412.3
B-3776	B-3554	18	24	222.4

Appendix I WWTP Capacity Assessment

6500 S Macadam Ave., Suite 200
Portland, OR 97239

T: 503.244.7005

Technical Memorandum

Prepared for: Oak Lodge Water Services

Project Title: Wastewater Master Plan

Project No.: 156789.061/3

Technical Memorandum

Subject: Wastewater Treatment Plant (WWTP) Capacity Assessment

Date: February 3, 2023

To: Brad Albert, District Engineer, P.E. Oak Lodge Water Services (OLWS)
Sarah Jo Chaplen, General Manager, OLWS

From: Art Molseed, P.E., WWTP Lead, Brown and Caldwell

Copy to: David Hawkins, Plant Superintendent, OLWS
Scott Duren, P.E., Project Manager, Water Systems Consulting

Prepared by: Patricia Tam, P.E.*

Reviewed by: Art Molseed, P.E.
OR License #15224PE, Exp. 12/31/24

PROFESSIONAL ENGINEER
15224PE
Arthur Craig Molseed
OREGON
DECEMBER 07, 1990
ARTHUR CRAIG MOLSEED
EXPIRES: DECEMBER 31, 2024

Reviewed by: Rick Kelly, Ph.D., P.E.
OR License #84102PE, Exp. 6/30/24

* Professionally licensed in the State of Washington.

Limitations:

This document was prepared solely for the Oak Lodge Water Services (OLWS) and Water Systems Consulting, Inc (WSC) in accordance with professional standards at the time the services were performed and in accordance with the contract between OLWS and WSC dated May 18, 2021. This document is governed by the specific scope of work authorized by OLWS; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by OLWS and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BOD	biochemical oxygen demand
BC	Brown and Caldwell
BFP	belt filter press
CBOD	carbonaceous biochemical oxygen demand
COD	chemical oxygen demand
DEQ	Oregon Department of Environmental Quality
DO	dissolved oxygen
DSVI	dilute sludge volume index
EPA	United States Environmental Protection Agency
MMDW	maximum month dry weather
MMWW	maximum month wet weather
GBT	gravity belt thickener
gpm	gallons per minute
hp	horsepower
HRT	hydraulic retention time
IBRE	interchange bioreactor effluent
I/I	inflow and infiltration
kJ/cm^2	kilojoules per square centimeter
lb/d	pounds per day
lb/hr	pounds per hour
MMF	maximum month flow
mgd	million gallons per day
mg/L	milligrams per Liter
mL	milliliters
mL/g	milliliters per gram
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MMF	maximum month flow
NPDES	National Pollutant Discharge Elimination System
OLSD	Oak Lodge Sewer District
OLWS	Oak Lodge Water Services
PDR	plant drain return
PSRP	Process to Significantly Reduce Pathogens
RAS	return activated sludge
SCADA	Supervisory Control and Data Acquisition
scfm	standard cubic feet per minute
SND	simultaneous nitrification denitrification
SOR	surface overflow rate
SRT	solids retention time
SVI	sludge volume index
TKN	total Kjeldahl nitrogen
TP	total phosphorus
TSS	total suspended solids
UV	ultraviolet
VSR	volatile solids reduction
VSS	volatile suspended solids
WAS	waste activated sludge
WERF	Water Environment Research Foundation
WWTP	wastewater treatment plant

Section 1: Introduction

This Technical Memorandum (TM) documents the capacity assessment of the Oak Lodge Water Services (OLWS) Wastewater Treatment Plant (WWTP). As part of the evaluation, special sampling was conducted to provide characterization data to set up and calibrate process and solids mass balance models. The calibrated models were then used to evaluate plant capacity under different seasonal conditions. The models can also be subsequently used to determine requirements for process improvements and equipment sizing for future operating conditions. This TM documents the sampling results and assessment of the existing capacity and potential future capacity limitations at the WWTP.

The objectives of this TM are as follows:

- Summarize results from the special wastewater characterization.
- Summarize calibration of the biological process and solids mass balance models.
- Evaluate unit process capacities using the calibrated models.
- Using the projected flows and loadings developed for the Master Plan, estimate timing of the unit process capacity limitations.
- Provide preliminary recommendations for addressing the capacity constraints.

Section 2: WWTP Description

The Oak Lodge WWTP is a secondary treatment facility with a current rated maximum month flow (MMF) of 10.5 million gallons per day (mgd). Plant treatment processes include preliminary treatment with screenings and grit removal, secondary treatment including aeration basins and secondary clarifiers operating as a modified Ludzack-Ettinger (MLE) process, aerobic digestion, and sludge dewatering.

Figure 1 shows a process flow schematic of the existing liquid and solid stream treatment processes.

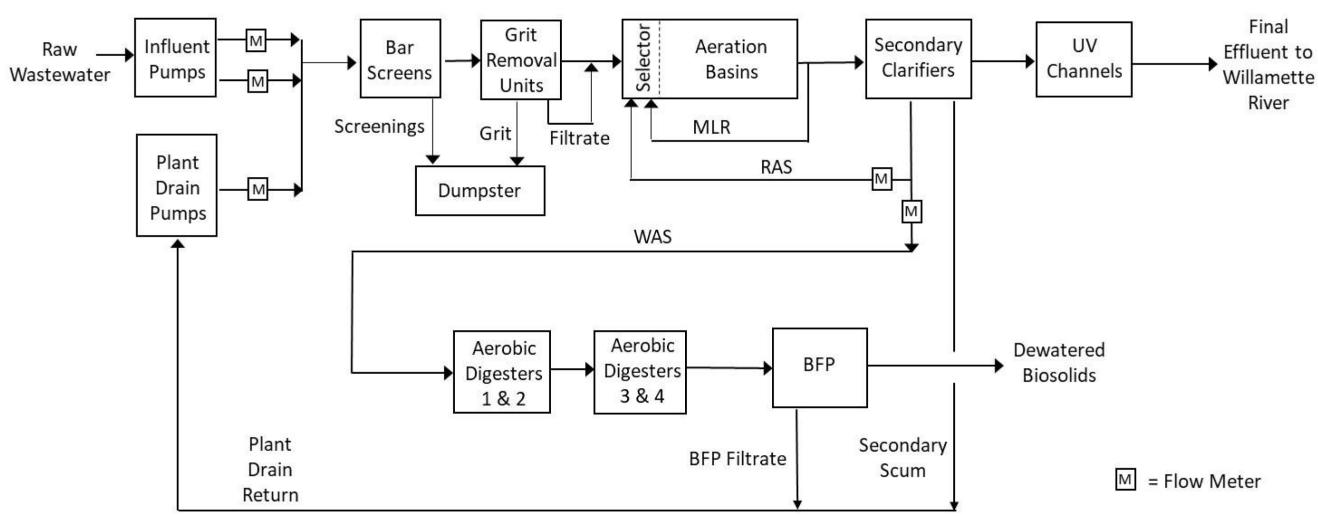


Figure 1. WWTP process schematic

OLWS has recently completed a Solids Piping Project that will allow waste activated sludge (WAS) to be pumped to an existing gravity belt thickener (GBT). WAS can then be thickened in the GBT prior to entering the aerobic digesters. Secondary sludge is currently thickened in two of the clarifiers by turning off the return activated sludge (RAS) pumps once a day to accumulate a sludge blanket in the clarifiers. More detailed descriptions of the current plant operation and equipment design criteria are included in the TMs for Tasks 6.1 and 6.4.

Table 1 summarizes the current design flows and loadings, and Table 2 summarizes the current National Pollutant Discharge Elimination System (NPDES) permit discharge limits.

Table 1. Current Design Flows and Loadings

Parameter	Flow (mgd)	BOD (lb/d)	TSS (lb/d)	TKN (lb/d)	NH_3-N (lb/d)
Average annual	4.3	6,680	7,450	994	775
Average dry weather	3.5	-	-	-	-
Average wet weather	5.2	-	-	-	-
Maximum month dry weather (MMDW)	-	7,250	8,960	1,354	1,055
Maximum day dry weather	8.6	10,900	12,970	-	-
Maximum month wet weather (MMWW)	10.5	7,440	8,390	1,244	970
Maximum day wet weather	17.3	11,090	13,290	-	-
Peak hour [a]	18.0	-	-	–	–

Note: Based on design flows and loadings shown in the Phase 1A and Phase 1B plant expansion record drawings (2012).

a. Hydraulic carrying capacity of all facilities is designed to pass a peak instantaneous flow of 20 mgd to avoid overtopping of walls, flooding of weirs, etc.

Table abbreviations:

BOD = biochemical oxygen demand

TSS = total suspended solids

TKN = total Kjeldahl nitrogen

NH_3-N =ammonia-nitrogen

Table 2. Current 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					
BOD_5	30	45	2,600	3.900	5,200
TSS	30	45	2,600	3,900	5,200

Note: Based on NPDES permit effective May 1, 2022.

Table abbreviations:

lb/d = pounds per day

mg/L = milligrams per Liter

Section 3: Wastewater Characterization

Historical plant data from 2016 to 2021 were reviewed as part of this capacity assessment task. The historical data allow development of flow and load peaking factors and were used for the flow and load projections. Review of the historical data was discussed in the TM prepared for Task 6.2. To supplement the historical data, a special wastewater characterization was conducted to provide data to calibrate the biological process and plant-wide solids mass balance models. Sampling took place from August 10 to 24, 2021. The sampling plan is summarized in the TM "Wastewater Characterization Sampling Plan" (dated October 4, 2021). The TM also includes descriptions of the sampling locations and types of samples collected.

During the sampling period, 24-hour composite samples were collected for 7 days and grab samples were collected for 9 days from selected process streams. These samples were analyzed for a range of parameters. In addition, 2-hourly diurnal sampling of the raw influent was also conducted. The diurnal samples were analyzed for total suspended solids (TSS), volatile suspended solids (VSS), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), total phosphorus (TP) and alkalinity. The diurnal sampling results were used in conjunction with hourly flow data to develop normalized diurnal patterns to facilitate dynamic simulation of the secondary system.

Table 3 summarizes the average flows and concentrations over the 15-day sampling period. Daily sampling data and measurements are provided in Attachment A to this TM.

Table 3. Oak Lodge WWTP Summary of Sampling Results

Parameter*	Raw Influent	Secondary Influent	Final Effluent	Anoxic Selector Effluent	Mixed Liquor	RAS	WAS	IBRE (Digester 2) [a]	Digested Sludge	Dewatered Cake	Plant Drain Return
Flow	1.78	-	1.73	-	-	0.567	0.020	-	0.0186	-	0.079
TSS, TS [b]	193	561	6.5	-	3,313	14,463	19,788	1.80	1.69	12.8	1,163
VSS, VS [b]	181	511	5.3	-	2,770	12,075	16,600	1.39	1.27	9.8	-
COD	451	-	28	-	-	-	-	-	-	-	-
sCOD	192	-	20	39	-	-	-	-	-	-	-
ffCOD	114	-	18	30	-	-	-	-	-	-	-
BOD	236	372	-	-	-	-	-	-	-	-	138
sBOD	85	-	-	-	-	-	-	-	-	-	-
CBOD	-	-	2.6	-	-	-	-	-	-	-	-
sCBOD	-	-	1.8	-	-	-	-	-	-	-	-
TKN	46	67	1.9	-	-	-	-	-	-	-	-
sTKN	37	-	-	-	-	-	-	-	-	-	-
NH_3-N	37	-	0.4	5.3	-	-	-	-	-	-	106
NO_3-N	-	-	3.1	0.2	-	-	-	-	-	-	1.7
NO_2-N	-	-	0.1	0.1	-	-	-	-	-	-	-
TP	5.8	9.6	2.9	-	-	-	-	-	-	-	-
PO_4-P	2.9	-	2.2	4.8	-	-	-	-	-	-	81
DO	0.04	-	-	-	2.13	-	-	-	-	-	-
Alkalinity	180	195	68	-	-	-	-	-	-	-	-
pH	7.52	-	6.6	-	5.2	-	-	-	-	-	-
Temperature	26.0	-	23.5	-	27.8	-	-	-	-	-	-

Note: Data shown are averages for the period from 8/10/21 to 8/23/21, except for plant drain return (PDR), for which the data are averages for 8/10/21 to 8/24/21. Samples were not collected every day.

a. Interchange bioreactor effluent (IBRE) samples collected from Aerobic Digester 2 (formerly referred to as IBR 2).

b. TSS and VSS data for all process streams, except for IBRE, digested sludge, and dewatered cake, for which TS and VS data are shown.

Parameter Definitions*

The abbreviations and units for the parameters listed in column 1 are defined as follows:

Flow (mgd)
TSS = total suspended solids (mg/L) TS = total solids (%)
VSS = volatile suspended solids (mg/L) VS = volatile solids (%)
COD = chemical oxygen demand (mg/L)
sCOD = soluble COD (mg/L)
ffCOD = flocculated and filtered COD (mg/L)
BOD = biochemical oxygen demand (mg/L)
sBOD = soluble BOD (mg/L)
CBOD = carbonaceous BOD (mg/L)
sCBOD = soluble carbonaceous BOD (mg/L)
TKN = total Kjeldahl nitrogen (mg/L)
sTKN = soluble TKN (mg/L)
NH_3-N = ammonia-nitrogen (mg/L)
NO_3-N = nitrate-nitrogen
NO_2-N = nitrite-nitrogen (mg/L)
TP = total phosphorus (mg/L)
PO_4-P = orthophosphate-phosphorus (mg/L)
SO_4 = sulfate (mg/L)
DO = dissolved oxygen (mg/L)
Alkalinity (mg/L calcium carbonate [$CaCO_3$])
Temperature (°C)

Section 4: Model Calibration

The sampling data summarized in Section 3 were used to calibrate the process models. These include BioWin and MABLE. BioWin is a commercially available software developed by EnviroSim Associates Limited of Ontario, Canada, that is based upon the International Water Association Activated Sludge Model 1. BioWin allows the prediction of complex biological interactions in suspended growth treatment systems using various mechanistic and empirical models to represent organic material transformations and removals in the process. BioWin incorporates the simulation of carbon oxidation, nitrification, denitrification, and enhanced biological phosphorus removal. For this task, BioWin was used to simulate operation of the secondary system. MABLE is a spreadsheet-based model developed by BC to perform plant-wide solids mass balance calculations.

The following sections discuss the calibration results of each of these models.

4.1 BioWin Calibration

BioWin was used to simulate the secondary system operation, including the aeration basins and secondary clarifiers. During the sampling period, both Aeration Basins 2 and 3 and two clarifiers were in service. Figure 2 illustrates the process flowsheet used in BioWin.

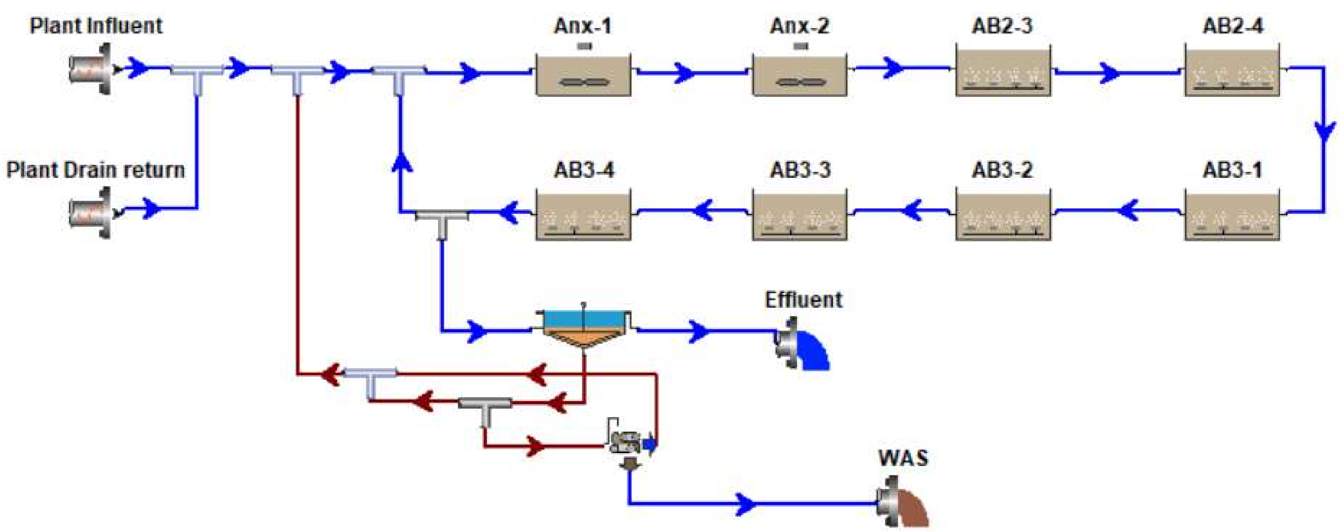


Figure 2. BioWin process flowsheet for secondary system

Table 4 summarizes the BioWin calibration results for the August 2021 sampling period. The model configuration was set up to simulate the typical wasting scheme during the sampling period (intermittent build-up of solids in the clarifiers and subsequent wasting). For a well-balanced model, there should be close correspondence between the simulated and observed behavior. When major discrepancies appear between measured and predicted values for effluent characteristics or major operating variables, investigation of the plant data is carried out to determine their cause.

For the BioWin calibration, it was found that without any adjustments to the influent concentrations (and thus loadings), it would not be possible to match both the measured mixed liquor suspended solids (MLSS), WAS and RAS TSS concentrations. A solids mass balance around the secondary clarifier shows fairly good closure, thus suggesting that the RAS and mixed liquor solids measurements are consistent. It was assumed that the concentrations of soluble components in the influent (e.g., soluble COD, soluble BOD, and ammonia) remain the same as the measured concentrations while the total concentrations were increased.

Table 4. BioWin Calibration Summary			
Parameter	**Measured**	**Model Inputs/Assumptions**	**Model Outputs**
Plant influent			
BOD, mg/L	236	332	
lb/d	3,500	4,920	-
TSS, mg/L	193	282	
lb/d	2,860	4,190	
Plant drain return			
Flow, mgd	0.079	0.079	
BOD, mg/L	138	138	-
TSS, mg/L	1,160	800	
WAS flow, mgd	0.02	0.02	-
TSS load, lb/d	3,300	-	3,100
RAS flow, mgd	0.57	0.52	-
TSS, mg/L	14,500	-	13,700
Solids Retention Time, day	-	-	10
MLSS, mg/L	3,310		3,150
MLVSS, mg/L	2,770	-	2,570
MLVSS/MLSS	0.84		0.82
Air flows, scfm			
Aeration Basin 2	510	-	530
Aeration Basin 3	1,070		1,120
Secondary effluent, mg/L			
COD	28		36
CBOD	2.6		3.4
sCBOD	1.8		1.2
TSS	6.5		6.1
VSS	5.3		5.0
TKN	1.9	-	2.9
NH_3-N	0.4		0.6
NO_3-N+NO_2-N	3.2		4.0
TP	2.9		2.6
PO_4-P	2.2		2.4
Alkalinity	69		44
Kinetic coefficients [a]			
AOB $\mu_{max,n}$	-	0.85	-
NOB $\mu_{max,n}$	-	0.90	

Note: Calibration results are from the August 2021 sampling period.

a. AOB µmax,n = ammonia oxidizing bacteria maximum specific growth rate (default = 0.90 d-1).

NOB µmax,h = nitrite oxidizing bacteria maximum specific growth rate (default = 0.70 d-1).

Table abbreviations:

lb/d = pounds per day

mg/L = milligrams per Liter

MVLSS = mixed liquor volatile suspended solids

NO_3-N+NO_2-N = nitrate-nitrogen+nitrite-nitrogen

scfm = standard cubic feet per minute

This adjustment is assumed to be the result of the periodic clogging issue the plant staff had observed with the influent sampler. The influent pumps were replaced in 2019 due to frequent plugging with rags and other debris. The current pumps (Flygt) are more effective at passing rags to the screen influent channel, where influent sampler draws from. Because debris could now accumulate in that channel, the strainer on the suction tubing for the sampler occasionally plugs with debris and ragging. This occurred on the first day of the August sampling period, resulting in the loss of the influent sample on that day (sampler collected only a small volume of samples). It is speculated that even when the sampler is functioning, some solids may be filtered out at the strainer on the sampler suction tubing, thus resulting in a reduction of the measured influent concentrations. Therefore, an increase in the influent concentrations is considered a reasonable adjustment.

The measured plant influent concentrations are also suspected to be underestimated by comparing with historical data. Plant influent monthly average BOD and TSS loads ranged from about 3,000 to 8,000 lb/d since early 2016 (through end of 2021) and have been above 3,500 lb/d since January 2018 (except for August 2021). There is a noticeable drop in loadings during the summer of 2021. Based on the sampling data, the influent BOD and TSS loads would be only 3,500 and 2,860 lb/d, respectively, which are quite low compared to recent plant data (in 2019 and 2020). One possible explanation is that the low plant flows during the August sampling period had exacerbated ragging around the sampler, so that more solids were being filtered out, thus resulting in lower measured influent concentrations.

In addition to adjustment to the influent concentrations, adjustments were also made to better match the effluent ammonia and oxidized nitrogen (nitrate- and nitrite-nitrogen) concentrations. These adjustments include reduction in the dissolved oxygen (DO) concentrations in the second half of Aeration Basin 2 and the kinetic coefficients (maximum specific growth rates for ammonia-oxidizing and nitrite-oxidizing bacteria). Currently, when the system is operated with Basins 2 and 3 in service, Basin 2 is operated at a constant air flow while air flow to Basin 3 is adjusted to meet the DO setpoint at around the midpoint of Basin 3. The model was able to match the measured air flows within 5 percent as shown by the results in Table 4.

4.2 MABLE Calibration

A plant-wide solids mass balance analysis was performed as part of the capacity assessment to:

- Check the validity of solids data.
- Assess existing equipment performance.
- Assist in the performance evaluation of individual unit processes and the whole treatment facility as plant flows and loadings increase.
- Help establish overall plant BOD and solids treatment capacity by correlating flows and loadings to and from the various unit processes.

A solids mass balance tracks the flow of solids in a system. It seeks closure of a solids inventory measurement across a system by solving the following expression:

$$\text{Mass of solids into process} = \text{Mass of solids out of process} \pm \text{Mass of solids generated/destroyed/converted in process}$$

Closure of solids mass balances may be difficult to achieve because of a lack of critical solids concentration and flow data or by the inaccurate measurement or inappropriate sampling of specific streams. When conducting solids balances, assumptions must be made concerning the validity of certain data to use them as the starting points for (or inputs to) the mass balance calculations. Plant-wide mass balance calculations are performed using MABLE. It is used in conjunction with the BioWin simulator, where the former provides inputs to the simulator and the latter is used to predict secondary sludge production rates and effluent concentrations for use in the mass balance calculations.

Plant-wide solids mass balances were performed to calibrate MABLE using data from the August 2021 sampling period. Tables 5 summarizes mass balance results. The following observations were made from the comparison of the observed and predicted data:

- Using the measured influent concentrations would result in over-prediction of the dewatered cake solids load. That is consistent with the BioWin modeling results discussed above. By increasing the influent concentrations, a better match of the dewatered cake solids load was achieved.
- Both the sampling data and MABLE results indicate low volatile solids reduction (VSR) in the aerobic digesters. In the model, VSR of 10 and 9 percent was used for Digesters 2 and Digesters 3/4, respectively. The overall VSR is 18 percent, less than the minimum volatile solids reduction of 38 percent to meet Class B biosolids requirements. It should be noted that this calculated VSR is based on samples that were collected on eight days during the sampling period and analyzed by an outside laboratory. It may differ from the VSR calculated for the month of August 2021 and reported by OLWS for compliance.

The calibrated MABLE model was subsequently used in the overall plant capacity assessment.

Table 5. MABLE Calibration Summary for August 2021 Sampling Period

Parameter	Observed	Assumed	Predicted
Plant influent			
Flow, mgd	1.78	1.78	-
BOD, mg/L	236	332	-
TSS, mg/L	193	282	-
VSS, mg/L	181	264	-
Final effluent			
Flow, mgd	1.73	–	1.78
CBOD, mg/L	2.6	2.6	–
TSS, mg/L	6.5	6.5	–
VSS, mg/L	5.3	5.3	–
WAS			
Flow, mgd	0.02		–
TSS, mg/L	19,800	0.02	18,900
VSS/TSS	0.84	–	0.83
Net yield, lb VSS/BODrem	–	–	0.54
Digester 2 effluent			
Flow, mgd	-	-	0.02
%TS	1.8	-	1.7
TVS/TS	0.77	-	0.81
VS reduction, %	-	10	-
Digested sludge			
Flow, mgd	0.02	–	0.02
%TS	1.7	–	1.6
TVS/TS	0.75	–	0.80
VS reduction, %	–	9	–
Dewatered sludge [a]			
Wet ton/day	8.6	-	8.6
%TS	12.6		12.6
TVS/TS	0.77		0.80
BFP Filtrate [b]			
Flow, mgd	0.079	–	0.079
TSS, mg/L	1,160	800	–
Centrifuge solids capture, %	–	–	80

a. *Dewatered sludge wet tons per day calculated from data for sludge hauled from WWTP. During the sampling period, sludge was hauled off-site on 4 days. Observed data are based on pounds of sludge hauled on those 4 days. In the mass balance model, an average daily dewatered sludge production rate was calculated.*

b. *Based on plant drain return flows and samples.*

Section 5: Capacity Assessment

This section describes the assessment of the overall existing capacity of Oak Lodge WWTP. To estimate plant capacity, the process modeling and plant-wide solids mass balance described above were integrated to develop a comprehensive understanding of how the plant will respond to increased flows and loadings. The result is a series of capacity curves for each operating scenario representing operating limits for each of the major unit processes in the WWTP. The curves were combined into a capacity rating chart that represents an integration of all the evaluation assessments performed in this study. These curves are representative of the current effluent permit conditions.

5.1 Simulation Scenarios

Influent flows and loads as well as plant operating strategies vary seasonally. Typically, a capacity rating chart is developed for dry weather or summer operation and another for wet weather or winter operation. These represent the opposite extremes of plant operating conditions. For the Oak Lodge WWTP, capacity charts were developed for both dry and wet weather conditions. In addition to differences in wastewater characteristics, the plant also needs to meet different permit requirements during these two periods, defined as May to October and November to April, respectively, in the plant's NPDES permit. Therefore, the two simulation scenarios are as follows:

- **Dry weather MMF and loadings.** Represents the plant operation at the MMF and loadings during the dry weather period. The secondary system operates with two aeration basins (assumed to be Basins 2 and 3) and three clarifiers in service at a solids retention time (SRT) of 10 days. The first half of Basin 2 is unaerated and serves as the anoxic zone. Mixed liquor temperature is 17.5 degrees Celsius (°C), which corresponds to the average of the minimum month influent temperature during the dry weather period in 2016 to 2021 (increased by 1.2 °C to account for temperature increase from the plant influent to the aeration basins).
- **Wet weather MMF and loadings.** Represents the plant operation at the MMF and loadings during the wet weather period. The secondary system operates with three aeration basins (assumed to be Basins 2, 3, and 4) and four clarifiers in service at an SRT of 8 days. The first half of Basin 2 is unaerated and serves as the anoxic zone. Mixed liquor temperature is 13 °C, which corresponds to the average of the minimum month influent temperature during the wet weather period in 2016 to 2021 (increased by 0.8 °C to account for temperature increase from the plant influent to the aeration basins).

Wastewater characteristics are derived from the special sampling data collected in August 2021. Simulations were conducted using BioWin for the secondary system, and mass balance calculations were performed using the MABLE model for a range of influent flow rates and BOD concentrations that are assumed to represent MMF and loading conditions. The matrix for the dry weather conditions is provided in Table 6, while the matrix for the wet weather conditions is provided in Table 7.

Table 6. Modeling Matrix of Ranges of Influent Flows and BOD Concentrations for Dry Weather

MMF (mgd)	Plant Influent BOD Concentration (mg/L)				
2.7	200	220	240	260	280
2.9	200	220	240	260	280
3.1	200	220	240	260	280
3.3	200	220	240	260	280
3.5	200	220	240	260	280

Table 7. Modeling Matrix of Ranges of Influent Flows and BOD Concentrations for Wet Weather					
MMF (mgd)	Plant Influent BOD Concentration (mg/L)				
6.2	100	120	140	160	180
6.4	100	120	140	160	180
6.6	100	120	140	160	180
6.8	100	120	140	160	180
7.0	100	120	140	160	180

Dynamic simulations were performed for both dry and wet weather conditions based on each set of influent flow and concentrations, with a diurnal pattern applied to account for diurnal variation. The normalized diurnal patterns were derived from the 2-hourly flow and grab sampling data collected during the August sampling period.

5.2 Controlling Parameters

To determine capacity limitations in a WWTP, a series of operating or controlling parameters need to be identified. From model simulations, the required operating and performance values can be established for each controlling parameter that limits operation for a combination of flows and BOD concentrations.

The controlling parameters for the Oak Lodge WWTP and their limiting values are given in Table 8. These values were developed based on original design criteria, current operating practices, and physical configurations. The basis/operating constraints and assumptions used in determining these limiting values are also listed in Table 8.

Table 8. Maximum Operating Limits			
Plant Parameter	Limiting Value	Time Averaging Period for Limit	Basis/Operating Constraints and Assumptions
Effluent quality	Dry weather: CBOD = 10 mg/L, TSS = 10 mg/L Wet weather: BOD = 30 mg/L, TSS = 30 mg/L	Max month	Current NPDES permit limits (effective 5/1/2022)
Liquid stream			
Influent pumps	Peak flow capacity = 20 mgd (with 1 large pump out of service)	Peak hour	Per OLSD WWTP Phase 1A and Phase 1B record drawings
Influent screens	Peak flow capacity = 23.5 mgd	Peak hour	Per OLSD WWTP Phase 1A and Phase 1B record drawings
Grit removal	Peak flow capacity = 23.5 mgd	Peak hour	Per OLSD WWTP Phase 1A and Phase 1B record drawings
Aeration basins	Diffuser max air flow capacity = 3 scfm (max month conditions) (dry weather), 2.5 scfm (wet weather)	Max month	Typical max sustained diffuser air flow is in the range of 2.5 to 3.5 scfm per manufacturer recommendation (sustained meaning for longer than a day)
Aeration blowers	Peak blower capacity =5,448 scfm (with one large blower out of service)	Peak day	Per Aeration Basin Evaluation & Upgrades Project report (June 2019)
Secondary clarifiers	Peak SOR = 1,186 gpd/ft^2 at 18 mgd	Peak hour (SOR)	Peak hour SOR per design data in OLSD WWTP Phase 1A and Phase 1B record drawings
	SLR evaluated at 90th % DSVI of 114 mL/g using state point analysis	Max month (SLR)	90th % DSVI from 2020 and 2021 plant data
UV disinfection	Peak capacity = 22 mgd	Peak hour	Per OLSD WWTP Phase 1A and Phase 1B record drawings
Hydraulic limitations	Peak capacity with all units in service = 20 mgd	Peak hour	Peak flow shown on hydraulic profile drawing in OLSD WWTP Phase 1A and Phase 1B record drawings
Solids stream			
Aerobic digesters	Min HRT for Class B biosolids = 40 days (total) or 28 days (total, accounting for credit given to in-series operation)	Max month	Environmental Protection Agency Part 503 Biosolids Rule Criterion for aerobic digestion operating at 20 °C EPA Manual (EPA-625/R-92/013)
Belt filter press	Max hydraulic loading limit = 120 gpm Max solids loading limit = 2,000 lb/hr	Max month	1999 design documents for solids handling building; 2021 Biosolids Management Plan

Table abbreviations:

OLSD = Oak Lodge Sanitary Sewer District (former name for OLWS)
DSVI = dilute SVI
gpm = gallons per minute
HRT = hydraulic retention time
lb/hr = pounds per hour
mL/g = milliliters per gram
scfm = standard cubic feet per minute
SLR = solids loading capacity
SOR = surface overflow rate

To estimate timing of the capacity limitations, the projected 2022 and 2052 flows and loadings were interpolated assuming linear increases. The 2022 and 2052 projections are summarized in Table 9. Comparing the projected flows and loadings with the current design values in Table 1, the projected 2052 MMF as well as maximum month BOD and TSS loadings are lower than the corresponding design flow and loadings. The projected peak hour flow (for both 2022 and 2052) is slightly higher than the design hour flow of 18 mgd, although the facilities were designed to pass a peak instantaneous flow of 20 mgd without over-topping channels and tanks. It should be noted that the projected peak hour flows shown in Table 9 are based on the current contribution of inflow and infiltration (I/I) flows in the collection system. If I/I reduction projects are implemented in the future, thus resulting in a decrease in the peak hour flow, any peak flow-related capacity constraints would occur later.

Table 9. Summary of 2022 and 2052 Flows and Loadings		
Parameter	2022	2052
Flow, mgd		
Average dry weather	2.18	2.51
MMDW	2.96	3.30
MMWW	6.33	6.67
Peak hour flow	19.06	19.52
BOD_5 , lb/d		
Annual average	4,953	5,854
MMDW	5,399	6,381
MMWW	6,290	7,435
TSS, lb/d		
Annual average	4,755	5,620
MMDW	5,230	6,182
MMWW	6,371	7,531

5.2.1 Influent Pumps

The influent pump station was designed to pump the original design 2030 peak flow of 20 mgd with one of the larger pumps out of service. There are four pumps each with a design capacity of 5.5 mgd and one pump with a design capacity of 3.5 mgd. With one of large pumps out of service, the total firm capacity is thus 20 mgd.

5.2.2 Influent Screens

There are two, multi-rake bar screens with one-quarter-inch spacing. There is also a manual screen that has one-half-inch spacing in the bypass channel. Each of the mechanical screens has a design capacity of 11.75 mgd. A total screening capacity of 23.5 mgd is therefore assumed for the capacity analysis.

5.2.3 Grit Removal

Grit removal is achieved in a stacked tray grit removal system (Eutek Headcell). There are two units, each with a design capacity of 11.75 mgd. Therefore, the total peak capacity is 23.5 mgd, matching the screening capacity.

5.2.4 Aeration Basins

There are four basins, each with two passes and a liquid volume of 571,000 gallons. The plant currently operates with two basins in service in the summer and two or three basins in the winter. The basins are equipped with 9-inch membrane disc diffusers. Diffuser counts for each zone in each basin were estimated from total diffuser counts for each basin given in the design drawings (for Phase 1A expansion) and diffuser grid layout shown in the drawings. The estimated diffuser counts are summarized in Table 10.

Table 10. Summary of Aeration Basin Diffuser Counts		
Basin/Zone	# Diffusers	Notes
Aeration Basin 1	296 (total)	• Total per basin per OLSD WWTP Phase 1A and Phase 1B record drawings
Pass 1 – first half	74	• One grid in each half of each pass
– second half	74	
Pass 2 – first half	74	
– second half	74	
Aeration Basin 2	1,145 (total)	• Total per basin per OLSD WWTP Phase 1A and Phase 1B record drawings
Pass 1 – first half	458	• Two grids in first half of Pass 1; 1 grid in second half of Pass 1, first half of Pass 2 and second half of Pass 2
– second half	229	
Pass 2 – first half	229	
– second half	229	
Aeration Basin 3	1,145 (total)	• Total per basin per OLSD WWTP Phase 1A and Phase 1B record drawings
Pass 1 – first half	458	• Two grids in first half of Pass 1; 1 grid in second half of Pass 1, first half of Pass 2 and second half of Pass 2
– second half	229	
Pass 2 – first half	229	
– second half	229	
Aeration Basin 4	810 (total)	• Total per basin per OLSD WWTP Phase 1A and Phase 1B record drawings
Pass 1 – first half	405	• Two grids in first half of Pass 1; 1 grid in second half of Pass 1, first half of Pass 2 and second half of Pass 2
– second half	135	
Pass 2 – first half	135	
– second half	135	

Aeration Basin 1 has the least number of diffusers. Submersible mixers are installed in Basins 1 and 2, with six mixers in each basin. Currently, when two basins are in service, the first basin is operated with the first half without air but with the mixers on (as an anoxic zone) and the second half with constant air flow, and the second basin operated with DO control based on measurements by a DO probe at the mid-point of the basin (at the U bend). When three basins are in service, the first basin is half without air (and with mixing) and half constant air flow, the second basin has constant air flow, and the third basin uses DO control based on measurements by the probe at the U bend. Air cannot be balanced within each basin because there are no air flow meters and control valves on the drop legs. DO data and model calibration results indicate frequent low DO concentrations in the second half Basin 2 and first half of Basin 3. Operating at low DO concentrations could result in proliferation of filamentous organisms (low DO filaments) and deterioration in sludge settling.

For this capacity analysis, the current typical operating scheme was assumed, with two basins (Basins 2 and 3) in service for the dry weather scenario (Pass 1 of Basin 2 operating as the anoxic zone), and three basins (Basins 2, 3, and 4) in service for the wet weather scenario (Pass 1 of Basin 2 operating as the anoxic zone). A DO concentration of 2 mg/L was assumed in the aerated zones, except for the last zone where a DO concentration of 1 mg/L was assumed (lower concentration in the last zone to minimize DO in the internal mixed liquor recycle stream routed back to the anoxic zone). These DO concentrations would result in air flow estimates for a system with sufficient DO concentration to prevent low DO filamentous bulking.

As part of the process model calibration, aeration calculations were performed, and the calculated air flow rates were compared with the measured air flows. Alpha factors were adjusted as part of the calibration process. Alpha is the ratio of process water to clean water oxygen mass transfer. Alpha values ranging from 0.45 (in the first aerated zone) to 0.65 (in the last aerated zone) were estimated. These alpha values were used in the capacity analysis. Maximum air flows per diffuser of 3 and 2.5 scfm were assumed under maximum month load condition for dry and wet weather periods, respectively. A lower limit was assumed for wet weather period because peak day loads generally occur during the wet weather period (to provide a bigger allowance for short-term air flow excursion beyond the maximum month limit).

5.2.5 Aeration Blowers

There were originally three high-speed centrifugal blowers that serve the aeration basins. Each blower has a design capacity of 1,824 scfm at a discharge pressure of 9.7 pounds per square inch gage. One of the blowers was not functioning properly and was out of service for several years. As part of the Aeration Blower and Baffle project recently implemented at the WWTP, a new screw hybrid blower is added, replacing the out-of-service high-speed blower. The new blower has a design capacity of 1,800 scfm. The total firm blower capacity is thus 3,624 scfm, with one of the two remaining high-speed blowers out of service.

5.2.6 Secondary Clarifiers

There are four secondary clarifiers, each with a 70-foot-diameter. The clarifiers have a design peak hour surface overflow rate (SOR) of 1,186 gallons per day per square feet (gpd/ft^2), based on the original design peak hour flow of 18 mgd. This SOR value is within the range typically recommended for activated sludge systems. The actual SOR limit could be determined by stress testing. It should be noted that as both the projected 2022 and 2052 peak hour flows are above 18 mgd as shown in Table 9, the design SOR limit has already been exceeded. At the projected 2052 peak hour flow of 19.41 mgd, the corresponding SOR is 1,260 scfm.

Secondary clarifier capacity can also be constrained by solids loading rate (SLR) limitation. The SLR limitation is evaluated using state point analysis (SPA). The ability of the clarifiers to process incoming solids load is greatly influenced by the sludge settling characteristics. Sludge volume index (SVI) was used as a surrogate parameter for sludge settling characteristics. SVI data from 2020 and 2021 were evaluated to select a 90th percentile value as a reasonably conservative estimate for use in the SPA. Review of the SVI data shows that the plant often operated with relatively high SVI (with a 90th percentile value of 186 mL/g) during the data period but the effluent TSS concentrations were typically below 15 mg/L. It was thus proposed that dilute SVI (DSVI) values be calculated and used in the SPA. The idea of using dilute DSVI to evaluate clarifier performance was brought up in a Water Environment Research Foundation (WERF) selector study (Gray et al., 2006). In that study, all surveyed SVI data were converted to DSVI using the Merkel correction (Merkel, 1971):

$$\text{DSVI (mL/g)} = \text{SVI (mL/g)} \times \left(\frac{300}{\text{SSV30}} \right)^{0.6}$$

where SSV30 = the settled sludge volume after 30 minutes

The authors of the WERF study reiterate previous studies suggesting that SVI equals the DSVI for SSV30 values less than 300 mL, but the SVI begins to diverge at SSV30 values higher than 300 mL. The SVI values for Oak Lodge were thus converted to DSVI using the above equation.

Figure 3 shows the daily SVI and DSVI values from 2016 to 2021. SSV30 data are available only since 2020; therefore, DSVI was calculated only using data from 2020 and 2021. While no seasonable trends can be observed from the SVI and DSVI data, the data show large variations. Table 11 summarizes the data for different percentile values. For assessing the secondary clarifier SLR capacity, the 90th percentile DSVI value of 114 mL/g was assumed.

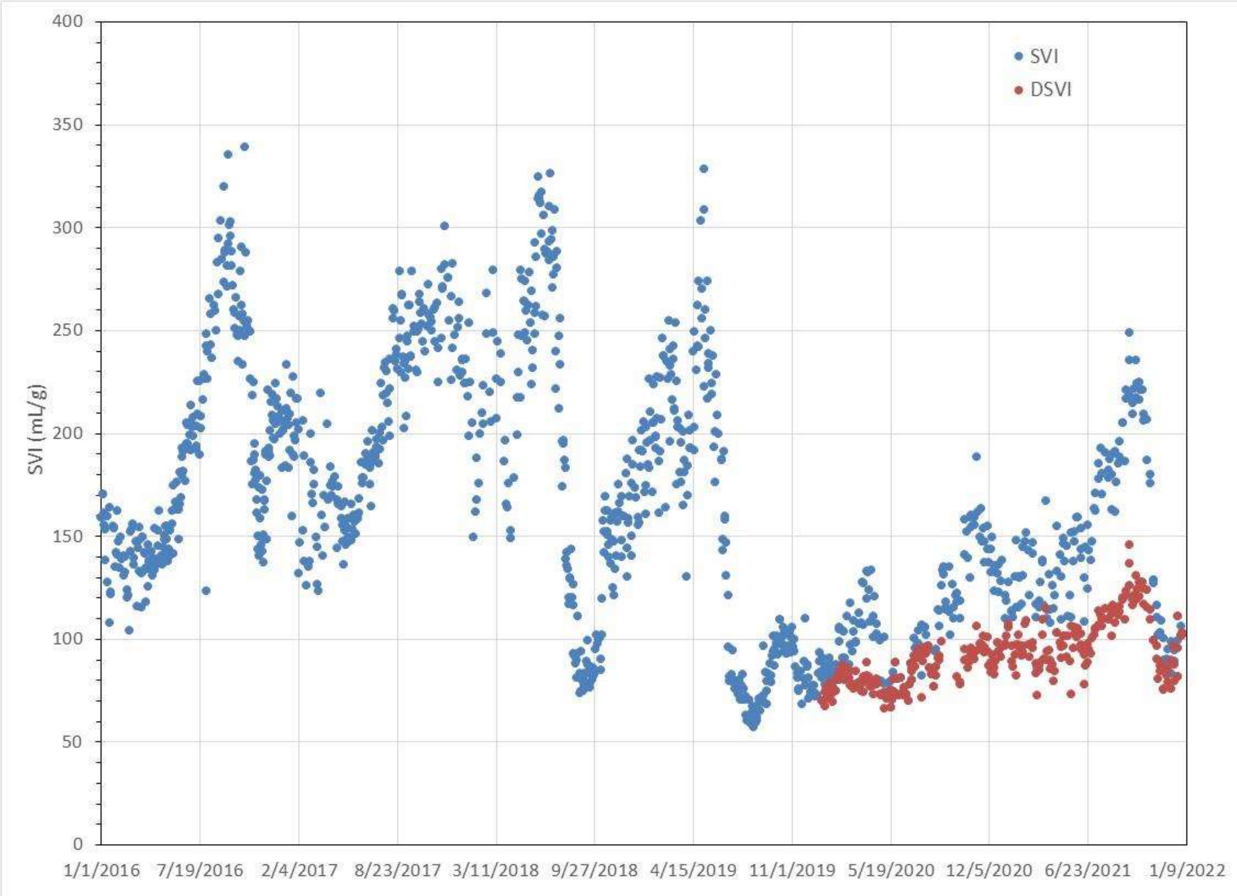


Figure 3. SVI and DSVI data from 2016 to 2021

Table 11. Summary of SVI and DSVI Data		
Parameter	SVI	DSVI
50th percentile	118	90
75th percentile	147	101
85th percentile	163	108
90th percentile	186	114
Maximum	248	146

Note: Percentile value calculated from daily SVI and SSV30 data from January 2020 to December 2021.

5.2.7 Ultraviolet Disinfection

The ultraviolet (UV) disinfection system consists of two open channels with two banks of UV lamps per channel. Low-pressure, high-intensity lamps are included, designed to deliver a UV dose of 35 kilojoules per square centimeter (kJ/cm^2). The peak design capacity is 22 mgd.

5.2.8 Gravity Belt Thickener

The Solids Piping Project currently being constructed at the plant will allow WAS to be pumped to the GBT that has been out of service since the 2012 plant upgrade. The GBT is a 2.2-meter unit made by Ashbrook. WAS thickening in the GBT has several advantages:

- Eliminates the need to thicken sludge in the secondary clarifiers. The RAS pumps can operate continuously and at a higher rate to maintain a low sludge blanket in the clarifiers. That would help minimize denitrification in the clarifiers and solids washout during high flow conditions.
- Increases solids concentration in the digesters, which reduces the hydraulic loading and increases digester HRT.
- Increases percent solids of the dewatered cake, which then reduces the amount of dewatered cake for disposal (in terms of wet tons of cake) and hauling costs.

There are two issues regarding future operation of the GBT that need to be first addressed. Operating at a higher solids concentration in the digesters may require increased aeration to maintain an adequate DO concentration. In addition, there is also a risk of having the process becoming autothermal, which would greatly increase odor generation. Typically, a solids concentration of no more than 3 percent (in the digester) is recommended to prevent autothermal condition, although sometimes that threshold could be as low as 2 percent. A detailed evaluation of these impacts and aeration requirements of the digesters to operate at higher solids concentrations is recommended. For this analysis, it is assumed that the system would continue to operate in the existing scheme without the GBT.

5.2.9 Aerobic Digesters

Solids stabilization is achieved through aerobic digestion. There are four digestion tanks. Aerobic Digesters 1 and 2 are rectangular tanks and were converted from the interchange bioreactors that were part of the Cannibal system installed in the Phase 1B upgrade and subsequently discontinued. Until recently, they were aerated with diffusers with the air supplied by a high-speed blower (K-Turbo blower). The K-Turbo blower failed in the summer of 2022 and was recently replaced by a screw hybrid blower (with the same design capacity as the blower installed as part of the Aeration Blower and Baffle project). In addition, two vertical turbine mixers in each tank provide additional mixing. Sludge from Digesters 1 and 2 is pumped to Digester 3.

Aerobic Digesters 3 and 4 are circular tanks converted from anaerobic digesters in 2012. They have a jet mixing system, with the air supplied by two, high-speed direct drive turbo blowers (Neuros blowers). The digesters are aerated intermittently. One of the blowers recently failed, and OLWS plans to replace it with a screw blower.

The blower for aerobic Digesters 1 and 2 is operated continuously, supplying approximately 2,000 scfm. With both digesters in service, that corresponds to approximately 17 scfm per 1,000 cubic feet (scfm/1,000 ft^3) of digester volume. Aeration mixing energy of 20 to 40 scfm/1,000 ft^3 is typically recommended to maintain adequate mixing in aerobic digesters. However, since aerobic Digesters 1 and 2 are also equipped with mechanical mixers, the combined effect of mechanical and aeration mixing may provide adequate mixing. For aerobic Digesters 3 and 4, each of the Neuros blowers supply approximately 440 scfm. If each blower supplies air to one digester, the calculated aeration rate is approximately 17 to 18 scfm/1,000 ft^3. Because those digesters have a jet mixing system that includes both aeration and pump mixing, there is also likely adequate mixing. No DO data are available, so it is not known if the available air flow is meeting the biological process requirements while maintaining an adequate DO concentration. In the future, when the GBT is placed in service providing thickening of the WAS prior to digestion, increased aeration is likely needed as discussed above.

To meet Class B biosolids requirements, the digestion process must meet both the residence time requirements (for pathogen reduction) and vector attraction reduction requirement. For the former, for aerobic digestion, the minimum mean cell residence time, which corresponds to the HRT without recuperative thickening, is 40 days at an operating temperature of 20 °C or 60 days at an operating temperature of 15 °C to qualify as one of the processes to significantly reduce pathogens (PSRPs) in the Part 503 rule by the Environmental Protection Agency (EPA) (EPA, 1994). Operating data indicate that the digesters at Oak Lodge typically operate at a temperature above 20 degrees Fahrenheit, therefore, the 40 days HRT criterion applies. However, because the digestion system at Oak Lodge consists of digesters operating in series (Digesters 1 and 2 followed by Digesters 3 and 4), a lower overall HRT criterion may apply. In accordance with the EPA manual “Control of Pathogens and Vector Attraction in Sewage Sludge” (EPA, 2003), completely mixed reactors in series would be more effective in reducing pathogens than a single reactor and the residence time required to meet pathogen reduction goals may be 30 percent lower than the residence time required in the PSRP definition for aerobic digestion. Therefore, the minimum HRT requirement could be reduced to 28 days at 20 °C or 42 days at 15 °C for systems with digesters in series. Since the lower HRT would not comply with the PRSP conditions required for aerobic digestion in the Part 503 rule, approval of the process as a PSRP by the permitting authority would be required.

The permitting authority for Oak Lodge, Oregon Department of Environmental Quality (DEQ), has given approval to use the lower HRT criterion. The credit for in-series digestion operation is also described in the current Biosolids Management Plan (OLWS, 2021).

Vector attraction reduction requirement is typically met by providing a minimum VSR of 38 percent. Vector attraction reduction can also be demonstrated with additional aerobic digestion in a bench-scale system or by measuring the specific oxygen uptake rate (SOUR). The solids mass balance results for the August 2021 sampling data indicate VSR less than 38 percent. Plant historical data have indicated that monthly average VSR has dropped below the 38 percent threshold a number of times in the past 3 years, often when one of the digesters was out of service. Recent digester operation in 2022 with all four digesters in service has resulted in VSR above the 38 percent level.

For the capacity analysis, it was assumed that all four digesters would be in service. The overall VSR was assumed to meet the minimum 38 percent level for Class B biosolids. It was also assumed that the digesters would have adequate aeration capacity after the failed blower for Digesters 3 and 4 has been rehabilitated or replaced and digester feed sludge concentration is maintained at no more than 2 percent solids. Digestion capacity is thus assessed based on HRT requirements only. Both the 40-day and 28-day limits are considered in the analysis.

5.2.10 Belt Filter Press

Digested sludge is pumped from Digester 4 to Belt Filter Press 1 (BFP1). BPF1 (a 2.2-meter unit made by Ashbrook) was originally designed for a maximum sludge flow of 150 gallons per minute (gpm) and solids loading rate of 2000 pounds per hour. A flow capacity of 120 gpm was shown in the most recent Biosolids Management Plan (February 2022) prepared by OLWS. Plant data indicate the dewatered cake percent solids ranging from approximately 12 to 14 percent, until early 2022 when the plant switched from dry to liquid polymer. The dewatered cake solids concentration has increased to between 16 and 17 percent. For the capacity analysis, 16 percent was assumed. In addition, solids capture is assumed to be higher (at 90 percent) instead of the 80 percent calculated as part of the solids mass balance model calibration described in Section 4.2. The dewatering system is assumed to operate 7 days a week and 6 hours a day, similar to the current operating schedule.

In addition to BPF1, a second belt filter press, BFP2, was temporarily installed as part of the BFP Installation Project in 2020 to provide redundancy for the dewatering system. After initial installation of BFP2, BFP1 was taken out of service and refurbished. Once BFP1 was put back on-line, BFP2 was uninstalled and is currently being stored adjacent to Aerobic Digesters 1 and 2. For the capacity analysis, BFP2 is assumed to serve as a redundant unit and does not change the dewatering capacity.

5.2.11 Plant Hydraulic Limitations for Gravity-Flow Systems

A plant hydraulic profile analysis was not included in this evaluation. Based on the hydraulic profile given in the Phase 1A and Phase 1B upgrade drawings, the plant was designed to pass a peak instantaneous flow of 20 mgd with all units in service. This matches the total firm raw sewage pumping capacity and is thus considered the maximum hydraulic capacity for the WWTP.

5.3 Capacity Rating Chart

A capacity rating chart provides a method of displaying the results of investigations described in previous sections. Expressed in terms of flow and organic loading, the chart consists of a series of curves that illustrate how each unit process in the WWTP impacts the overall plant capacity. Each curve represents a specific plant process and the condition under which that process reaches its capacity. The chart also contains a curve that represents the projected raw influent BOD concentrations at increasing flow. This curve was developed from the projected plant flow and loadings summarized in Table 9.

Progressing along the raw influent BOD curve from left to right across the chart intersects each plant process capacity curve; each intersection of the influent BOD curve with a plant process curve represents a capacity limitation related to that process at the corresponding influent flow rate and BOD concentration. For that specific plant process curve, the area to the left of and below the curve or just left of a vertical curve corresponds to underloaded operating conditions. The area to the right of and above the curve or just right of a vertical curve corresponds to overloaded conditions. Overall plant capacity is dictated by the plant process constraint that is furthest to the left along the raw influent BOD curve.

Figures 4 and 5 show the composite capacity charts for the MMF and loading conditions for the dry and wet weather scenarios, respectively, as described in Section 5.1. On each chart, the raw influent BOD loading curve represents the influent BOD concentration during the month of MMF and maximum month loadings, with a timeline from 2022 to 2052 labeled on the curve.

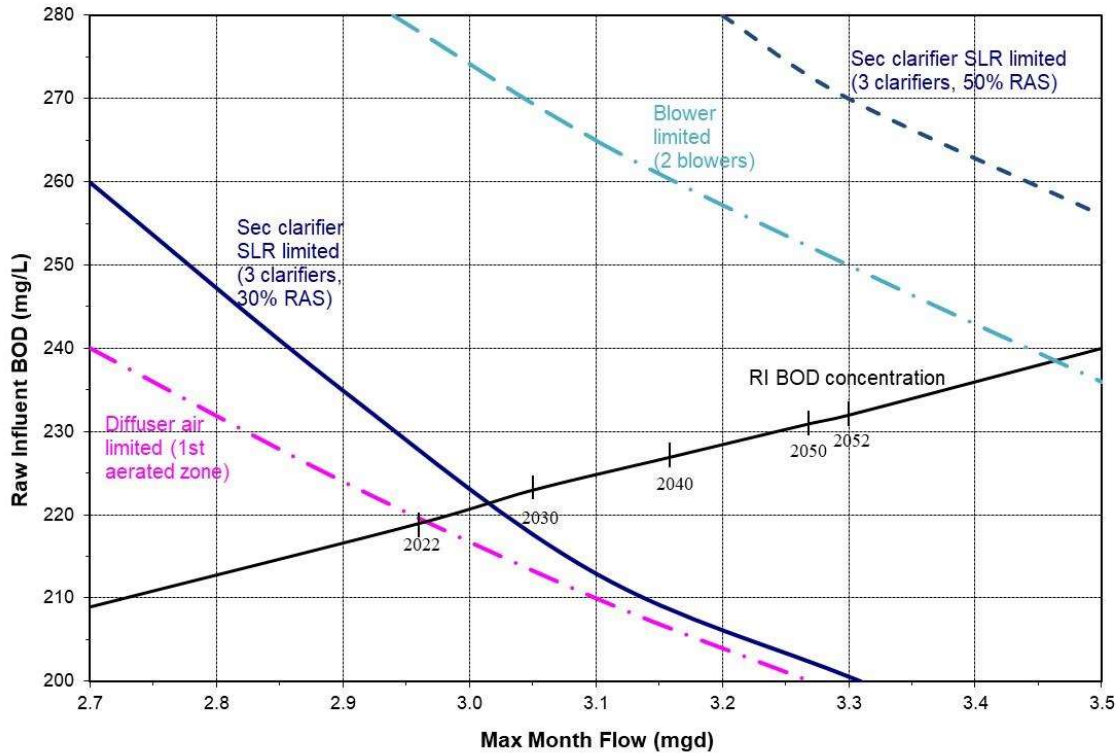


Figure 4. Composite capacity chart for dry weather conditions

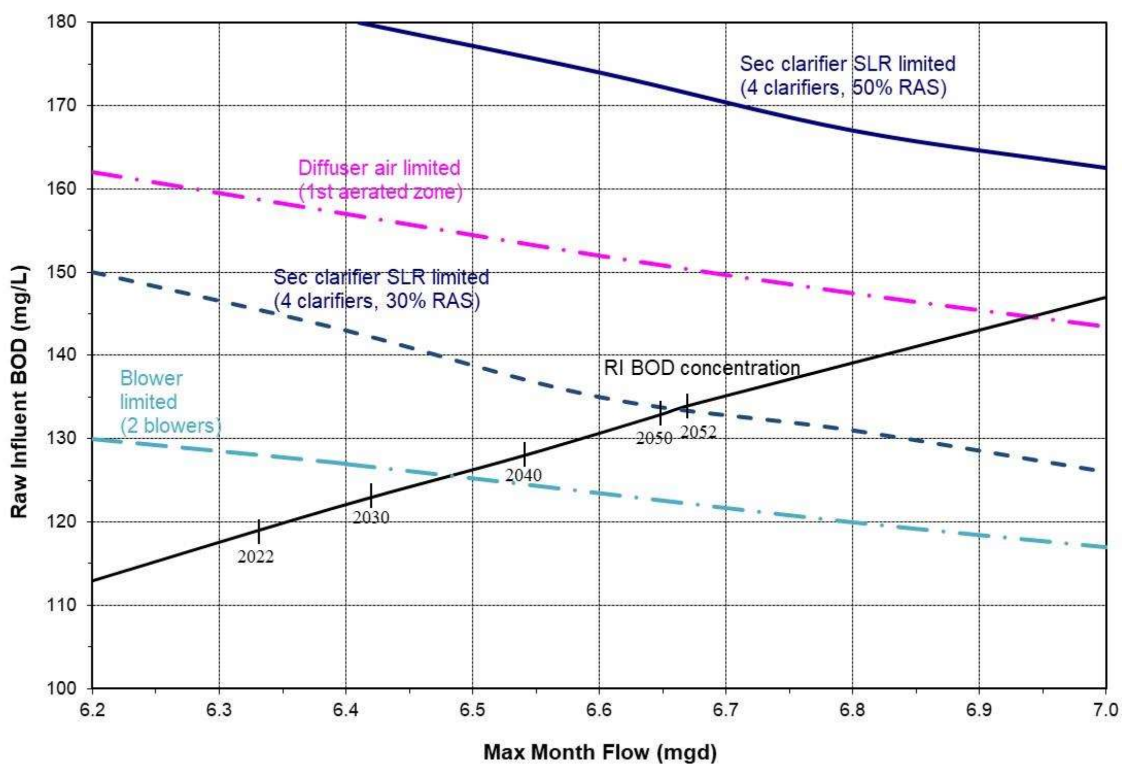


Figure 5. Composite capacity chart for wet weather conditions

5.3.1 Dry Weather Conditions

The results for dry weather conditions, as illustrated in Figure 4, are summarized below.

- **Aeration Basin Diffusers**: The most stringent limitation is associated with the aeration basin diffusers. This limitation is based on the diffusers in the first aerated zone (in the second half of Basin 2), which are projected to currently approach the estimated diffuser air flow limit. Excessive diffuser air flows result in reduced oxygen transfer efficiency and high headloss across the diffuser membrane and orifice. As mentioned above, this first aerated zone is currently operated with constant air flow rate and low DO concentration. For the capacity analysis, it was assumed that a DO concentration of 2 mg/L would be maintained in all aerated zones (except in the last zone where a DO concentration of 1 mg/L was assumed). That would require addition of air control valves at the droplegs and changes in the aeration control strategy. It should be noted that assuming lower concentrations similar to how the basins are currently operated with limited DO control would result in underpredicting the air flow requirements needed to prevent low DO filamentous bulking.
- **Secondary Clarifiers**: The secondary clarifiers are projected to reach their solids loading limit in the next few years, at a dry weather MMF of approximately 3.02 and maximum month BOD loading of 5,600 lb/d. This limitation is based on having one clarifier out of service, a RAS rate of 30 percent, and deteriorated settling characteristics (90th percentile DSVI). The plant typically operates at a low RAS rate (less than 50 percent) to produce higher WAS concentration. In addition, the RAS pumps for clarifiers 1 and 2 are turned off for a few hours each day to build up a blanket and further thicken the sludge, providing a digester feed sludge concentration of up to around 20,000 mg/L without a separate thickening step. Operating at a higher RAS rate (and thus a lower sludge blanket) would increase the solids loading capacity. A sensitivity analysis was thus performed to evaluate the impact of operating at a RAS rate of 50 percent. The results, also presented on Figure 4, show that the clarifier SLR limitation can be delayed to beyond 2052 by increasing the RAS rate to 50 percent. In order to operate at the higher RAS rate, operation of the GBT would likely be required to thicken the WAS prior to digestion.
- **Aeration Blowers**: The aeration blowers are projected to have sufficient capacity until beyond 2052.
- **Other Processes**: For other processes not shown in Figure 3 including digestion and dewatering, the analysis results indicate that they have adequate capacity until beyond 2052. Processes with hydraulic (peak hour) limitations are not included in Figure 3 since peak hour flow occurs during wet weather period.

5.3.2 Wet Weather Conditions

The results for wet weather conditions, as illustrated in Figure 5, are summarized below.

- **Aeration Blowers**: The most stringent limitation under wet weather conditions is associated with the aeration blowers. The limitation is projected to occur around 2035, at a maximum month flow of approximately 6.48 mgd and maximum month BOD loading of 6,810 lb/d. The aeration blower limitation was found to be more stringent under wet weather conditions than dry weather conditions because maximum month and peak day loading typically occur during wet weather period, even though aeration requirements associated with nitrification are lower.
- **Aeration Basin Diffusers**: While aeration diffusers are shown to be the most stringent loading-related limitation shown in Figure 5, the limitation is not projected to occur until after 2052. The difference between the results for dry and for wet weather conditions is mainly due to the number of basins in service (3 for wet weather versus 2 for dry weather) and the lower degree of nitrification during the wet weather period (lower temperature and SRT) and thus lower aeration demand.
- **Secondary Clarifiers**: The secondary clarifiers are projected to have sufficient solids loading capacity until beyond 2052. The analysis was conducted assuming all four clarifiers in service, a RAS rate of 50 percent, and deteriorated setting characteristics (90th percentile DSVI). A higher RAS rate was assumed

for the wet weather conditions than for dry weather conditions because it is recommended to maintain a low sludge blanket to prevent solids washout during a peak flow period. However, as mentioned above, the plant typically operates at a low RAS rate to produce higher WAS concentration. Under the current maximum month load conditions, a digester feed solids concentration of at least 11,000 or 16,000 mg/L is needed during wet weather period to meet the 28- or 40-day HRT requirements, respectively, depending on whether the credit for in-series digestion operation is included. Similar to the dry weather evaluation, a sensitivity analysis was thus performed to evaluate the impact on clarifier capacity by operating at a lower RAS rate (30 percent instead of 50 percent). The results are also presented on Figure 5. The analysis shows that the clarifiers would not become SLR limited until near the end of the planning period (around 2051) but the limitation is shown to be more stringent than at a 50 percent RAS rate. Similar to the dry weather condition, in order to operate at the higher RAS rate, operation of the GBT would be required to thicken the WAS prior to digestion.

Besides SLR limitation, SOR limitation is also considered. The clarifiers were originally designed for a peak hour SOR of 1,186 gpd/ft^2, based on the original design peak hour flow of 18 mgd. The projected 2022 peak hour flow, at 19.07 mgd, already exceeds the original peak hour flow and at the projected 2052 peak hour flow of 19.41 mgd, the corresponding SOR is 1,260 gpd/ft^2. A peak hour SOR of 1,260 gpd/ft^2 is still within the range typically recommended for activated sludge systems. To confirm the clarifier capacity in terms of SOR, stress testing is recommended.

- **Digestion and Dewatering**: Capacity curves associated with digestion and dewatering are not shown on Figure 4. Digester and dewatering limitations are greatly impacted by digester feed sludge solids concentrations. As mentioned above, a digester feed solids concentration of at least 11,000 or 16,000 mg/L is needed to meet the 28- or 40-day HRT requirements at the current flow and loadings. If the secondary system is operated with a 50 percent RAS rate, without any further thickening, the digester total HRT would drop below 28 days under all flow and loading conditions evaluated. In addition, the belt filter press hydraulic load would exceed the 120-gpm limit. Minimum digester feed concentrations of about 13,000 mg/L, 19,000 mg/L and 14,000 mg/L would be needed to meet the 28-day digester HRT requirement, 40-day digester HRT requirement and to stay below the belt filter press hydraulic limit, respectively, through 2052. It should be noted that this analysis was conducted assuming all four digesters are in service. The credit for in-series digestion operation, and thus the lower 28-day HRT requirement, could be applied to allow taking one digester out of service for maintenance, although the vector attraction reduction requirements may not be met under those conditions.
- **Other Processes**: For other processes that have hydraulic (peak hour) limitations, including influent pumping, influent screening, grit removal, UV disinfection, and plant hydraulics, the peak hour limits were all above the projected 2052 peak hour flow, thus indicating that those processes should have adequate capacity through 2052.

Section 6: Summary

This capacity assessment was conducted for the Oak Lodge 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 Oak Lodge 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 GBT as a dedicated thickening process.

6.1 Summary of Capacity Constraints by Unit Process

Table 12 summarizes the unit process capacity evaluation results. The capacity limits presented are expressed in terms of plant influent flow and BOD loadings.

Table 12. Maximum Capacities by Unit Process

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

a. Capacity expressed as plant influent peak hour flow.

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

6.2 Summary of Capacity Constraints by Timing

Capacity constraints at the Oak Lodge WWTP are divided into two phases according to the timing of when they will likely occur. In addition, recommendations were developed to potentially address these capacity constraints or to improve performance. These are summarized below.

Near-Term (now to 2030) Capacity Constraints

- **Aeration system limitations.** Assuming the 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 headloss 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, generally 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.
- **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 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 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 SVIs and cause other operational problems. Potential solutions include addition of water sprays, a classifying selector, and a foam wasting station.
- **Aerobic digestion limitations.** With all four digesters in service, the digesters have sufficient capacity to meet the HRT requirements for Class B biosolids as long as the digester feed solids concentration is above a certain level. 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 percent solids is recommended.

Recent digester performance and review of plant data indicate that, to consistently meet the 38 percent 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 to investigate the option of taking one digester out of service and potentially operating at a concentration higher than the recommended 2.5 percent solids concentration level.

- **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.

Long-Term (after 2030) Capacity Constraints

- **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.
- **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.

The recommended improvements discussed above, upon review by OLWS staff and modified as needed, will be incorporated in the WWTP alternatives analysis.

References

A Plain English Guide to the EPA Part 503 Biosolids Rule, EPA/832/R-93/003, September 1994.

Control of Pathogens and Vector Attraction in Sewage Sludge, EPA/625/R-92/013, July 2003.

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Attachment A: August 2021 Sampling Data

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Raw Influent

Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C	Alk (mmol/L)
8/10/2021	1.789																				7.6	26.3	
8/11/2021	1.775	50	43	294	212	97.9	129	86.4			39.3	34.3		ND	ND	4.56	3.83	*0.6*		175	7.5	26.6	3.5
8/12/2021	1.733	176	170	450	166	87.5	222	*273*			44.2	34.6		ND	ND	5.83	3.69	2.88		182	7.5	26.5	3.64
8/13/2021	1.799																				7.5	26.6	
8/14/2021	1.768																						
8/15/2021	1.853																						
8/16/2021	1.797	198	188	502	250	105	256	91.5			46.9	38.8	29.10	ND	ND	5.89	4.68	2.82		182			3.64
8/17/2021	1.763	240	222	419	175	132	258	87.2			45.9	36.8	29.40	ND	ND	5.94	3.59	2.81		182	7.5	25.5	3.64
8/18/2021	1.750	208	196	426	176	124	225	78.8			46.5	*36.3*	*39.50*	ND	ND	5.87	3.56	2.84		174	7.5	25.6	3.48
8/19/2021	1.754	190	175	410	190	111	210	86.9			45.9	38.3	35.90	ND	ND	5.86	4.05	3.21		179	7.6	25.6	3.58
8/20/2021	1.738																						
8/21/2021	1.820																						
8/22/2021	1.866																						
8/23/2021	1.748	148	135	500	194	122	244	82.6			44.4	*34.9*	*39.20*	ND	ND	5.58	3.44	2.84		180			3.6
8/24/2021	1.752																				7.5	24.8	
Average	1.780	172.9	161.3	428.7	194.71	111.34	220.6	85.6			44.4	36.6	31.5			5.65	3.83	2.57		179	7.53	25.94	3.58
Count	15	7	7	7	7	7	7	7	0	0	7	7	5	0	0	7	7	7	0	7	8	8	
8/10-8/23 av	1.78	172.86	161.29	428.71	194.71	111.34	220.57	85.57			44.73	36.56	31.47			5.65	3.83	2.57		179.14	7.53	26.10	3.58
8/12-8/23 avg		193.33	181.00	451.17	191.83	113.58	235.83	85.40			45.63	37.13	31.47			5.83	3.84	2.90		179.83	7.52	25.96	3.60
											58.867					7.51855							

CALCULATED PARAMETERS

Raw Influent

Day	ISS	VSS / TSS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS	COD / TP	sBOD / BOD	sCBOD / CBOD	NH3 / TKN	FupP	FupN	TP / VSS		Fbs	Fus	Fnox	Fpo4	COD / Alk
8/10/2021																						
8/11/2021	7.0	0.86			2.28	1.91		7.48	0.91	64.47	0.67					0.106		0.26	0.07		0.12	84.00
8/12/2021	6.0	0.97			2.03	1.67		10.18	0.26	77.19	1.23					0.034		0.16	0.04		0.49	123.63
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	10.0	0.95			1.96	1.34		10.70	0.25	85.23	0.36		0.62			0.031		0.17	0.04	0.455	0.48	137.91
8/17/2021	18.0	0.93			1.62	1.10		9.13	0.21	70.54	0.34		0.64			0.027		0.27	0.05	0.552	0.47	115.11
8/18/2021	12.0	0.94			1.89	1.28		9.16	0.24	72.57	0.35		0.85			0.030		0.26	0.04		0.48	122.41
8/19/2021	15.0	0.92			1.95	1.26		8.93	0.26	69.97	0.41		0.78			0.033		0.21	0.08	0.760	0.55	114.53
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021	13.0	0.91			2.05	2.27		11.26	0.33	89.61	0.34		0.88			0.041		0.19	0.04		0.51	138.89
8/24/2021																						
Average	11.6	0.93			1.97	1.55		9.55	0.35	75.65	0.53		0.76			0.04		0.22	0.046	0.59	0.44	119.5
8/10-8/23 av	11.57	0.925			1.97	1.55							0.68					0.219	0.046	0.503	0.44	
8/12-8/23 av	12.33	0.936			1.92	1.48							0.68					0.211	0.040	0.503	0.50	

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Screened Influent																							
Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C	Alk (mmol/L)
8/10/2021		68	64	301			128				35.5					4.79				180			3.6
8/11/2021		53.3	48	284			112				40.8					6.56				176			3.52
8/12/2021		150	134	361			179				40.1					5.94				180			3.6
8/13/2021																							0
8/14/2021																							
8/15/2021																							
8/16/2021		1100	1010	881			846				77.4					14.20				185			
8/17/2021		947	893	1210			763				80.1					12.30				188			3.76
8/18/2021		653	607	942			935				74.1					11.40				194			3.88
8/19/2021		1300	1140	1380			334				140.0					15.30				274			
8/20/2021																							
8/21/2021																							
8/22/2021																							
8/23/2021		215	195	506			240				45.6					6.56				181			
8/24/2021																							0
Average		561	511.4	733.1			371.7				66.7					9.63				195			2.62
Count	0	8	8	8	0	0	8	0	0	0	8	0	0	0	0	8	0	0	0	8	0	0	

CALCULATED PARAMETERS

Screened Influent																						
Day	ISS	VSS / TSS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021	4.0	0.94			2.35			8.48	0.55							0.075						83.61
8/11/2021	5.3	0.90			2.54			6.96	0.85							0.137						80.68
8/12/2021	16.0	0.89			2.02			9.00	0.30							0.044						100.28
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	90.0	0.92			1.04			11.38	0.08							0.014						
8/17/2021	54.0	0.94			1.59			15.11	0.09							0.014						321.81
8/18/2021	46.0	0.93			1.01			12.71	0.12							0.019						242.78
8/19/2021	160.0	0.88			4.13			9.86	0.12							0.013						
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021	20.0	0.91			2.11			11.10	0.23							0.034						
8/24/2021																						
Average	49.4	0.91			2.10			10.57	0.29							0.04						165.8

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Anoxic Selector Effluent																						
Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021					33.9								8.5	0.0985	ND			7.72				
8/11/2021					44.2								3.76	0.193	0.0307			13.2				
8/12/2021					29.2	19.7							3.94	0.0511	0.031			0.268				
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021					46.5	30.7							2.75	ND	0.0282			3.14				
8/17/2021					52	37.2							10.40	ND	ND			3.62				
8/18/2021					40.2	30.3							6.98	0.0957	0.043			3.84				
8/19/2021					13.7	29.5							3.69	ND	ND			3.54				
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021					49.2	32.1							2.46	0.399	0.0929			2.72				
8/24/2021					41.2	31.9							2.07	0.49	0.0907			2.34				
Average					38.90	30.20							4.95	0.22	0.05			4.49				
Count	0	0	0	0	9	7	0	0	0	0	0	0	9	6	6	0	0	9	0	0	0	0
8/10-8/23 avg					38.61	29.92							5.32	0.17	0.05			4.76				

CALCULATED PARAMETERS

Anoxic Selector Effluent																						
Day	ISS	VSS / TSS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021																						
8/11/2021																						
8/12/2021																						
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021																						
8/17/2021																						
8/18/2021																						
8/19/2021																						
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021																						
8/24/2021																						
Average																						

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Mixed Liquor																						
Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021		2160	1840																		6.5	27.3
8/11/2021		3620	3040																		6.3	27.6
8/12/2021		3520	2920																		6.5	27.5
8/13/2021																						27.6
8/14/2021																						
8/15/2021																						
8/16/2021		2940	2380																			
8/17/2021		3420	2840																		6.4	26.5
8/18/2021		3460	2900																		6.4	26.6
8/19/2021		3440	2940																		6.5	26.6
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021		3940	3300																			
8/24/2021		3180	2640.0																		6.5	25.8
Average		3298	2755.6																		6.44	26.94
Count	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	8
8/10-8/23 avg		3312.50	2770.00																			27.10

CALCULATED PARAMETERS

Mixed Liquor																						
Day	ISS	VSS / TSS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021	320.0	0.85																				
8/11/2021	580.0	0.84																				
8/12/2021	600.0	0.83																				
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	560.0	0.81																				
8/17/2021	580.0	0.83																				
8/18/2021	560.0	0.84																				
8/19/2021	500.0	0.85																				
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021	640.0	0.84																				
8/24/2021	540.0	0.83																				
Average	542.2	0.84																				

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

	Final Effluent																						
Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C	Alk (mmol/L)
8/10/2021	1.720	3.2	3.2	30.7	29	10.2			1.66	ND	1.46		0.145	2.93	0.0668	3.24		2.97		66.9	6.6	23.306	1.338
8/11/2021	1.720	2.8	5.2	32.3	22	22			4.25	2.67	1.39		0.179			3.3				65.1	6.3	23.611	1.302
8/12/2021	1.660	10	8	28.5	15.9	17.2			3.27	2.13	2.44		0.567	3.42	0.0789	4.28		4.01		65.3	6.7	23.815	1.306
8/13/2021	1.690																				6.6	24.03	
8/14/2021	1.700																					23.947	
8/15/2021	1.840																					23.991	
8/16/2021	1.760	4.4	5.2	27.2	17.8	17.5			2.87	2.01	2.20		0.557	3.17	0.129	2.38		2.17		75.5		23.908	1.51
8/17/2021	1.670	3.6	3.2	27.2	20.9	19.1			1.83	1.39	1.55		0.180	2.98	0.0786	2.28		2.11		66.2	6.7	23.482	1.324
8/18/2021	1.710	4.4	5.2	20.2	17	12.4			2.23	1.25	1.43		0.144	2.72	0.0623	2.05		1.72		67.9	6.7	23.235	1.358
8/19/2021	1.670	6	4.8	27.4	31.8	23.5			ND	ND	2.57		0.934	3.6	0.137	3.66		0.71		66.4	6.8	23.301	
8/20/2021	1.640																					23.357	
8/21/2021	1.800																					23.167	
8/22/2021	1.910																					22.943	
8/23/2021	1.770	5	7	32.3	19.4	25.1			1.97	1.07	1.83		0.436	2.54	0.113	2.21		1.91		71.4	6.7	22.765	1.428
8/24/2021	1.690																				6.7		
Average	1.730	5	5.2	28.2	21.73	18.38			2.6	1.8	1.9		0.393	3.05	0.10	2.93		2.23		68	6.64	23.49	1.37
Count	15	8	8	8	8	8	0	0	7	6	8	0	8	7	7	8	0	7	0	8	9	14	
8/10-8/23 av	1.73	6.53	5.33	28.23	20.29	18.38			2.58	1.75	1.86		0.39	3.05	0.10	2.93		2.23		68.09	6.64		1.37

CALCULATED PARAMETERS

	Final Effluent												
Day	ISS	VSS/TSS	COD/BOD5	Prt COD/VSS	COD/TKN	TKN/VSS	sBOD/BOD	sCBOD/CBOD	NH3/TKN	COD/TP	TP/VSS	COD/Alk
8/10/2021	0.0	1.00		0.53	21.03	0.46			0.10	459.58	1.013	22.94
8/11/2021	-2.4	1.86		1.98	23.24	0.27		0.6	0.13		0.637	24.81
8/12/2021	2.0	0.80		1.58	11.68	0.31		0.7	0.23	361.22	0.535	21.82
8/13/2021												
8/14/2021												
8/15/2021												
8/16/2021	-0.8	1.18		1.81	12.36	0.42		0.7	0.25	210.85	0.458	18.01
8/17/2021	0.4	0.89		1.97	17.55	0.48		0.8	0.12	346.06	0.713	20.54
8/18/2021	-0.8	1.18		0.62	14.13	0.28		0.6	0.10	324.24	0.394	14.87
8/19/2021	1.2	0.80		-0.92	10.66	0.54			0.36	200.00	0.763	
8/20/2021												
8/21/2021												
8/22/2021												
8/23/2021	-2.0	1.40		1.84	17.65	0.26		0.5	0.24	285.84	0.316	22.62
8/24/2021												
Average	-0.3	1.14		1.18	16.04	0.38		0.64	0.19	312.54	0.60	20.8

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet Start Date = 8/10/2021

MEASURED PARAMETERS

Return Activated Sludge																						
Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021	0.633	13500	11300																			
8/11/2021	0.590	14300	12100																			
8/12/2021	0.472	14600	12200																			
8/13/2021	0.588																					
8/14/2021	0.554																					
8/15/2021	0.607																					
8/16/2021	0.615	16400	13500																			
8/17/2021	0.594	14500	12100																			
8/18/2021	0.600	13000	11100																			
8/19/2021	0.544	14400	12000																			
8/20/2021	0.488																					
8/21/2021	0.530																					
8/22/2021	0.549																					
8/23/2021	0.578	15000	12300																			
8/24/2021	0.548	15100	13200.0																			
Average	0.566	14533	12200.0																			
Count	15	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10-8/23 av	0.567	14463	12075																			

CALCULATED PARAMETERS

Return Activated Sludge																						
Day	ISS	VSS/TSS	%Q		COD/BOD5	Prt COD/VSS		COD/TKN	TKN/VSS		sBOD/BOD	sCBOD/CBOD	NH3/TKN		COD/TP	TP/VSS						COD/Alk
8/10/2021	2200.0	0.84	35.4%																			
8/11/2021	2200.0	0.85	33.3%																			
8/12/2021	2400.0	0.84	27.2%																			
8/13/2021			32.7%																			
8/14/2021			31.3%																			
8/15/2021			32.7%																			
8/16/2021	2900.0	0.82	34.2%																			
8/17/2021	2400.0	0.83	33.7%																			
8/18/2021	1900.0	0.85	34.3%																			
8/19/2021	2400.0	0.83	31.0%																			
8/20/2021			28.1%																			
8/21/2021			29.1%																			
8/22/2021			29.4%																			
8/23/2021	2700.0	0.82	33.1%																			
8/24/2021	1900.0	0.87	31.3%																			
Average	2333.3	0.84	31.8%																			

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Waste Activated Sludge																						
Day	Flow gpd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021	23050	19200	16000																			
8/11/2021	20019	21700	18300																			
8/12/2021	19379	19700	16700																			
8/13/2021	18897																					
8/14/2021	18547																					
8/15/2021	18512																					
8/16/2021	21848	19700	16200																			
8/17/2021	21114	17800	15000																			
8/18/2021	24305	19300	16200																			
8/19/2021	29894	22100	18600																			
8/20/2021	15558																					
8/21/2021	15558																					
8/22/2021	14810																					
8/23/2021	18596	18800	15800																			
8/24/2021	17924	21700	18600.0																			
Average	19867	20000	16822.2																			
Count	15	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8/10-8/23 av 20006 19788 16600 3301.58

0.027372

CALCULATED PARAMETERS

Waste Activated Sludge																						
Day	ISS	VSS / TSS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021	3200.0	0.83																				
8/11/2021	3400.0	0.84																				
8/12/2021	3000.0	0.85																				
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	3500.0	0.82																				
8/17/2021	2800.0	0.84																				
8/18/2021	3100.0	0.84																				
8/19/2021	3500.0	0.84																				
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021	3000.0	0.84																				
8/24/2021	3100.0	0.86																				
Average	3177.8	0.84																				

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

IBR Effluent																						
Day	Flow mgd	TS % solids	%VS	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021		1.82	77.10%																			
8/11/2021		1.81	77.30%																			
8/12/2021		1.82	77.20%																			
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021		1.78	77.50%																			
8/17/2021		1.85	77.70%																			
8/18/2021		1.76	77%																			
8/19/2021		1.79	77.70%																			
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021		1.8	76.90%																			
8/24/2021		1.73	77.60%																			
Average		1.80	0.77																			
Count	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10-8/23 avg		1.8038	0.7730																			

CALCULATED PARAMETERS

IBR Effluent																						
Day	IS	VS %TS			COD BOD5	Prt COD VSS		COD TKN	TKN VSS		sBOD BOD	sCBOD CBOD	NH3 TKN		COD TP	TP VSS						COD Alk
8/10/2021	1.0	1.40																				
8/11/2021	1.0	1.40																				
8/12/2021	1.0	1.41																				
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	1.0	1.38																				
8/17/2021	1.1	1.44																				
8/18/2021	1.0	1.36																				
8/19/2021	1.0	1.39																				
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021	1.0	1.38																				
8/24/2021	1.0	1.34																				
Average	1.0	1.39																				

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Aerobic Digested Sludge																						
Day	Flow gpd	TS % solids	%VS	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021	22853	1.68	74.10%																		7.6	31.7
8/11/2021	21537	1.68	74.30%																		7.5	32.4
8/12/2021	27462	1.69	74.60%																		7.5	32.7
8/13/2021	25802																				7.6	33.2
8/14/2021	20625																				7.2	34.7
8/15/2021	22353																				7.3	34.4
8/16/2021	22931	1.69	74.70%																		7.5	33.2
8/17/2021	0	1.71	75%																			
8/18/2021	0	1.71	75.50%																			
8/19/2021	25457	1.69	75.30%																		7.6	32.4
8/20/2021	25367																				7.3	32.5
8/21/2021	21580																				7.3	32.5
8/22/2021	0																					
8/23/2021	24499	1.68	74.90%																		7.7	31.3
8/24/2021	23858	1.67	75.20%																		7.6	32.2
Average	18955	1.69	0.75																		7.48	32.77
Count	15	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	12
8/10-8/23 av	18605	1.6913	0.7480																			

CALCULATED PARAMETERS

Aerobic Digested Sludge																						
Day	IS	VS %TS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021	0.9	1.24																				
8/11/2021	0.9	1.25																				
8/12/2021	0.9	1.26																				
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	0.9	1.26																				
8/17/2021	1.0	1.28																				
8/18/2021	1.0	1.29																				
8/19/2021	0.9	1.27																				
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021	0.9	1.26																				
8/24/2021	0.9	1.26																				
Average	0.9	1.26																				

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Dewatered Cake																						
Day	Flow mgd	TS % solids	%VS	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021		11.7	77%																			
8/11/2021		11.9	77.30%																			
8/12/2021		12.1	77.30%																			
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021		12.3	71.20%																			
8/17/2021		15.2	78%																			
8/18/2021																						
8/19/2021		12.7	77.70%																			
8/20/2021		13.3	78.30%																			
8/21/2021																						
8/22/2021																						
8/23/2021		13.2	77.50%																			
8/24/2021		13.40	78.10%																			
Average		12.9	76.93%																			
Count	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10-8/23 avg		12.80	0.768																			

CALCULATED PARAMETERS

Dewatered Cake																						
Day	IS	VS %TS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021	10.9	9.01																				
8/11/2021	11.1	9.20																				
8/12/2021	11.3	9.35																				
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021	11.6	8.76																				
8/17/2021	14.4	11.86																				
8/18/2021																						
8/19/2021	11.9	9.87																				
8/20/2021	12.5	10.41																				
8/21/2021																						
8/22/2021																						
8/23/2021	12.4	10.23																				
8/24/2021	12.6	10.47																				
Average	12.1	9.91																				

Values in *Italics* and magenta are inconsistent.

Daily Testing Worksheet

Start Date = 8/10/2021

MEASURED PARAMETERS

Plant Drain Return																						
Day	Flow mgd	TSS mg/L	VSS mg/L	COD mg/L	sCOD mg/L	ffCOD mg/L	BOD5 mg/L	sBOD5 mg/L	CBOD mg/L	sCBOD mg/L	TKN mg/L	sTKN mg/L	NH3-N mg/L	NO3-N mg/L	NO2-N mg/L	TP mg/L	sTP mg/L	PO4-P mg/L	DO mg/L	Alk mg/L	pH	Temp deg C
8/10/2021							59.5						88.0	1.73				90.20				
8/11/2021		80					45						77.30	1.49				74.7				
8/12/2021																						
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021		260					206						106.00	1.83				82.60				
8/17/2021		1180					364						88.00	1.74				76.10				
8/18/2021																						
8/19/2021		600					> 408.87						123.00	1.91				89.70				
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021		4520					>1253.7						118.00	1.42				71.50				
8/24/2021		340					17						143.00	1.61				83.10				
Average		1163					138.3						106.19	1.68				81.13				
Count	0	6	0	0	0	0	5	0	0	0	0	0	7	7	0	0	0	7	0	0	0	0

389.6

CALCULATED PARAMETERS

Plant Drain Return																						
Day	ISS	VSS / TSS			COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		sBOD / BOD	sCBOD / CBOD	NH3 / TKN		COD / TP	TP / VSS						COD / Alk
8/10/2021																						
8/11/2021																						
8/12/2021																						
8/13/2021																						
8/14/2021																						
8/15/2021																						
8/16/2021																						
8/17/2021																						
8/18/2021																						
8/19/2021																						
8/20/2021																						
8/21/2021																						
8/22/2021																						
8/23/2021																						
8/24/2021																						
Average																						

Values in *Italics* and magenta are inconsistent.

Diurnal Testing Worksheet

Start Date = 8/11/2021

Number of samples requested = 84
Current number of samples taken = 84
Number of sample mismatches = 0

MEASURED PARAMETERS

Raw Influent																			
Date	Time	Flow	TSS	VSS	COD	sCOD	ffCOD	BOD5	sBOD5	TKN	sTKN	NH3-N	NO3-N	TON	TP	PO4-P	DO	Alk	Temp
8/11/2021	12:00	2.11	48	45.3	272					44.9					6.48			217	
8/11/2021	14:00	2.04	40	37.3	336					38.2					6.42			188	
8/11/2021	16:00	1.87	42.7	38.7	330					35.1					4.6			170	
8/11/2021	18:00	2.11	53.3	50.7	322					33.8					4.06			159	
8/11/2021	20:00	2.12	53.3	54.7	296					32.4					3.89			165	
8/11/2021	22:00	1.97	42.7	40	308					36					3.99			163	
8/11/2021	0:00	1.33	40	41.3	288					36.4					3.56			160	
8/12/2021	2:00	0.91	61.3	60	288					35.3					4.08			138	
8/12/2021	4:00	0.99	53.3	53.3	248					34.2					4.27			159	
8/12/2021	6:00	1.38	29.3	32	152					30.6					3.67			158	
8/12/2021	8:00	2.24	38.7	38.7	134					38					4.46			178	
8/12/2021	10:00	2.12	64	60	246					49.8					6.41			223	
Average		1.766	47	46	268					37.1					4.66			173.17	
Count		12	12	12	12	0	0	0	0	12	0	0	0	0	12	0	0	12	0

Check																			
Count	12	12	12	12	12	0	0	0	0	12	0	0	0	0	12	0	0	12	0
Mis-match	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CALCULATED PARAMETERS

Raw Influent																			
Date	Time	ISS	VSS / TSS		COD / BOD5	Prt COD / VSS		COD / TKN	TKN / VSS		NH3 / TKN		COD / TP	TP / VSS					
8/11/2021	12:00	3	0.94					6.06	0.99				41.98	0.143					
8/11/2021	14:00	3	0.93					8.80	1.02				52.34	0.172					
8/11/2021	16:00	4	0.91					9.40	0.91				71.74	0.119					
8/11/2021	18:00	3	0.95					9.53	0.67				79.31	0.080					
8/11/2021	20:00	-1	1.03					9.14	0.59				76.09	0.071					
8/11/2021	22:00	3	0.94					8.56	0.90				77.19	0.100					
8/11/2021	0:00	-1	1.03					7.91	0.88				80.90	0.086					
8/12/2021	2:00	1	0.98					8.16	0.59				70.59	0.068					
8/12/2021	4:00	0	1.00					7.25	0.64				58.08	0.080					
8/12/2021	6:00	-3	1.09					4.97	0.96				41.42	0.115					
8/12/2021	8:00	0	1.00					3.53	0.98				30.04	0.115					
8/12/2021	10:00	4	0.94					4.94	0.83				38.38	0.107					
	0:00	1	0.98					7.35	0.83				59.84	0.105					

Appendix J WWTP Alternatives Workshop Materials

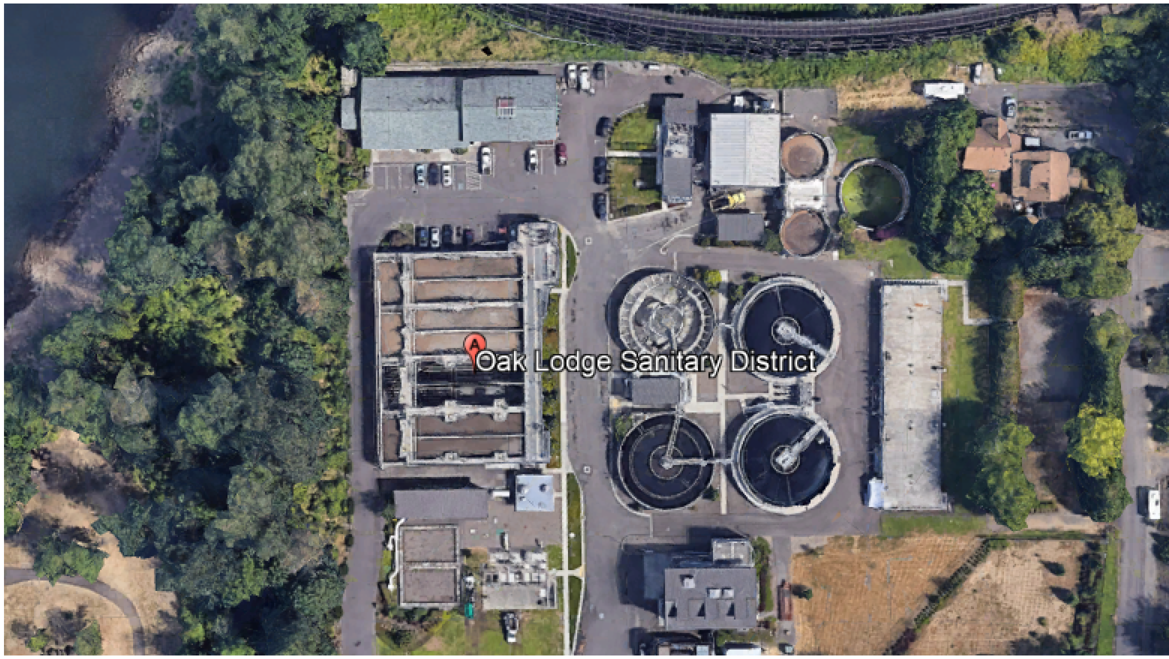
WRF Conceptual Analysis of Alternatives (9/28/22)

WWMP Alternatives Analysis Update (10/26/22)

WWMP Workshop (11/30/22)

J

OAK LODGE
WATER SERVICES



Wastewater Master Plan
Task 6.6 Conceptual Analysis of Alternatives for WRF

September 28, 2022

Agenda

1. Introductions
2. Recap of projected flows and loads and WRF capacity assessment
3. Approach to alternatives development and evaluation for unit processes
4. Conceptual analysis for a range of alternatives for each unit process
5. Next steps

Note: Projects to address O&M considerations will be incorporated into the wastewater master plan but are not the focus of the meeting today.

Recap of projected flows and loads and WRF capacity assessment

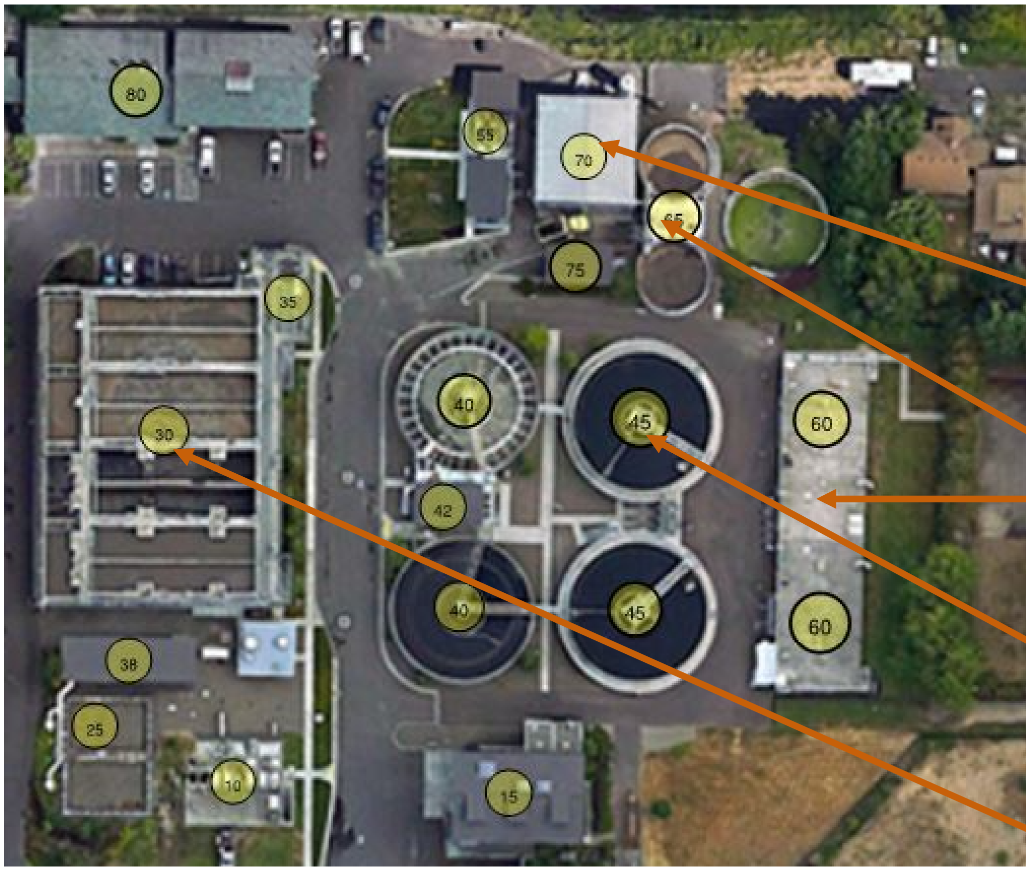
Summary of Projected Flows and Loads

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
	Max month dry weather	5.9	3.0	3.3
	Max month wet weather	10.5	6.3	6.7
	Peak hour	18.0	19.1	19.4
BOD (lb/d)				
	Annual average	6,680	4,960	5,860
	Max month dry weather	7,250	5,400	6,390
	Max month wet weather	7,440	6,300	7,440
TSS (lb/d)				
	Annual average	7,450	4,740	5,610
	Max month dry weather	8,960	5,220	6,170
	Max month wet weather	8,390	6,360	7,510

10 INFLUENT/PLANT DRAIN PUMP STATION
15 HEADWORKS
25 ODOR CONTROL
30 AERATION BASINS
35 MIXED LIQUOR FLOW SPLIT STRUCTURE
38 PROCESS AERATION BLOWERS
40 SECONDARY CLARIFIERS 1& 2
42 RAS / WAS PUMPING AND AEROBIC DIGESTER BLOWERS
45 SECONDARY CLARIFIERS 3 & 4
55 DISINFECTION AND 3W SYSTEMS
60 INTERCHANGE BIOREACTORS
65 AEROBIC DIGESTER FACILITY
70 SOLIDS HANDLING BUILDING
75 ELECTRICAL BUILDING
80 ADMIN BUILDING
Brown and Caldwell

Task 6.3 WRF Capacity Assessment

- Use calibrated process model to characterize current performance
- Perform capacity assessment of each unit process
- Identify capacity limited processes
- Draft WRF capacity assessment TM recently delivered to OLWS



WRF Capacity Constraints

BC0

- Digestion limited – Operate GBT
- Digestion limited – Upgrade digester aeration system
- Clarifier limited – Operate clarifiers at higher return rate
- Aeration limited – Add diffusers, improve DO controls

Slide 7

BC0 Recommend maintaining reference to the numbering as shown on the previous slide
Brown and Caldwell, 2022-09-27T18:33:29.410

AM0 0 Will add numbering from site graphic.
Art Molseed, 2022-09-27T20:42:05.385

Task 6.6 Alternatives Development and Evaluation

—Initial conceptual analysis to identify range of alternatives followed by workshop

—More detailed analysis of up to two conceptual alternatives followed by workshop

—Next steps for tertiary treatment

Evaluation Criteria

Evaluation Criteria

1. Plan for future needs and opportunities (space planning, meet potential future regulatory discharge requirements, etc)
2. Consider operability, maintainability, constructability and reliability
3. Protect the environment including compliance with regulatory requirements for discharge to the Willamette River and minimize energy usage
4. Minimize capital and O&M costs

Evaluation Process

1. Present current system design criteria and compare to future design criteria
2. Identify key assumptions in the analyses for confirmation by OLWS
3. Summarize pros and cons for analyses that include several preliminary alternatives
4. Use numerical scoring system from 1 to 3, see next slide for explanation of scoring rationale.

Slide 11

BC0 Make sure that the basis for this scoring is stated. Who scored? Why is something a 3 vs 2 (are there scoring definitions?)

Brown and Caldwell, 2022-09-27T18:48:01.399

Scoring Rationale

1. Relative ranking of alternatives
2. Alternative that ranks more favorably (e.g., lowest cost, smallest footprint, easier to construct, etc) scores a 3.
3. Alternative that ranks least favorably (e.g., highest cost, largest footprint, most difficult to construct) scores a 1 or 2.
4. Alternatives that have approximately equal ranks have similar scores.
5. Criteria are not weight, but scores can be adjusted if this is desired.

Alternatives Analysis for Preliminary Treatment-Screening Removal and Processing

Existing Screenings Removal and Processing Equipment

INFLUENT MECAHNICAL SCREENS	
UNITS	2
TYPE	MULTI-RAKE BAR SCREEN
SIZE (WIDTH), INCHES	42
CAPACITY/UNIT, MGD	11.75
OPENING SIZE, IN	1/4
MOTOR, EA, HP	1
DRIVE TYPE	CS-R
INFLUENT BYPASS BAR SCREEN	
UNITS	1
TYPE	STATIC
SIZE (WIDTH), INCHES	42
CAPACITY, MGD	11.75
OPENING SIZE, IN	1/2
SCREENING CONVEYANCE	
UNITS	1
TYPE	SLUICE TROUGH
FLOW, GPM	80
SCREENING WASHER/COMPACTOR	
UNITS	2
TYPE	GRINDER/AUGER
CAPACITY, CF/HOUR	150
MOTOR, HP	10 /3
DRIVE TYPE	CS-R/CS-R

Assumptions

1. Alternatives assume continued use of Headworks Building constructed in 2012
2. Existing equipment includes fine (1/4-inch bar spacing) screens that have an estimated remaining useful life of 10 to 15 years but could be replaced sooner, if desired.
3. Existing fine screens still allow rags and other debris to pass through based on bar spacing and gaps around equipment frame
4. Installation of even finer screens (3/16-inch) should trap more rags and debris but may require channel modifications

Proposed Scoring

Screenings Removal and Processing 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

OLWS Scoring Input

Alternatives Analysis for Preliminary Treatment-Grit Removal and Processing

Existing Grit Removal and Processing Equipment

GRIT REMOVAL	
UNITS	2
TYPE	EUTEK HEAD CELL
CAPACITY/UNIT, MGD	11.75
GRIT PUMPS	
UNITS	3 (2 DUTY/1 STAND BY)
TYPE	RECESSED IMPELLER CENTRIFUGAL
MOTOR (EACH), HP	20
DRIVE TYPE	ADJUSTABLE
GRIT WASHING/DEWATERING	
UNITS	1
TYPE	EUTEK SLURRY CUP AND SNAIL
MOTOR (EACH), HP	1/3
DRIVE TYPE	ADJUSTABLE

Assumptions

1. Alternatives assume continued use of Headworks Building constructed in 2012
2. Existing equipment has an estimated remaining useful life of 10 to 15 years but access to Headcell units is difficult due to cover
3. Replacement of vortex system with aerated grit tanks would be costly and there are space limitations
4. Grit washing and dewatering equipment was selected for use with the Cannibal system, so system returns finer solids to liquid stream that can accumulate in the aeration basins

Proposed Scoring

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

OLWS Scoring Input

Proposed Scoring

Grit Processing Equipment Alternatives

Criteria	Keep Existing Eutek Slurry Cup and Snail	Replace with Alternative Washing and Dewatering System
Planning for future		
• Footprint and future expansion	3	3
• Potential regulatory changes	3	3
O&M considerations		
• Operability	2	3
• Maintainability	3	3
• Constructability	3	2
• Reliability	3	1
Environmental	3	3
Cost and rate impacts		
• Construction	3	2
• O&M	3	2
TOTAL	26	22

OLWS Scoring Input

Alternatives Analysis for Secondary Treatment

Existing Secondary Treatment Equipment

AERATION BASINS	
UNITS	4
VOLUME, EA, GAL	571,000
ANOXIC ZONE MIXERS	
UNITS	12 (6 IN EACH OF BASINS 1 AND 2)
TYPE	VERTICAL TURBINE
MOTOR, HP	1.5
AERATION DIFFUSERS	
TYPE	FINE BUBBLE (9" DISC)
NUMBER OF UNITS	296 (BASIN 1), 1145 (BASIN 2), 1145 (BASIN 3), 810 (BASIN 4)
MIXED LIQUOR RECYCLE PUMPS	
UNITS	3
TYPE	VERTICAL TURBINE, AXIAL FLOW
CAPACITY, EA, GPM	4400
MOTOR, HP	30

AERATION BLOWERS	
UNITS	3 (NOT INCLUDING BLOWER FOR DIGESTERS 1 AND 2)
HIGH SPEED TURBO	
UNITS	2
CAPACITY, EA, SCFM @ PSIG	1,824 @ 9.7
HYBRID SCREW	
UNITs	1
CAPACITY, EA, SCFM	1,800
MOTOR, HP	100

SECONDARY CLARIFIERS	
UNITS	4
DIAMETER, FT	70
SIDEWATER DEPTH, FT	18
RAS PUMPS (CLARIFIER 1 AND 2)	
UNITS	4
TYPE	NON-CLOG CENTRIFUGAL
CAPACITY, EA, GPM @ FT	700 @ 36
MOTOR, HP	10
RAS PUMPS (CLARIFIER 3 AND 4)	
UNITS	3
TYPE	NON-CLOG SUBMERSIBLE
CAPACITY, EA, GPM @ FT	1400 @ 12
MOTOR, HP	7.5

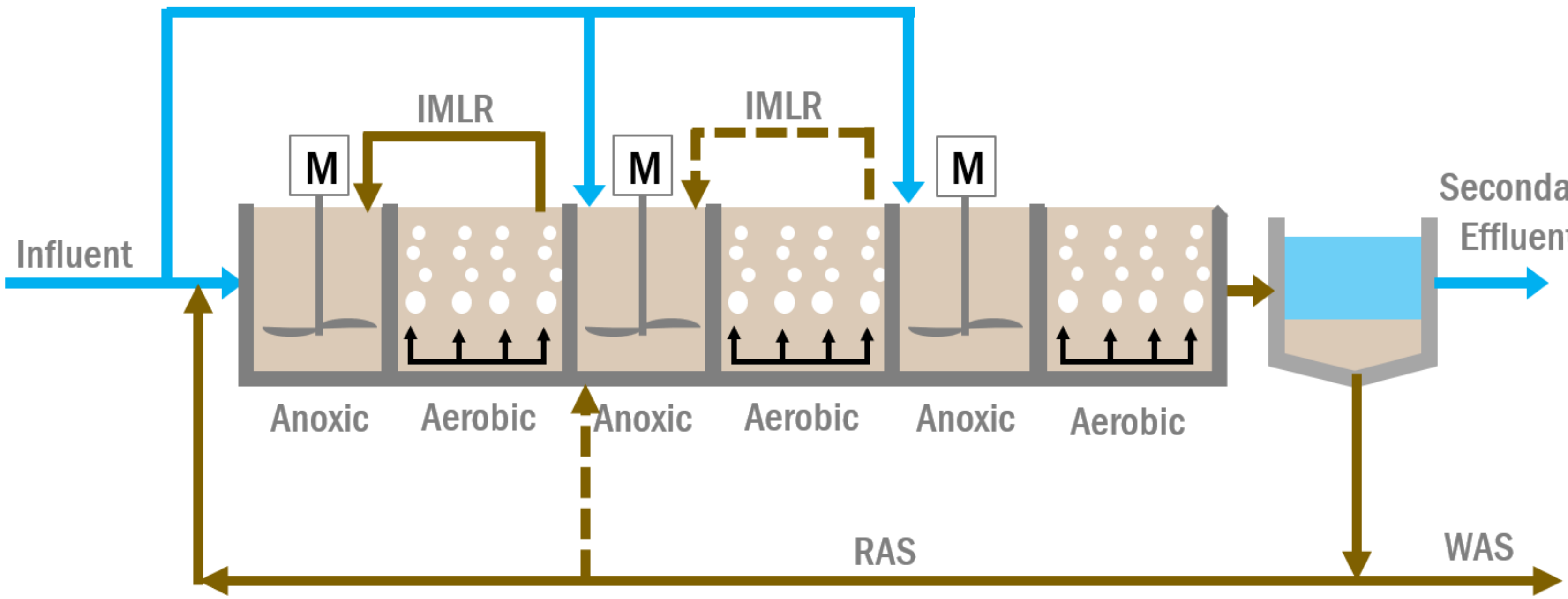
Assumptions

1. Alternatives assume continued use of aeration basins
2. Current NPDES permit discharge limits will continue to apply in future (but with possible future ammonia and phosphorus limits)

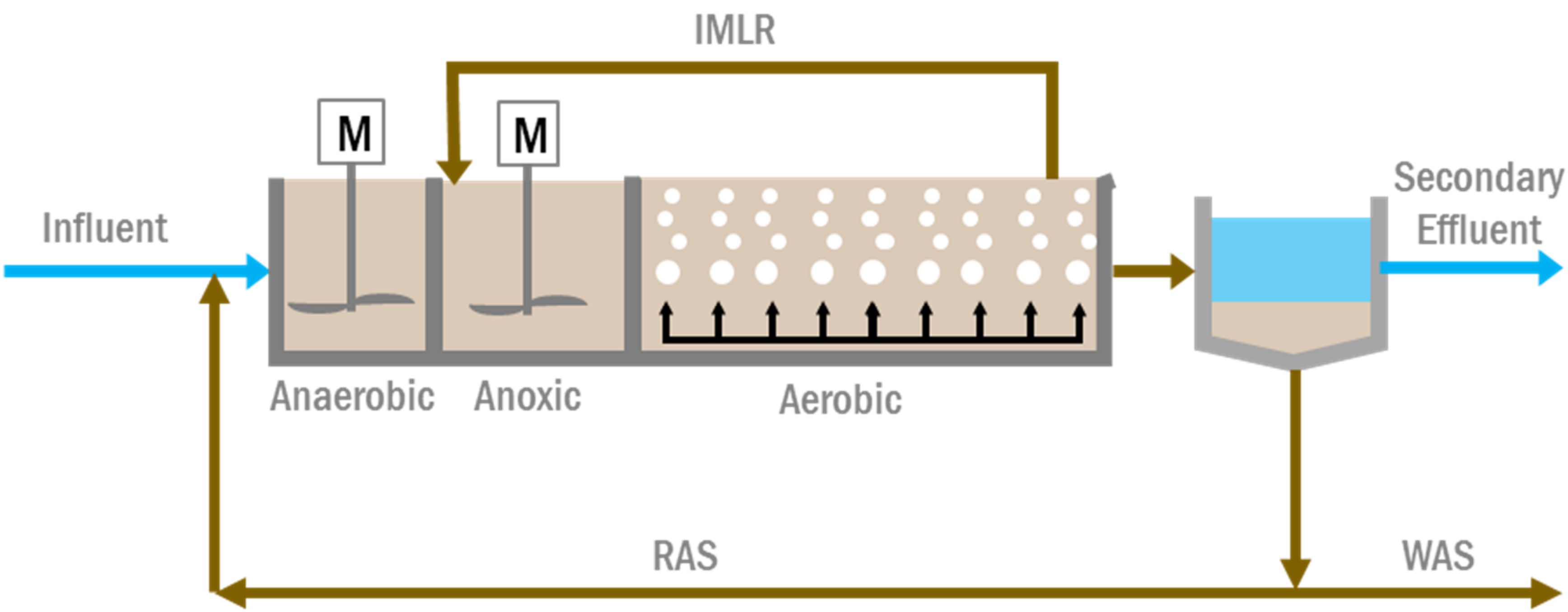
Range of Alternatives – Secondary Treatment

- 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)

Anoxic Step-Feed



A2O

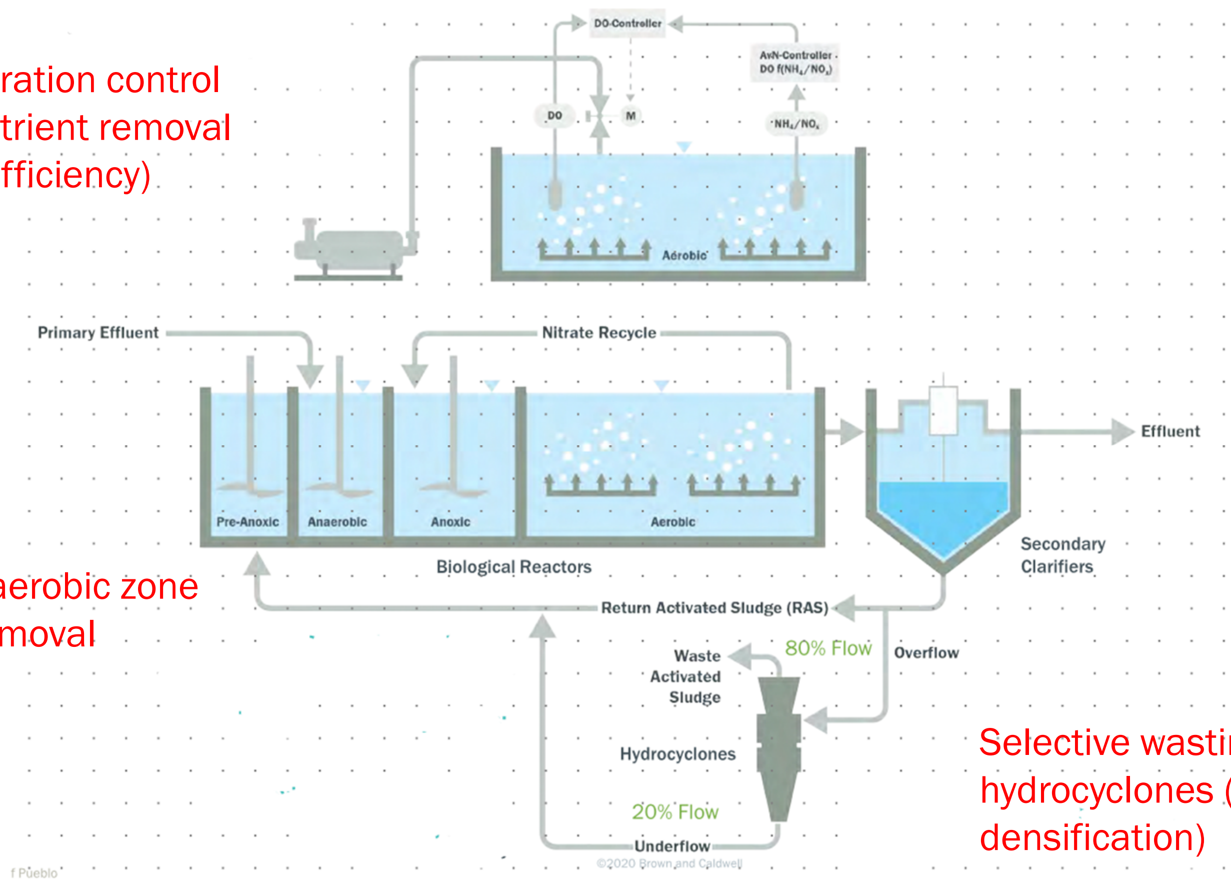

IMLR
M
M
Influent
Secondary
Effluent
Anaerobic
Anoxic
Aerobic
RAS
WAS

SND (may be used with hydrocylones as Ntensify™)

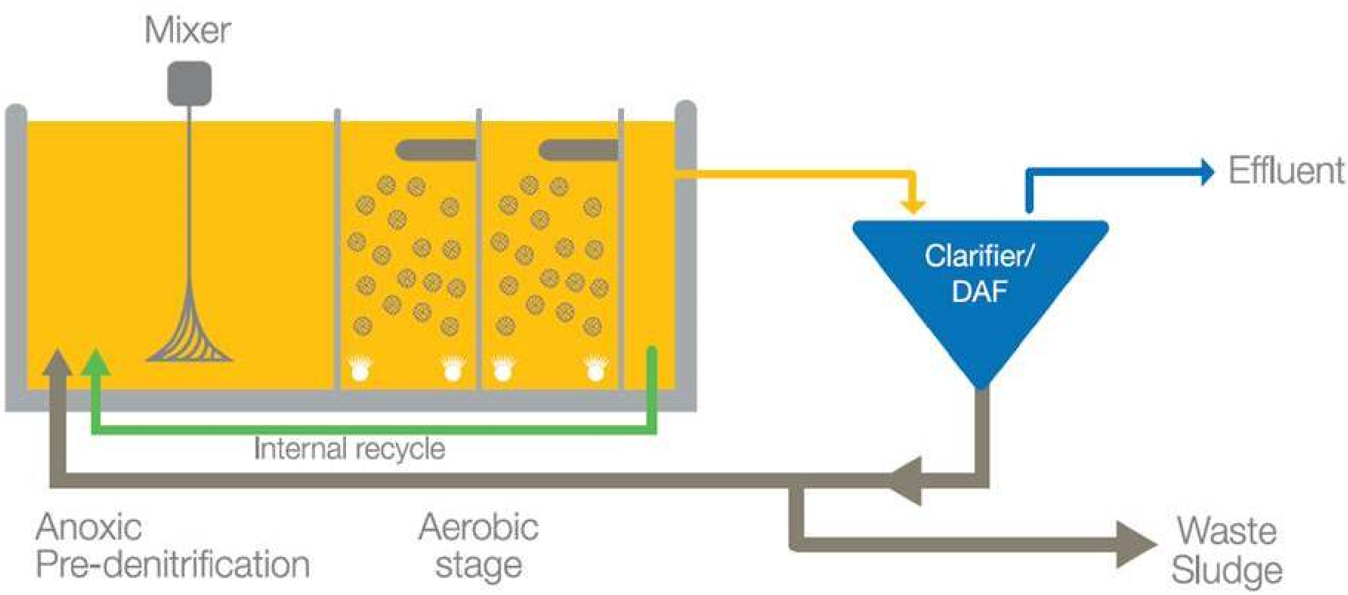
Advanced aeration control (improves nutrient removal and energy efficiency)

Include anaerobic zone for Bio-P removal

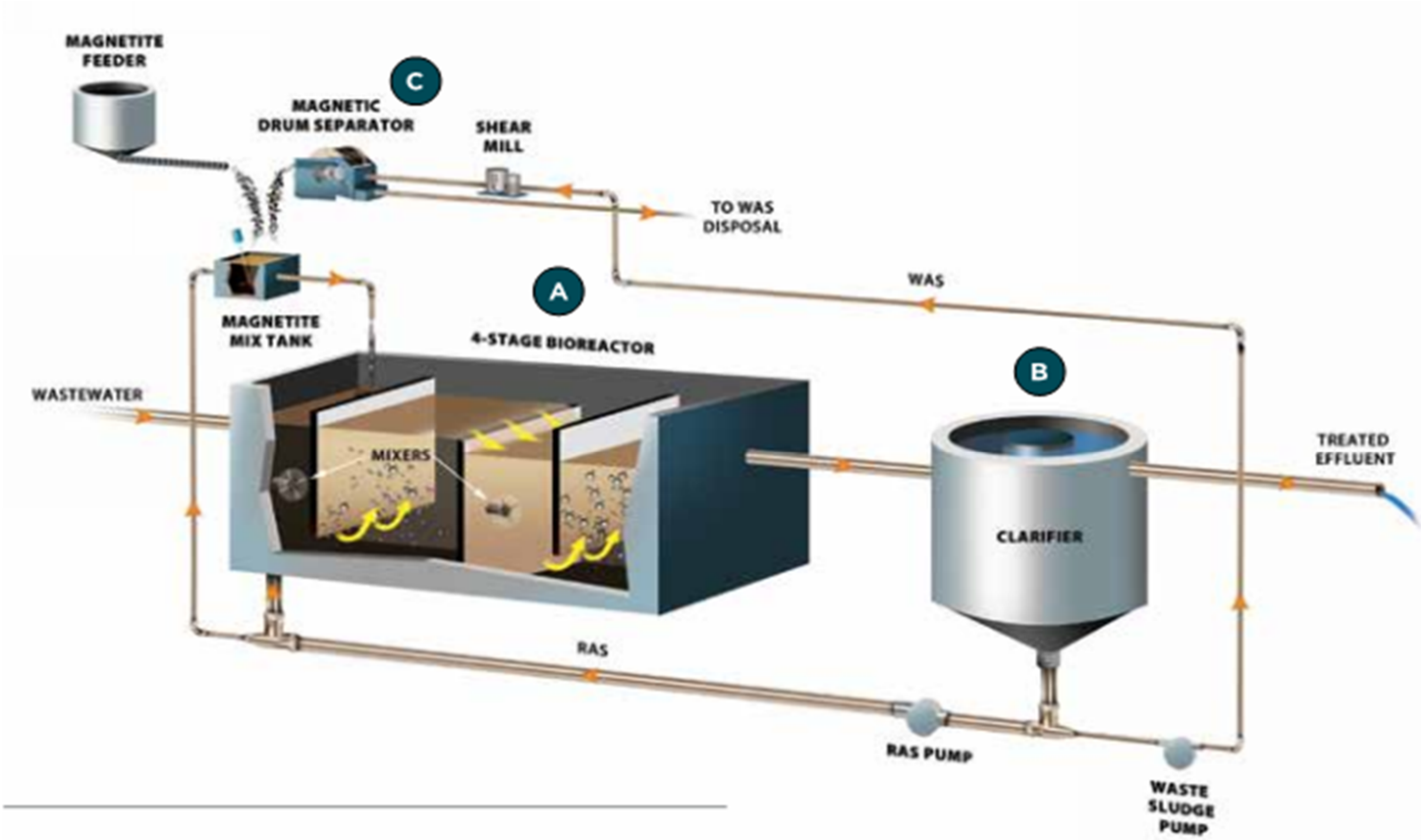
Selective wasting using hydrocyclones (promotes densification)



IFAS

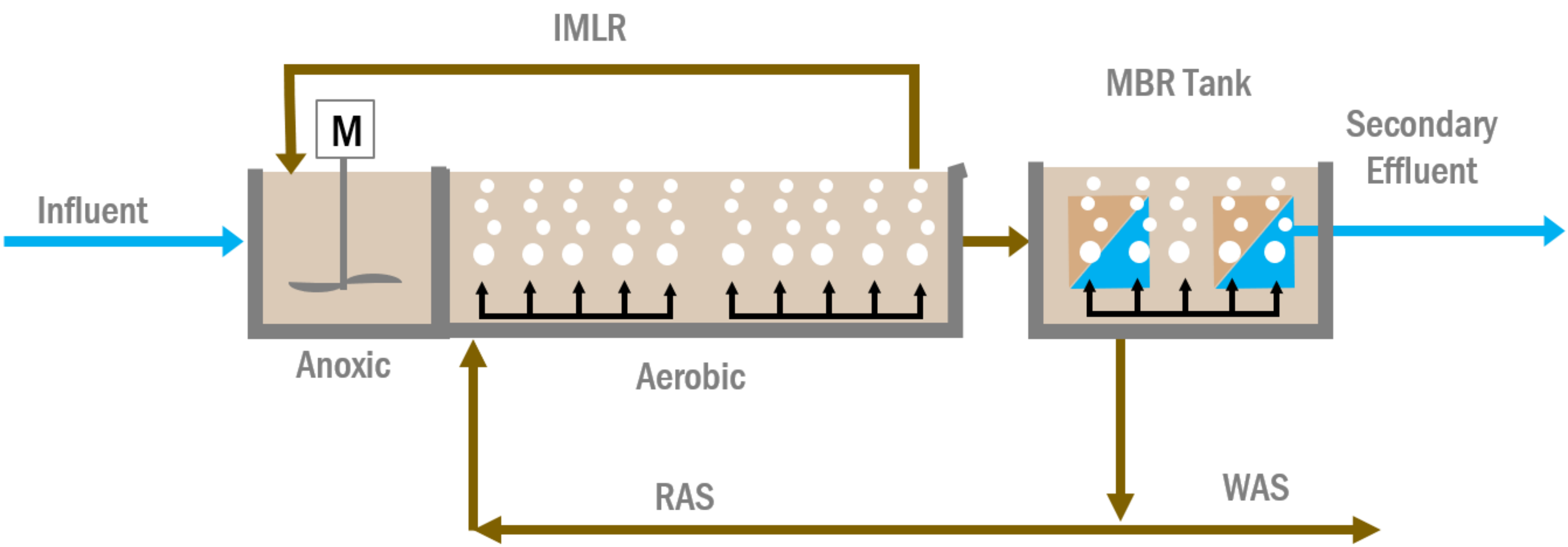

Mixer
Effluent
Clarifier/
DAF
Internal recycle
Anoxic
Pre-denitrification
Aerobic
stage
Waste
Sludge

Ballasted Sedimentation (BioMag)



THE BIOMAG™ SYSTEM AS PART OF A TRADITIONAL SECONDARY TREATMENT CONFIGURATION

MBR


IMLR
M
MBR Tank
Secondary
Effluent
Influent
Anoxic
Aerobic
RAS
WAS

Secondary Treatment Alternatives – Pros & Cons

Alternatives	Pros	Cons
MLE (existing process)	• Operator familiarity • Low cost for upgrade (new diffusers)	• Limited denitrification capability • Require chemical addition for P removal
Anoxic step-feed	• Reduce aeration requirements by increasing denitrification capability	• Current configuration limited to 2-point step-feed; limited flow split control • Requires chemical addition for P removal
A2O	• Provides both N and P removal	• Require changes in IMLR piping • Likely require more basins in service
SND	• Reduce aeration requirements by increasing denitrification capability • Can include anaerobic zone for Bio-P removal • Increase clarifier capacity (if hydrocyclones included)	• Require more instrumentation/ controls • If include anaerobic zone, likely require more basins in service
IFAS	• Increase treatment capacity and nitrification capability	• Require proprietary media/new diffusers • High risk for filamentous bulking
Ballasted sedimentation (BioMag)	• Increase treatment capacity and nitrification capability • Increase clarifier capacity	• Require magnetite addition (for initial installation and continued replenishment) • Require additional screening and equipment for magnetite recovery
MBR	• Increase treatment capacity and nitrification capability • Eliminate need for tertiary filters	• High cost for upgrade • High operating costs

Proposed Scoring

GU1

Secondary Treatment Alternatives - Screening BC2

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

Slide 40

GU0 What does Environmental category entail? Is that energy use?
Guest User, 2022-09-26T15:48:56.508

GU1 Also feels like the MLE is worst on potential regulatory changes but those may be well beyond the horizon of our work (who knows?) so that category may not carry as much weight. I would just discuss that (it doesn't need to be on the slide) but I think the conclusion still makes sense that these 3 alts should be carried forward.
Guest User, 2022-09-26T15:50:28.292

BC2 So - these are the screening options requiring a more robust alternatives analysis, or are we going to cost alternatives and integrate one into the CIP?
Brown and Caldwell, 2022-09-27T18:50:11.230

OLWS Scoring Input

Alternatives Analysis for Tertiary Treatment

Background

Tertiary filtration has added benefits for future phosphorus removal and mitigation of settling challenges.

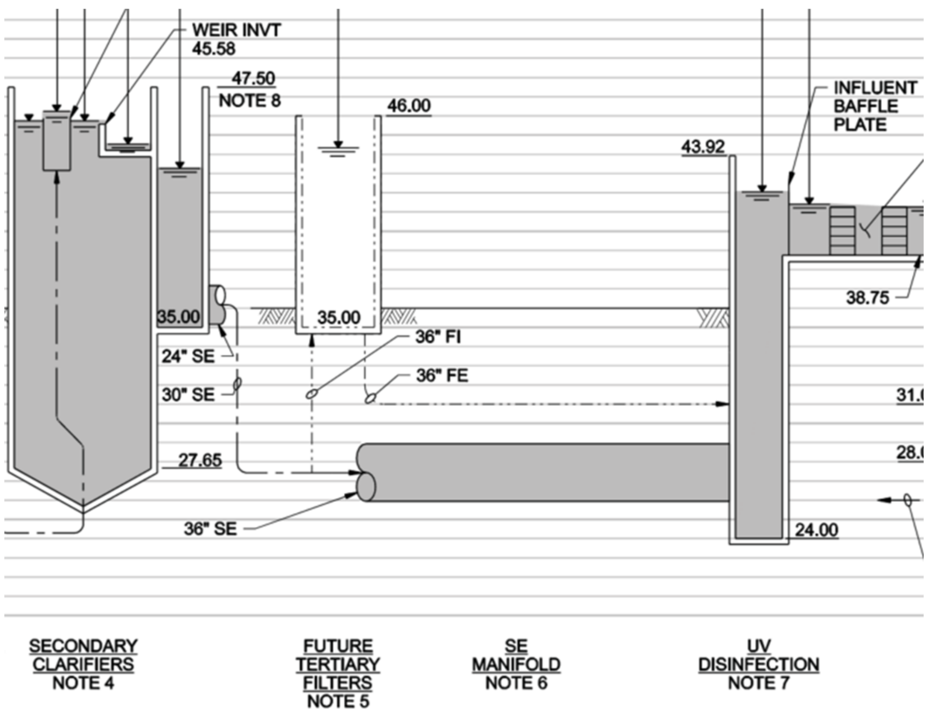
1. Tertiary filtration anticipated to be needed in future when last master plan was prepared– space allocated onsite with piping connections
2. 2022 NPDES permit includes seasonal TSS limits that will require filtration for compliance (exceedance has already occurred)

Table A1: Combined Outfalls 001 and 001A Permit Limits

Parameter	Units	Average Monthly (See note a.)	Average Weekly (See note a.)	Daily Maximum (See note a.)
$CBOD_5$ (May 1 – October 31)	mg/L	10	15	-
	lb/day	490	740	980
	% removal	85	-	-
TSS (May 1 – October 31)	mg/L	10	15	-
	lb/day	490	740	980
	% removal	85	-	-
BOD_5 (November 1 – April 30)	mg/L	30	45	-
	lb/day	2600	3900	5200
	% removal	85	-	-
TSS (November 1 – April 30)	mg/L	30	45	-
	lb/day	2600	3900	5200
	% removal	85	-	-

Limited Space and Hydraulic Profile Available

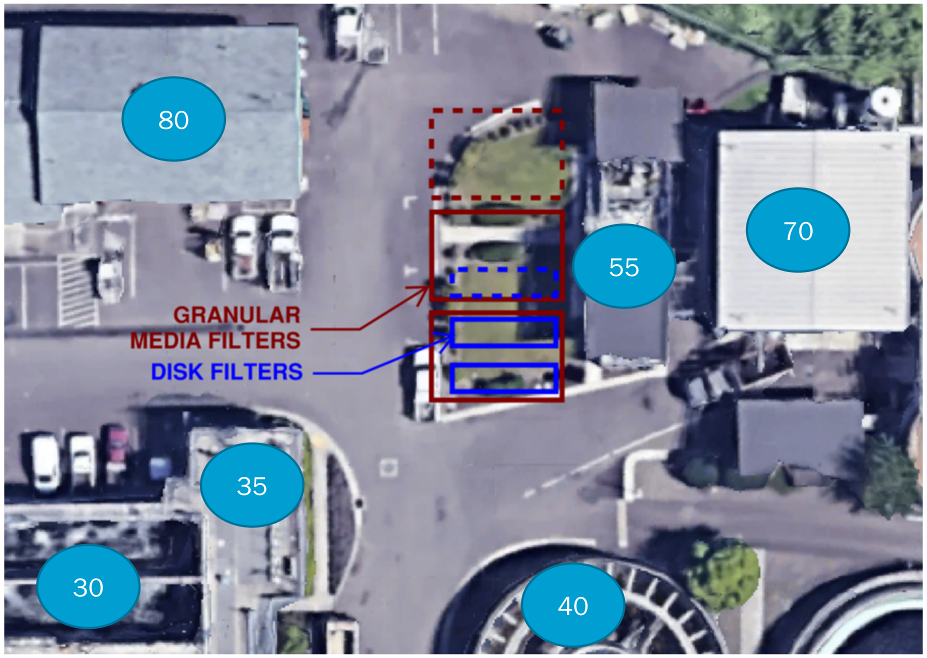
From Phase 1B Record Drawings dated November 2010:



5. ASSUMES FUTURE CLOTH MEDIA FILTERS WITH APPROXIMATELY 2 FEET OF HEADLOSS. GRANULAR FILTERS (WITH APPROXIMATELY 7-10 FEET OF HEADLOSS) WOULD REQUIRE INTERMEDIATE PUMPING. FILTER EFFLUENT FLOWS THROUGH UV DISINFECTION. MAXIMUM FUTURE FILTER CAPACITY ASSUMED TO BE 8.6 MGD.

From OLWS June 2022 Online Community Conversation

Comparison of Site Footprint – Disk Filters and Granular Media Filters



Alternatives may be limited based on available space. Could defer third train (shown as dashed line) depending on design flows decided upon for tertiary filtration.

Industry standard sizing criteria:

- Design peak hourly flow (19.4 mgd for OLWS)
- 5 gpm / SF of filter area

Requires three trains as shown at left

Other design criteria:

- Additional storage for 3W (non-potable water) system
- Maintain parking if possible – limited available onsite

Will it fit? – Tertiary Filtration Alternatives

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

Proposed Scoring

Tertiary Treatment Alternatives - Screening

Criteria	Disk Filters	Granular Media Filters Downflow	Granular Media Filters Upflow	Membrane Filters	Iron-coated sand filter (BluePro®)	Ballasted / chemical clarifiers	Compress-ible media filters
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

OLWS Scoring Input

Potential Approaches – Tertiary Filtration Alternatives Evaluation

Approach No.	Description	Summary
1	Evaluate Disk filters only	• Solicit quotes from 3-4 manufacturers • Compare layouts, anticipated O&M costs, anticipated capital costs • Select basis for design configuration (flows **outside-in** or **inside-out**)
2	Evaluate Disk filters and Granular Media Filters (with intermediate pumping)	• Solicit quotes from one manufacturer of each • Compare layouts, anticipated O&M costs, anticipated capital costs • Select disk filters or upflow filters as basis for design. Additional evaluation needed for preliminary design to confirm disk filter configuration (outside-in or inside-out)

Alternatives Analysis for Disinfection

Existing UV Disinfection Equipment

ULTRAVIOLET DISINFECTION	
TYPE	LOW PRESSURE, HIGH INTENSITY
NUMBER OF CHANNELS	2
CAPACITY, MGD	22
CHANNEL WIDTH (EACH), INCHES	28
NUMBER OF LAMPS	224
NUMBER OF BANKS	4
NUMBER OF LAMPS/BANKS	56
POWER (EACH CHANNEL), KW	28
UV DOSAGE	35,000 mW-s/cm^2
UV TRANSMITTANCE	65%

Assumptions

1. Alternatives assume continued use of UV Disinfection Building constructed in 2012
2. Existing equipment has an estimated remaining useful life of 10 to 15 years
3. There are issues with upstream and downstream gate actuators, flow distribution between channels, and bulb retrieval

Proposed Scoring

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

OLWS Scoring Input

Solids End Use Considerations

Existing Biosolids Management

LAND APPLICATION OF CLASS B BIOSOLIDS	
PROCESS TO SIGNIFICANTLY REDUCE PATHOGENS (PSRP)	HRT OF 40 DAYS AT 20 DEG. C BASED UPON CURRENT OPERATION
VOLATILE SOLIDS REDUCTION (VSR)	AT LEAST 38%
STORAGE	STORED ONSITE IN A COVERED SHED (HAS TO BE MOVED)
HAULING	CONTRACT HAULER PICKS UP 2-3 TIMES PER WEEK
DISPOSAL	LAND APPLICATION AT BENEFICIAL REUSE SITE

Assumptions

1. Alternatives assume aerobic digestion will be continued and operated such that the minimum requirements for producing Class B biosolids can be met
2. Air drying beds are not being considered due to land required, proximity to neighbors and odor concerns, and limited months available to air-dry

Biosolids End Use Alternatives – Pros & Cons

Alternatives	Advantages	Disadvantages
Continue to produce/store Class B biosolids in onsite storage shed with contract hauling to beneficial reuse land application sites	• Operator familiarity • No upgrade costs	• High O&M costs to move biosolids from Solids Bldg. to storage shed • Potential for odors, especially during warmer months • Potential interruption to hauling due to inclement weather/road closures
New drive under storage hopper with contract hauling of Class B biosolids to beneficial reuse land application sites	• Less maintenance for operators • Decreased potential for odors due to covered storage hopper	• High cost for new Solids Bldg. and storage hopper • Potential interruption to hauling due to inclement weather/road closures
Thermal drying solids to produce Class A biosolids	• Reduced hauling with higher cake solids percent • Possible revenue selling bulk or bagged solids to customers • No restrictions for land application, could possibly land apply more locally	• High cost and energy usage for thermal dryer • High O&M costs to operate dryer • Rigorous testing requirements

Proposed Scoring

Biosolids Alternatives

Criteria	Continue to produce/store Class B biosolids in onsite storage shed with contract hauling to land application	New drive under storage hopper with contract hauling of Class B biosolids to land application	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

OLWS Scoring Input

Alternatives Analysis for Solids Thickening

Existing Solids Thickening Equipment

Thickening	
Parameter	Value
GBT	
Units	1
Type	GBT
Width (meter)	2.2
TWAS Pumps	
Units	2
Type	Rotary lobe
Capacity (each), gpm @ psi TDH	160 @ 25
Power (each), hp	7.5
Drive type	Constant speed

Assumptions

1. Although GBT is over 20 years old, it hasn't been operated since 2012, so assume it has an estimated remaining useful life of 7.5 to 15 years
2. Dissolved Air Flotation (DAF) was utilized previously at the facility with limited success and is not being considered further

Proposed Scoring

Thickening Alternatives

Criteria	GBTs	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

OLWS Scoring Input

Alternatives Analysis for Solids Stabilization

Existing Aerobic Digesters

Aerobic Digesters 1 and 2	
Parameter	Value
Units	2
Interior length x width (each), ft	40 X 80
Sidewater depth, ft	18
Number of diffusers (each)	120
Mixers, number (each)	2
Mixers, type	Vertical turbine
Mixer power (each), hp	1
Floating decanter, number (each)	1

Aerobic Digesters 3 and 4	
Parameter	Value
Units	2
Diameter (each), ft	35
Sidewater depth, ft	1 @ 25.8, 1 @ 26.3
Volume (each), gallons	1 @ 185,400, 1 @ 189,000

Assumptions

1. Will continue to operate with aerobic digestion
2. Waste activated sludge is thickened to 2% maximum to maintain hydraulic residence time in the digesters
3. Increased aeration capacity will likely be necessary and included with all options

Proposed Scoring

Digestion Alternatives

Criteria	Replace Digesters 3 and 4 in current location and refurbish Digesters 1 and 2 and make necessary aeration and pump improvements	Construct two new digesters east of Digesters 1 and 2 and utilize Digester 3 and 4 area for new SHB	Replace Digesters 3 and 4 to the east and refurbish Digesters 1 and 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

OLWS Scoring Input

Alternatives Analysis for Solids Dewatering

Existing Solids Dewatering Equipment

Table 38. Dewatering	
Parameter	Value
BFP1	
Units	1
Width (meter)	2.0
Cake solids, percent dry weight	15
Solids capture, percent	90
BFP2	
Units	1
Width (meter)	1.5
Cake solids, percent dry weight	15
Solids capture, percent	90

Assumptions

1. Existing BFP1 was partially rebuilt in 2021 and is in good condition with an estimated remaining useful life of 10 to 15 years
2. BFP2, which was recently installed for redundancy, was refurbished and has a remaining useful life of 5 to 10 years and can be installed if needed until new facilities are constructed

Proposed Scoring

Dewatering Alternatives

Criteria	Replace BFP in kind and add 2nd unit for redundancy	Replace BFP with two centrifuge units	Replace BFP with two screw press units
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

OLWS Scoring Input

Open Discussion

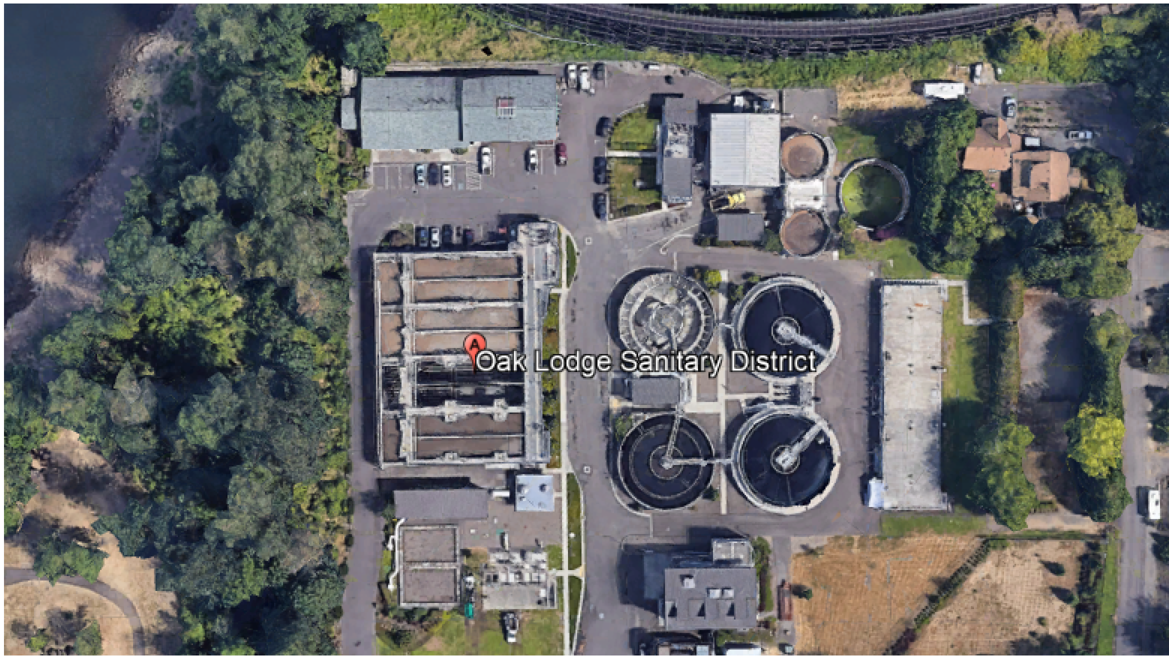
What comes next?

Next Steps

1. Week of Oct 3 or 17: Follow-up on solids stream alternatives
2. October 26 meeting: Present more detailed information and costs for
   A. Secondary treatment alternatives
   B. Recommended tertiary treatment alternative

Thank you!

OAK LODGE
WATER SERVICES



Wastewater Master Plan
Wastewater Treatment Plant
Alternatives Analysis Update

October 26, 2022

Agenda

1. Tertiary Treatment Alternatives Analysis
2. Solids Handling Alternatives Development
3. Secondary Treatment Alternatives Development
4. Next steps

Alternatives Analysis for Tertiary Treatment

Objectives

1. Review tertiary filter design criteria and equipment options
2. Discuss conceptual layout and associated costs
3. Determine next steps

PTO

Evaluation and Design Criteria

Criteria	Description
WWTP (2052) flows	• 3 parallel filtration units to handle **peak hour flow** (no standby) o Annual average flow of 3.5 mgd (1 train in service) o Max month flow of 6.7 mgd (1 train in service) o Peak hour flow of 19.4 mgd (3 trains in service)
Filter hydraulic loading	• 5 gpm[1] per SF of **submerged** filter area
Water quality	• Secondary effluent TSS = 35 mg/L • Tertiary filter effluent TSS < 5 mg/L
Ancillary equipment provided by manufacturer	• Dedicated local control panels with ability to monitor equipment status via SCADA • Backwash pumps
Other Considerations	• Additional storage for 3W (non-potable water) system • Maintain parking if possible • Potential chemical addition to meet future phosphorous limits (chemicals can be added at both secondary and tertiary treatment)

Notes

[1] *Hydraulic loading should be 5 gpm/SF or less of submerged filter area to meet industry guideline for filter efficacy*

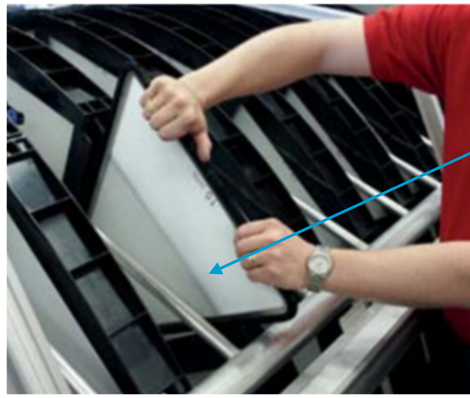
Slide 5

PT0 Other considerations may also include potential chemical addition to meet future P limit (chemicals may be added at both secondary and tertiary treatment.)
Patricia Tam, 2022-10-24T05:37:12.843

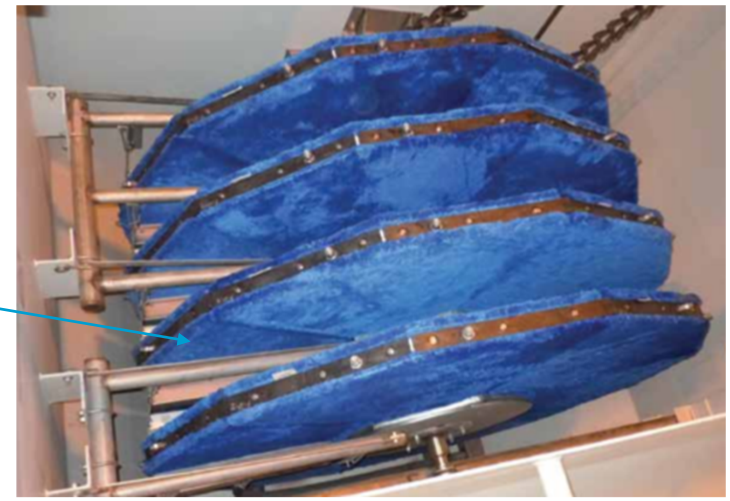
AM0 0 @Patricia Tam added
Art Molseed, 2022-10-25T23:23:15.311

Alternatives

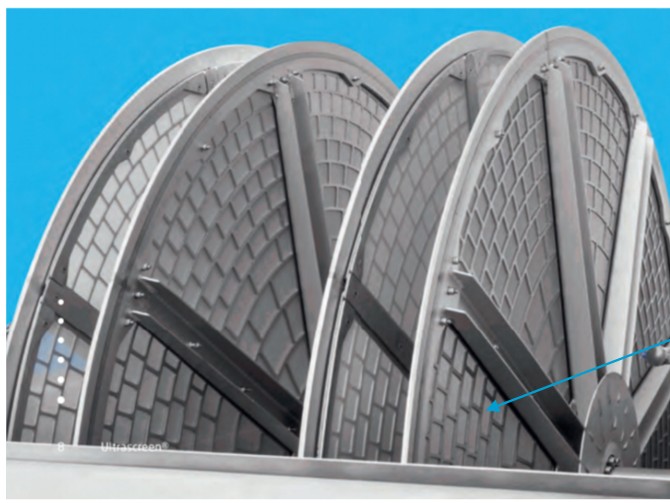
- Veolia – woven fabric media
- Aqua Aerobic – cloth media
- Nuove Energie – SST mesh media



Woven fabric media



Cloth media

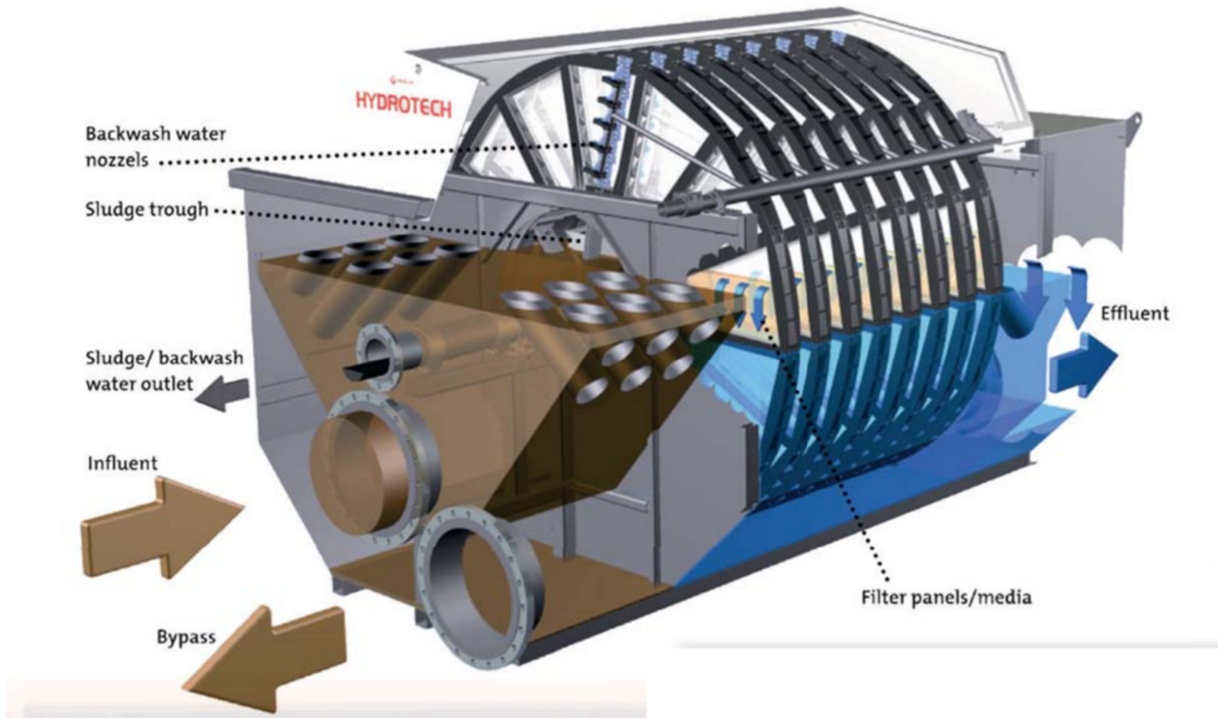


Stainless steel mesh media

Veolia

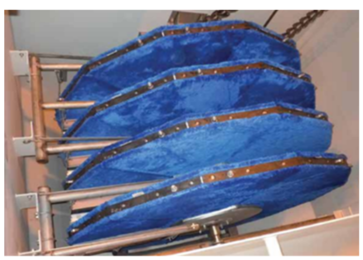
Equipment Cost	$1,423,000
Pore Size	10 micron
HLR at ADF/PHF (gpm/sf)	2.56/4.73
Total No. of Disks	66
Submerged Filter Area	2,847
Max Headloss (ft)	2.18
Tank Material	304 SST
Height (ft)	8.2
Wet Weight (lbs) per Unit	40,785
Drive Motor HP	1.5
Backwash pump HP	20
Power Consumption (kWh/d)	134
Backwash Flow (% of INF)	1.6%

1. Meets all design criteria, including filter HLR
2. Middle equipment cost
3. Highest power consumption

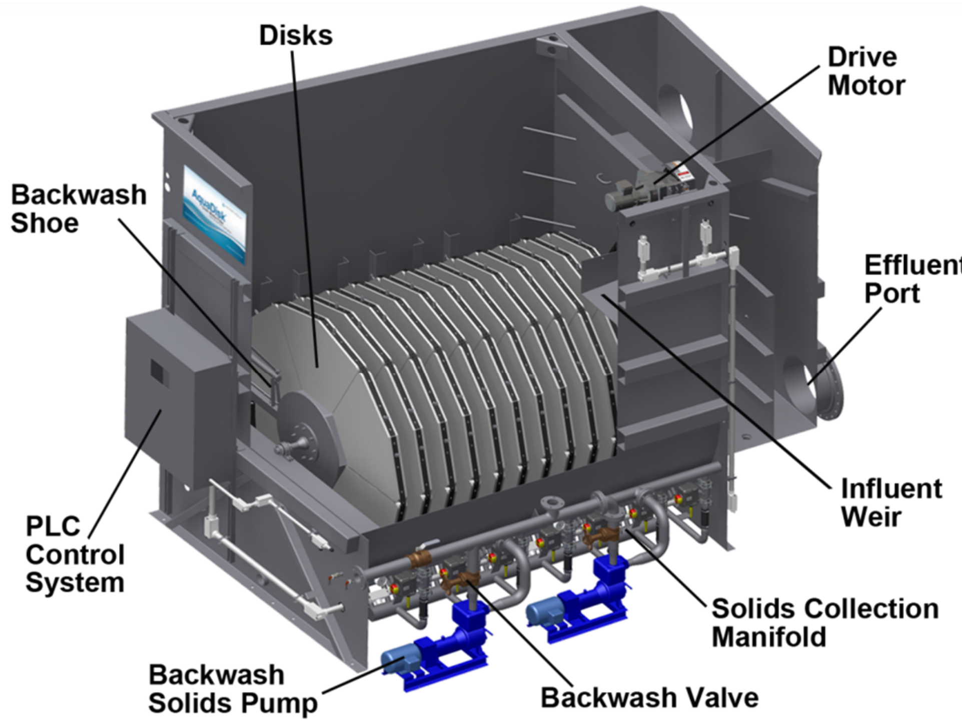


Aqua Aerobic

Equipment Cost	$1,569,720
Pore Size	10 micron
HLR at ADF/PHF (gpm/sf)	3.23/5.96
Total No. of Disks	42
Submerged Filter Area	2,260
Max Headloss (ft)	3.06
Tank Material	Painted Steel
Height (ft)	12
Wet Weight (lbs) per Unit	75,000
Drive Motor HP	2
Backwash pump HP	2
Power Consumption (kWh/d)	114
Backwash Flow (% of INF)	1-3%



1. Slightly above HLR criterion at peak flows
2. Highest equipment cost
3. Middle power consumption

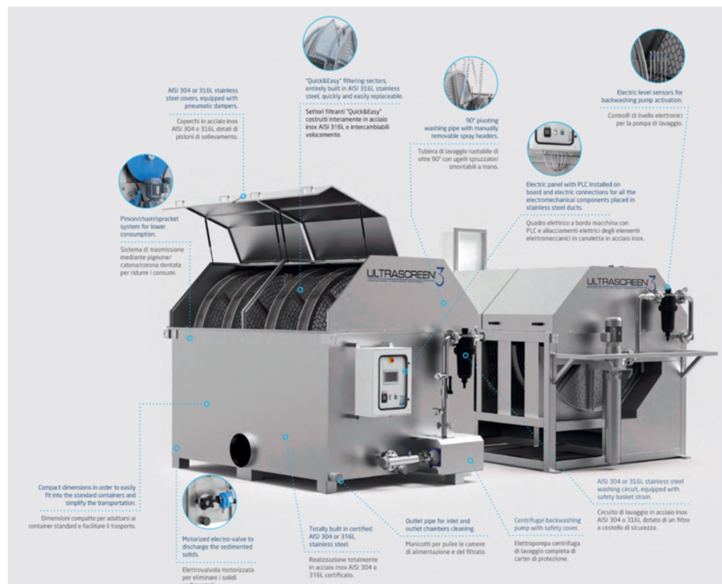


PT1

Nuove Energie

Equipment Cost	$1,132,401	KP0
Pore Size	20 micron	
HLR at ADF/PHF (gpm/sf)	**5.5/10.2**	
Total Filter Area (sf)	1324	
Submerged Filter Area (sf)	1321	
Max Headloss (ft)	2.20	
Tank Material	304 SST	
Height (ft)	7.6	
Wet Weight (lbs) per Unit	45,100	
Drive Motor HP	3	
Backwash pump HP	15	
Power Consumption (kWh/d)	69	
Backwash Flow (% of INF)	1.5%	

1. Does not meet HLR design criteria, furthest off
   - More conservative offering meets criterion but does not fit in available footprint.
   - Manufacturer’s statement that they’re an ultrascreen rather than a disk filter
2. Lowest equipment cost
3. Lowest power consumption



Slide 9

KP0 Is number of discs still unkown?

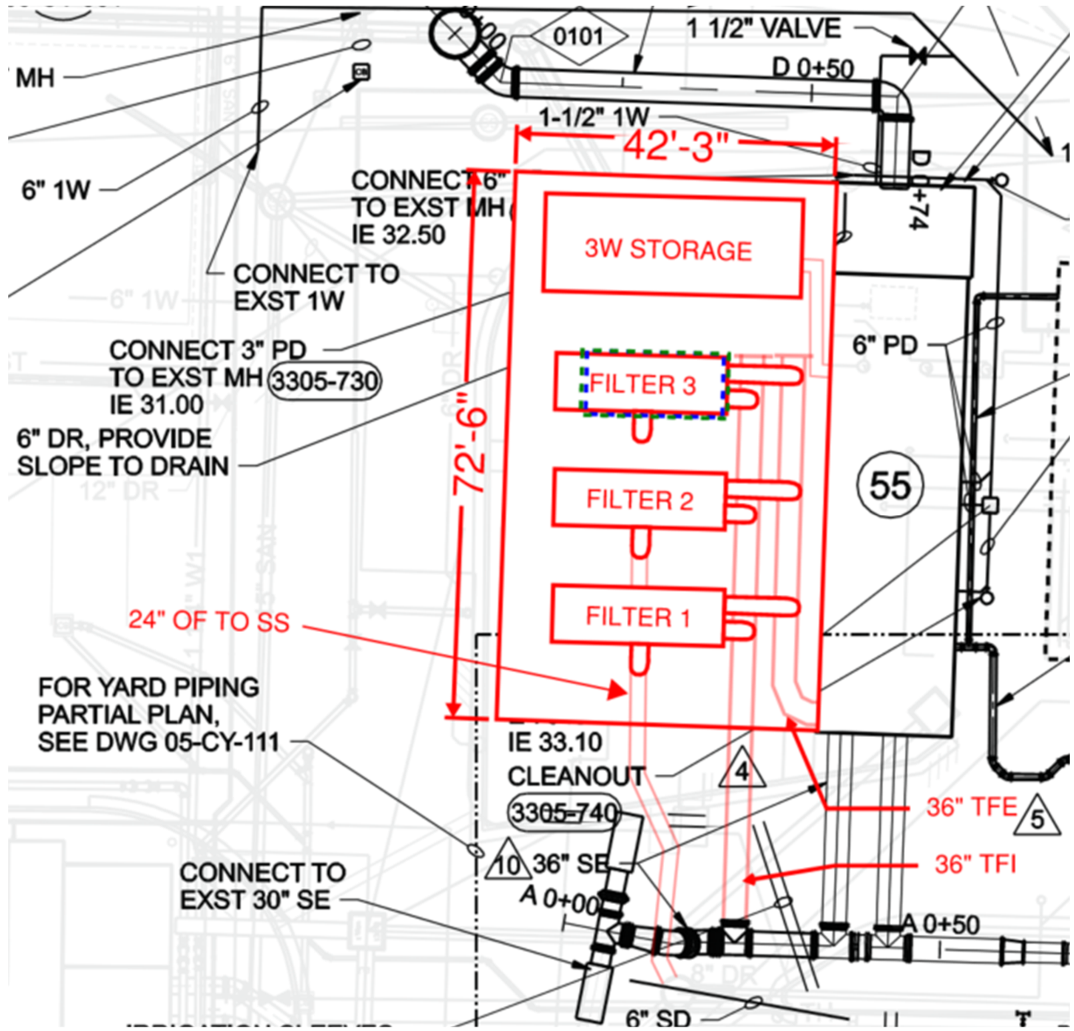
Katie Pollock, 2022-10-20T23:58:04.064

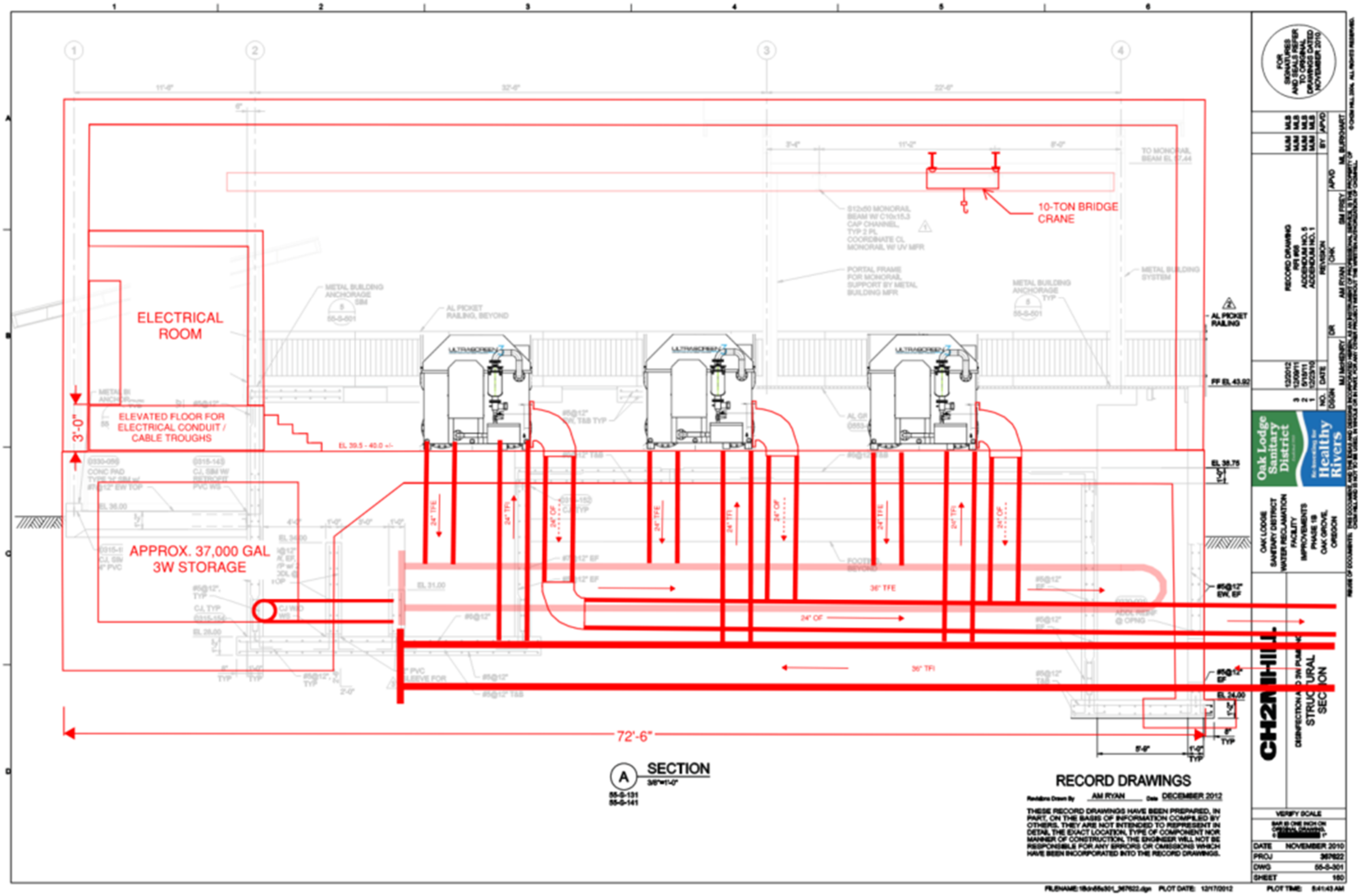
PT1 Do they have very many existing installations (for municipal WW)? I haven't heard of this company. Also, an an ultrascreen, can they meet the effluent quality requirement? What about potential future P limit (if chemical is added for P removal, possibly at both the secondary clarifier and tertiary filters)?

Patricia Tam, 2022-10-24T05:32:25.261

Footprint Comparison

- Similar footprint sizes
  - Veolia
  - Aqua Aerobic
  - Nuove Energie (largest) used as basis for conceptual layout – still fits




10-TON BRIDGE CRANE
ELECTRICAL ROOM
ELEVATED FLOOR FOR ELECTRICAL CONDUIT / CABLE TROUGHS
3'-0"
APPROX. 37,000 GAL 3W STORAGE
72'-6"
SECTION
RECORD DRAWINGS
Oak Lodge Sanitary District
Healthy Rivers
CH2MHILL

Cost Estimate

Opinion of Probable Construction Costs

Phase	Description	Gross Total Cost with Markups
01 TOTAL ESTIMATE		
01 Tertiary Filtration, 2 filters with room for 1 future		
01 Site Work		450,584
02 Structural / Architectural		2,009,851
03 Mechanical		2,477,091
04 Site Piping		1,460,837
05 Electrical and Instrumentation Allowance		2,196,407
	01 Tertiary Filtration, 2 filters with room for 1 future	8,594,769
02 Tertiary Filtration, add 3rd (future) filter		
03 Mechanical		1,228,929
05 Electrical and Instrumentation Allowance		405,933
	02 Tertiary Filtration, add 3rd (future) filter	1,634,861
	01 TOTAL ESTIMATE	10,229,630

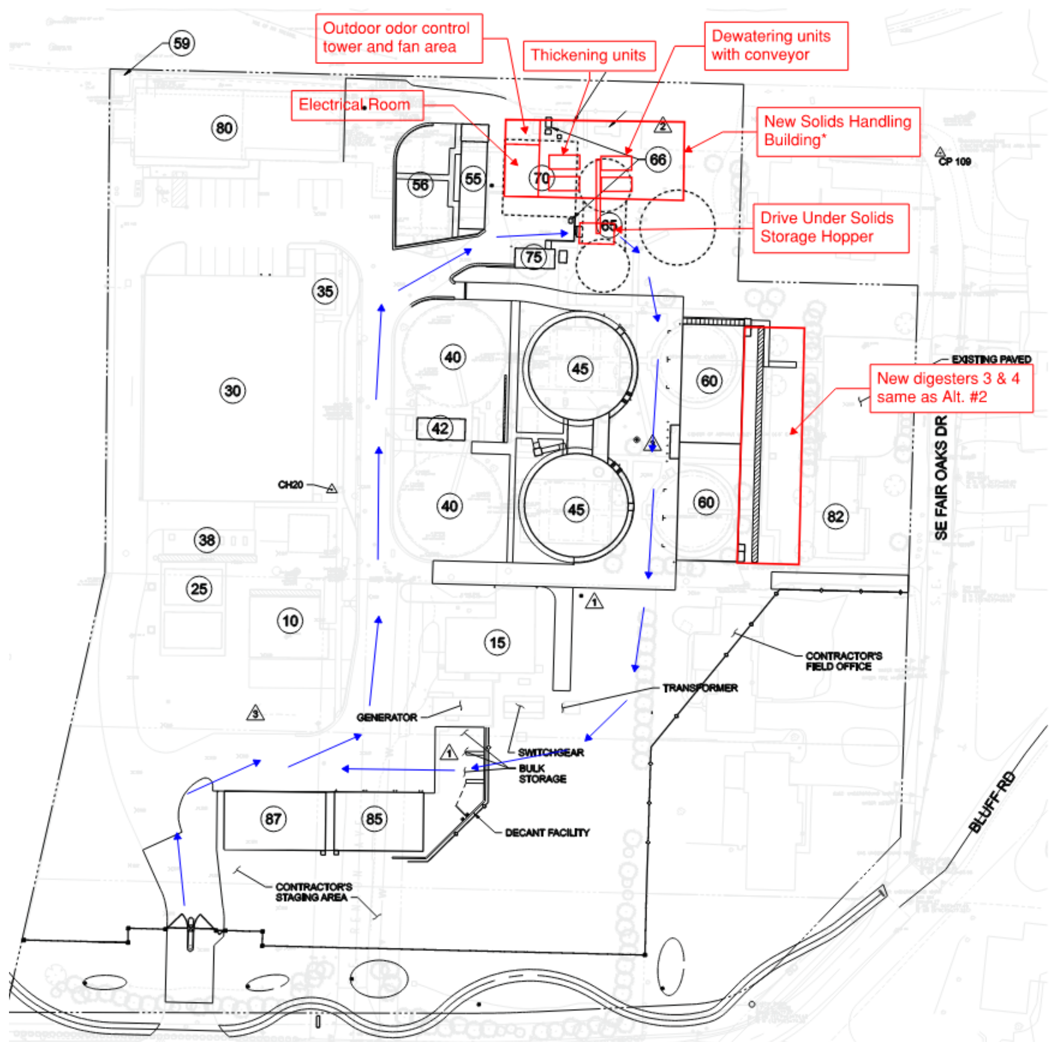
Alternatives Analysis for Solids Treatment

Evaluation and Design Criteria

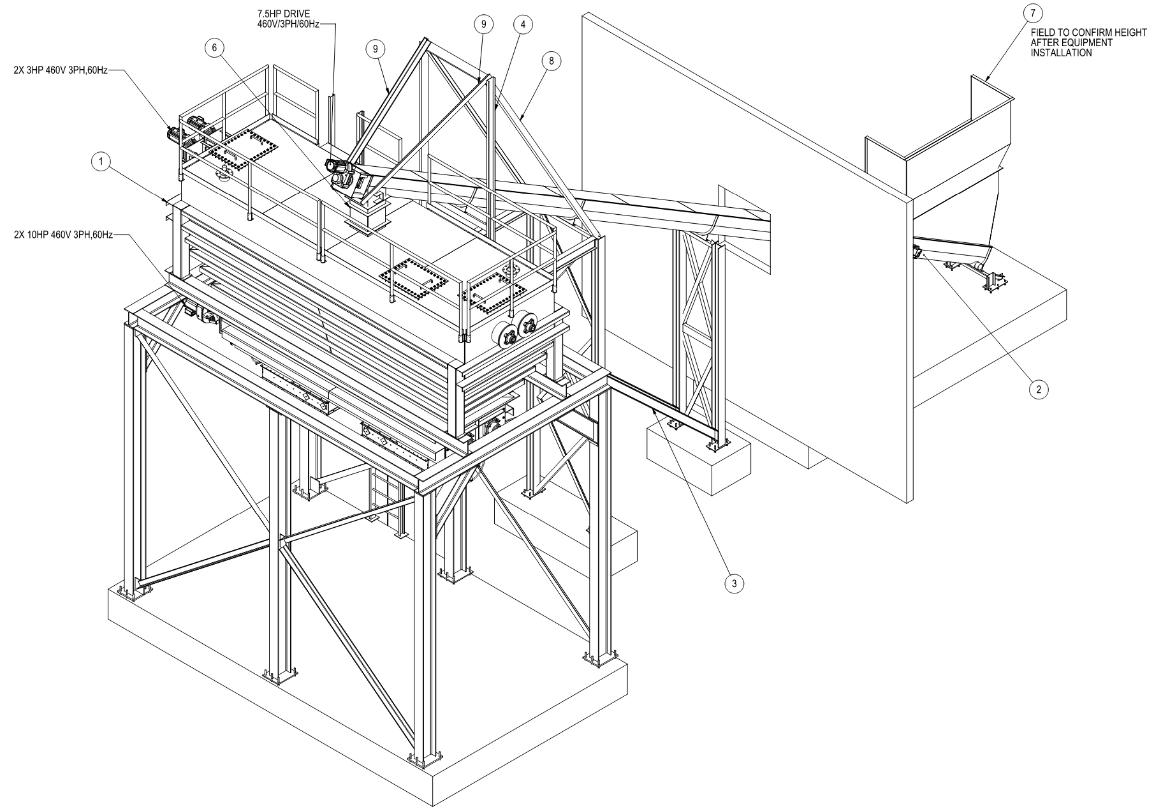
- Design year: 2052,   Startup year = ~2037
- Design for HRT in digesters of 40 days 20 deg. C
  - Will be dependent upon the secondary treatment option chosen
- Assume 4 digesters with 3 being in operation and one redundant unit

Alternative 1

- New Digesters 3 & 4 east of 1 & 2 and new Solids Handling Building in existing location.
- New building would include redundant thickening and dewatering units, TWAS and DS pumps, polymer feed units and storage, electrical room, and other appurtenant equipment.
- Odor control fan and scrubber would be located outside the building similar to existing.
- There would be a drive through sludge storage hopper and truck access as shown with blue arrows.
- Temporary dewatering, and possibly thickening facilities would be needed during construction of the new building after Digesters 3 & 4 are constructed.

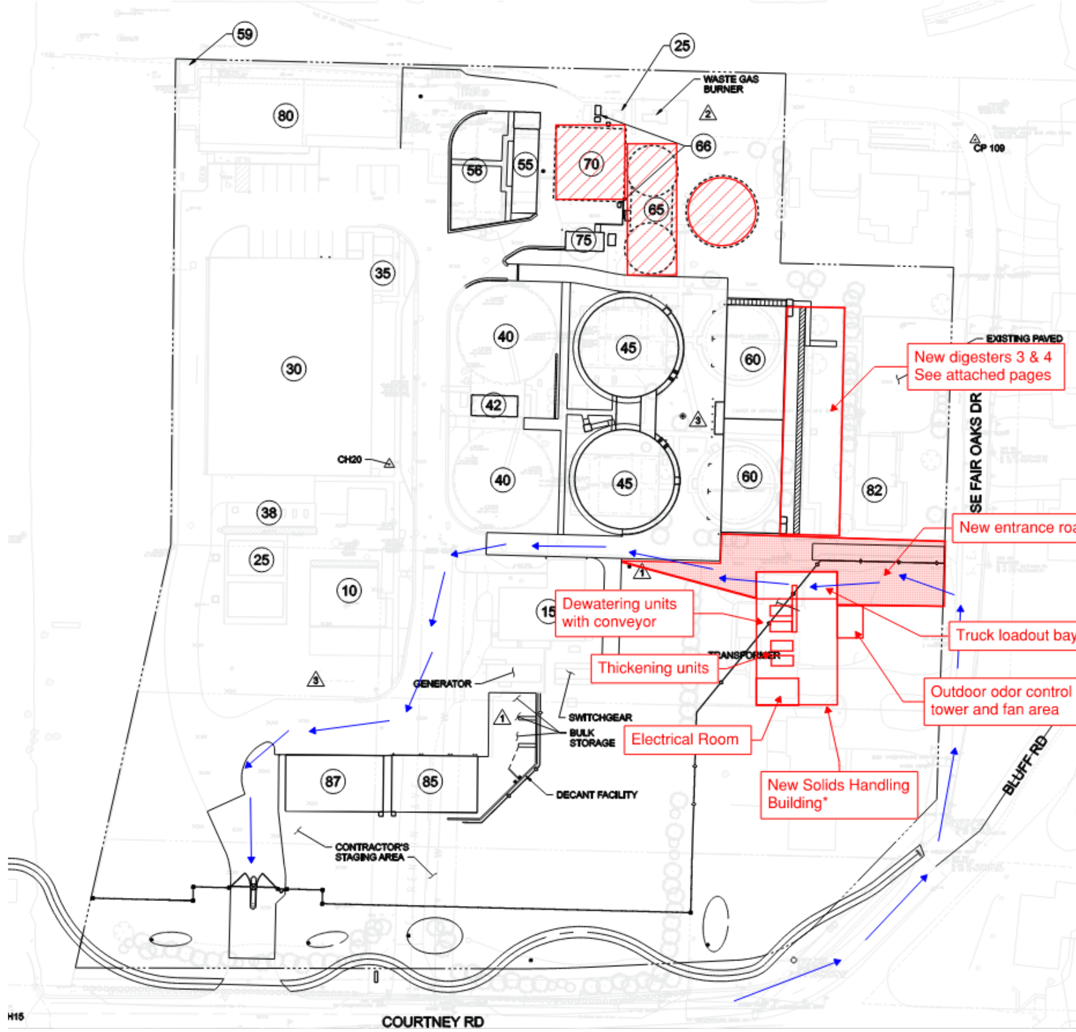


Drive Through Storage Hopper



Alternative 2

- New Digesters 3 & 4 east of 1 & 2 and new Solids Handling Building located south of digesters.
- New building would include redundant thickening and dewatering units, TWAS and DS pumps, polymer feed units and storage, electrical room, and other appurtenant equipment.
- Odor control fan and scrubber would be located outside the building.
- There would be a drive through truck bay connected to the building with a new entrance road on the east side. Truck traffic would be as shown in blue arrows.



Alternative 2 Preliminary Cost Estimate

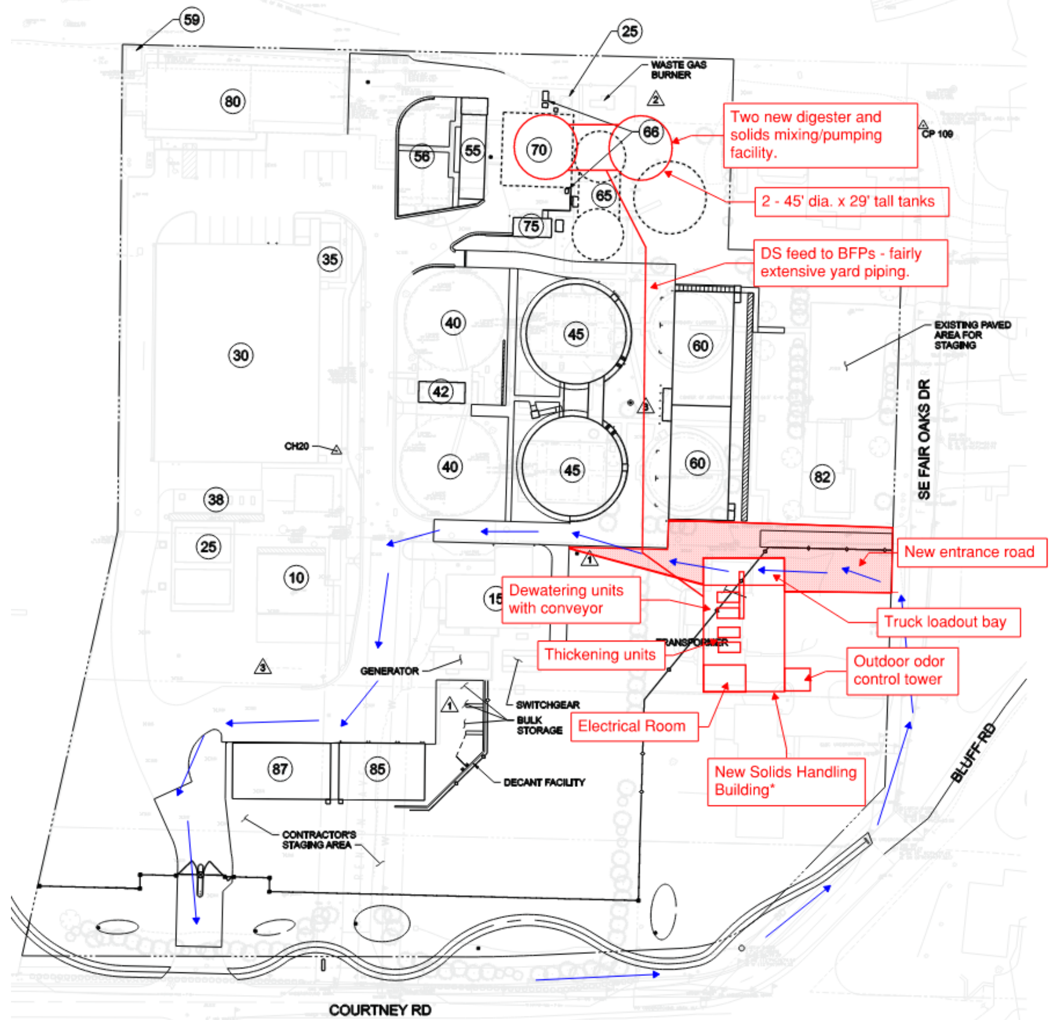
$29,400,00

-50% to +100% for Class 5

$14,700,000 to $58,800,000

Alternative 3

- New Digesters 3 & 4 would be constructed in the location of the existing Solids Handling Building and digesters. Building between digesters would house digester mixing pumps and DS pumps.
- New Solids Handling Building would be constructed south of Digesters 1 and 2 and include redundant thickening and dewatering units, TWAS pumps, polymer feed units and storage, electrical room, and other appurtenant equipment.
- Odor control fan and scrubber would be located outside the building.
- There would be a drive through truck bay connected to the building with a new entrance road on the east side. Truck traffic would be as shown in blue arrows.



Solids Treatment Alternatives Comparison

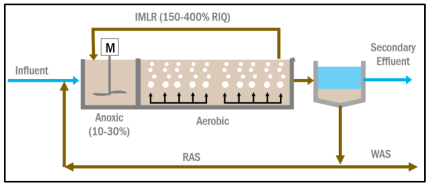
Alternative	Advantages	Disadvantages
Alternative 1	• Would make use of the existing plant site and not require expansion into the current "park" area.	• Truck access for solids pickup could be challenging at the back of the plant. • Temporary dewatering, and possibly thickening, facilities would be needed for many months during demo of the existing building and construction of a new building.
Alternative 2	• Truck access to the solids loading bay as part of the new building would seemingly be easier.	• Expansion into the "park" area south of Digesters 1 and 2 may require permitting and community acceptance.
Alternative 3	• Truck access to the solids loading bay as part of the new building would seemingly be easier.	• Expansion into the "park" area south of Digesters 1 and 2may require permitting and community acceptance • Extensive yard piping through a likely congested area to pump digested sludge from new Digesters 3 and 4 to the new building.

Alternatives Analysis for Secondary Treatment

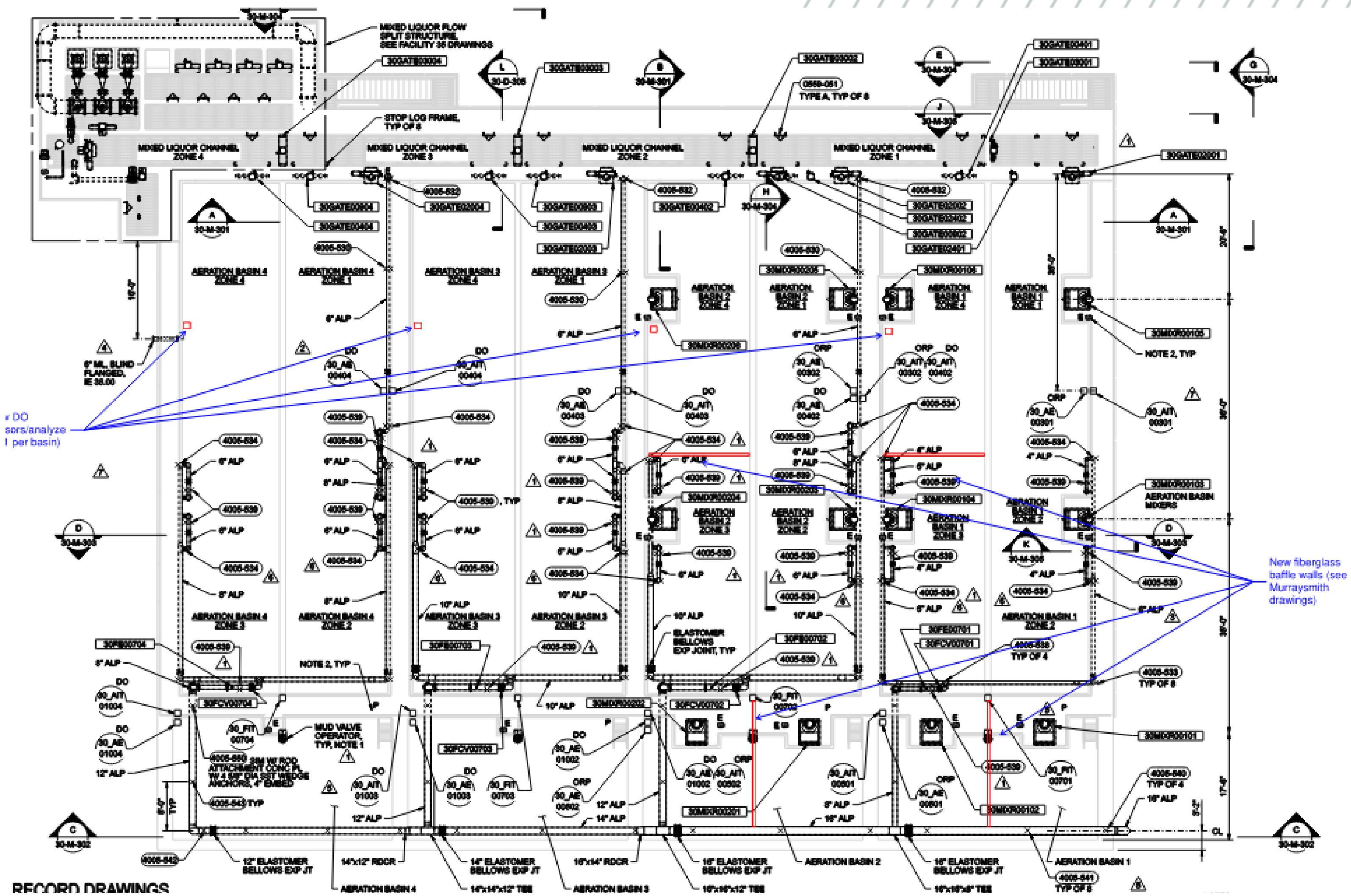
Evaluation and Design Criteria

- Design year: 2052,   Startup year = 2032
- Existing aeration basins (no expansion or new basins)
- Assumed ammonia limits: 0.5 mg/L (dry weather), 2 mg/L (wet weather)
- Assumed TP limit: 1 to 2 mg/L

MLE

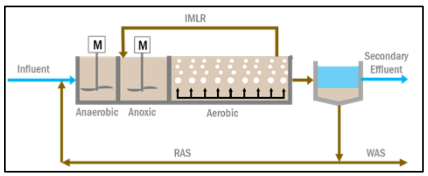


IMLR (150-400% RIQ)
M
Influent
Secondary Effluent
Anoxic (10-30%)
Aerobic
RAS
WAS

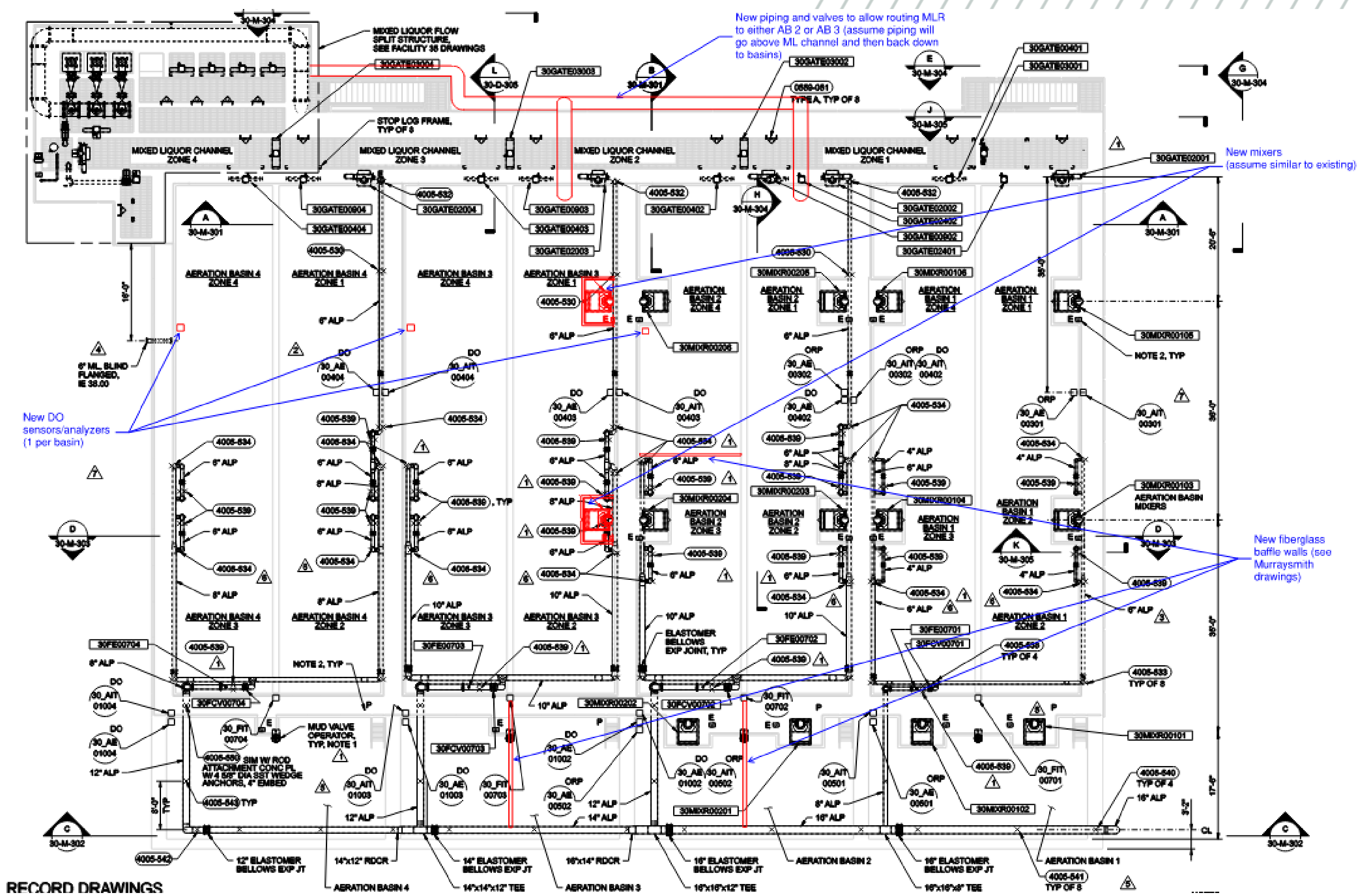


New fiberglass baffle walls (see Murraysmith drawings)
RECORD DRAWINGS

A20

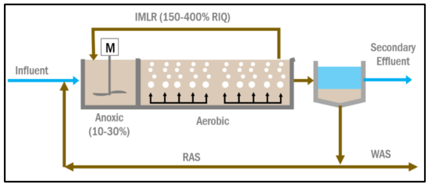


IMLR
M
M
Influent
Secondary Effluent
Anaerobic
Anoxic
Aerobic
RAS
WAS



New piping and valves to allow routing MLR to either AB 2 or AB 3 (assume piping will go above ML channel and then back down to basins)
New mixers (assume similar to existing)
New DO sensors/analyzers (1 per basin)
New fiberglass baffle walls (see Murraysmith drawings)
MIXED LIQUOR CHANNEL ZONE 4
MIXED LIQUOR CHANNEL ZONE 3
MIXED LIQUOR CHANNEL ZONE 2
MIXED LIQUOR CHANNEL ZONE 1
AERATION BASIN 4
AERATION BASIN 3
AERATION BASIN 2
AERATION BASIN 1
RECORD DRAWINGS

SND


IMLR (150-400% RIQ)
M
Influent
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Anoxic
(10-30%)
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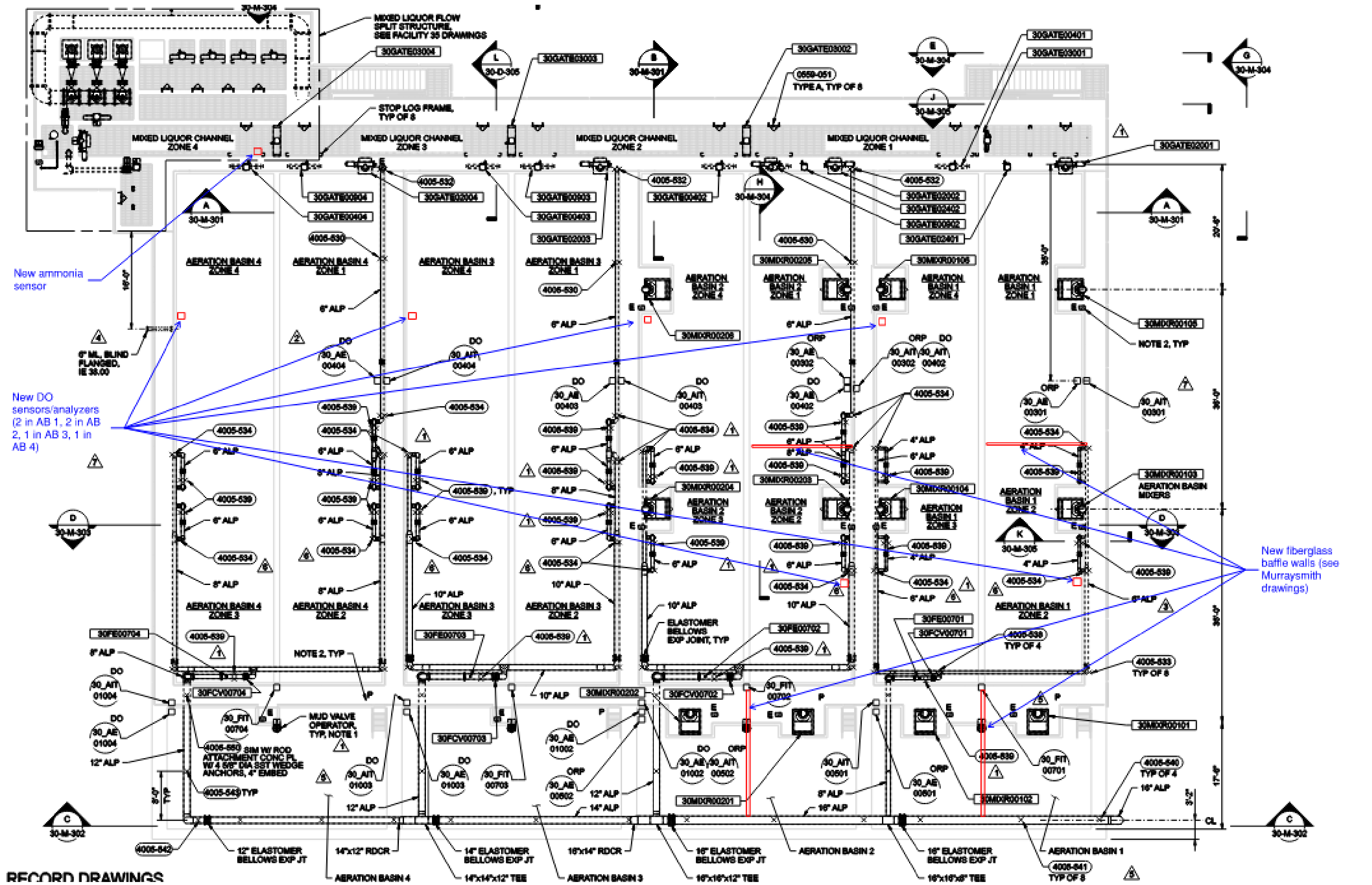
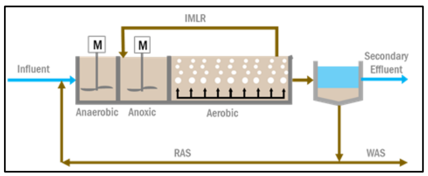
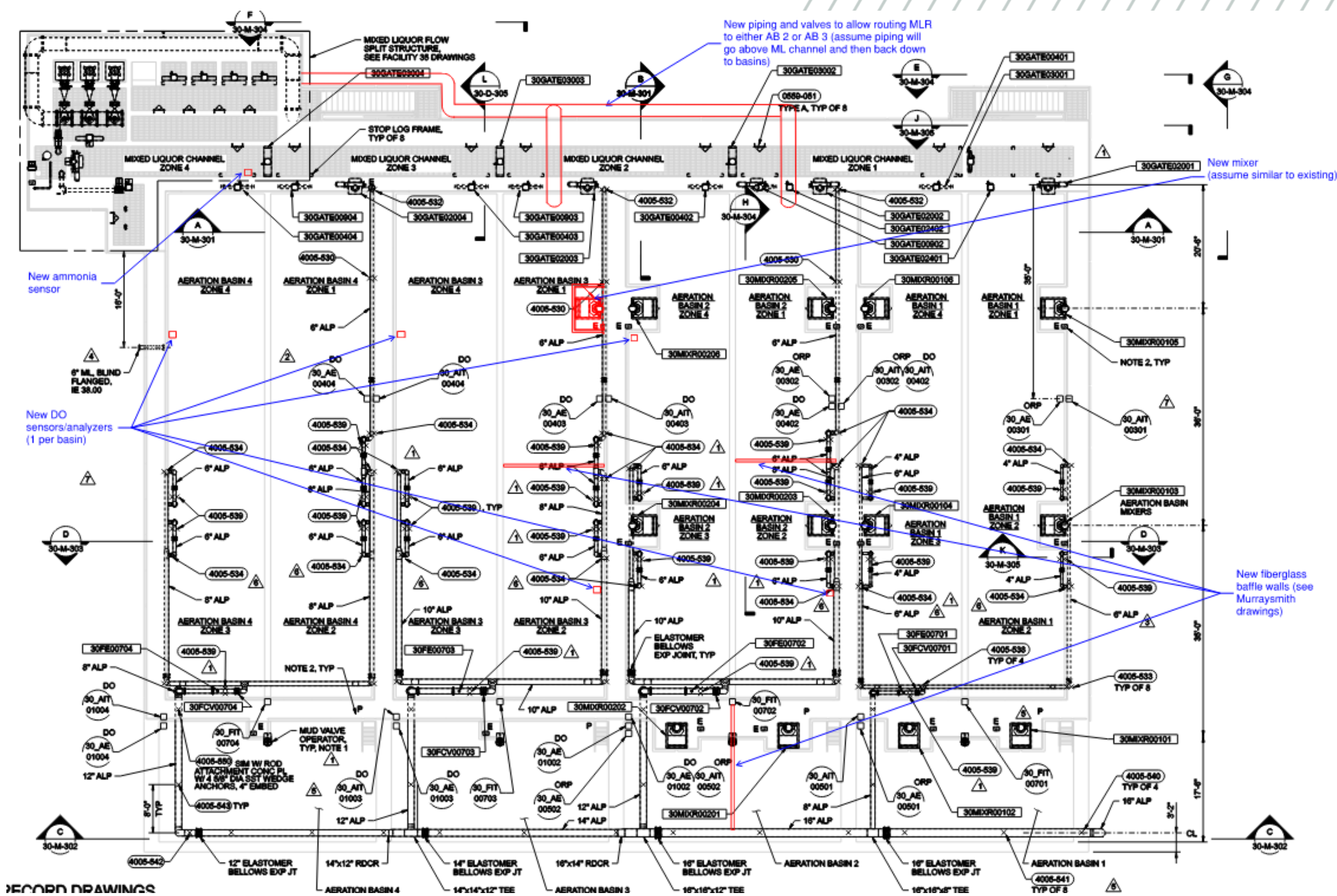
WAS


New ammonia
sensor
New DO
sensors/analyzers
(2 in AB 1, 2 in AB
2, 1 in AB 3, 1 in
AB 4)
New fiberglass
baffle walls (see
Murraysmith
drawings)
MIXED LIQUOR CHANNEL
ZONE 4
MIXED LIQUOR CHANNEL
ZONE 3
MIXED LIQUOR CHANNEL
ZONE 2
MIXED LIQUOR CHANNEL
ZONE 1
RECORD DRAWINGS

SND/A2O



IMLR
M
M
Influent
Secondary Effluent
Anaerobic
Anoxic
Aerobic
RAS
WAS



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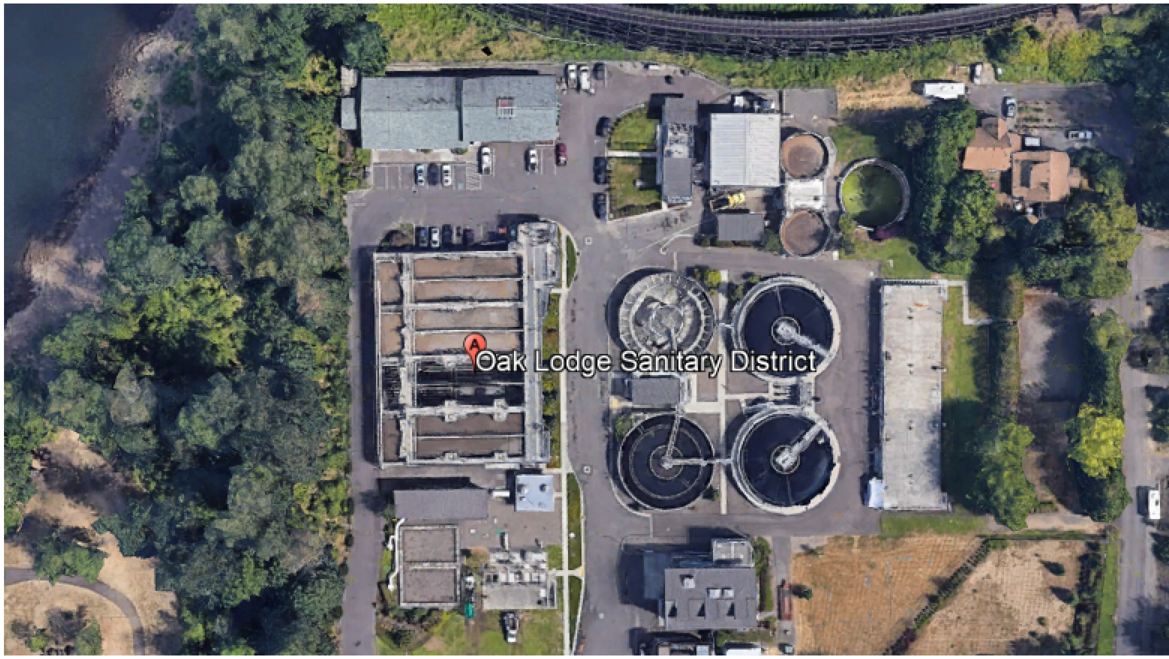
New mixer (assume similar to existing)
New ammonia sensor
New DO sensors/analyzers (1 per basin)
New fiberglass baffle walls (see Murraysmith drawings)
MIXED LIQUOR FLOW SPLIT STRUCTURE, SEE FACILITY 35 DRAWINGS
STOP LOG FRAME, TYP OF 8
MIXED LIQUOR CHANNEL ZONE 4
MIXED LIQUOR CHANNEL ZONE 3
MIXED LIQUOR CHANNEL ZONE 2
MIXED LIQUOR CHANNEL ZONE 1
AERATION BASIN 4
AERATION BASIN 3
AERATION BASIN 2
AERATION BASIN 1

Secondary System Alternatives Comparison

Alternatives	MLE	A2O	SND	SND/A2O
AB modifications	• New baffle walls, DO sensors, air flow meters/control valves, diffusers	• New baffle walls, DO sensors, air flow meters/control valves, diffusers, mixers • Re-route IMLR • New IMLR pumps	• New baffle walls, DO sensors, NH3 sensor, air flow meters/ control valves, diffusers	• New baffle walls, DO sensors, NH3 sensor, air flow meters/ control valves, diffusers, mixers • Re-route IMLR • New IMLR pumps
Chemical addition	• Alum for P removal • Caustic for pH control (max month)	• Alum for P removal (if limit < 2 mg/L) • Caustic for pH control (max month)	• Alum for P removal	• Alum for P removal (if limit < 1 mg/L)
AB requirements	• 2 (dry weather) • 3 (wet weather)	• 3 (dry weather) • 4 (wet weather)	• 2 (dry weather) • 3 (wet weather)	• 3 (dry weather) • 4 (wet weather)
Secondary clarifier requirements	• 3 (dry weather) • 4 (wet weather)	• 3 (dry weather) • 4 (wet weather) (≈capacity at max mo)	• 3 (dry weather) • 4 (wet weather)	• 3 (dry weather) • 4 (wet weather) (≈capacity at max mo)
Effluent quality	• Meets NH3-N criterion • PO4-P ≥ 2 mg/L	• Meets NH3-N criterion • PO4-P ≤ 2.5 mg/L	• Meets NH3-N criterion • PO4-P ≥ 2 mg/L	• Meets NH3-N criterion • Meets TP criterion
Average air flow	• 2300 - 2500 scfm	• 2300 – 2600 scfm	• 1800 – 2000 scfm	• 1900 – 2100 scfm

Thank You



OAK LODGE
WATER SERVICES

Wastewater Master Plan
Wastewater Treatment Plant
Draft Facility Plan Workshop

November 30, 2022

Agenda

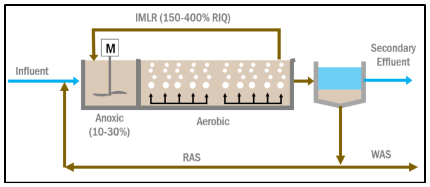
1. Secondary Treatment Alternatives Update
2. Solids Handling Alternatives Update
3. CIP Priorities and Costs

Secondary Treatment Alternatives Analysis Update

Evaluation and Design Criteria

- Design year: 2052,   Startup year = 2032
- Existing aeration basins (no expansion or new basins)
- Assumed ammonia limits: 0.5 mg/L (dry weather), 2 mg/L (wet weather)
- Assumed TP limit: 1 to 2 mg/L

MLE



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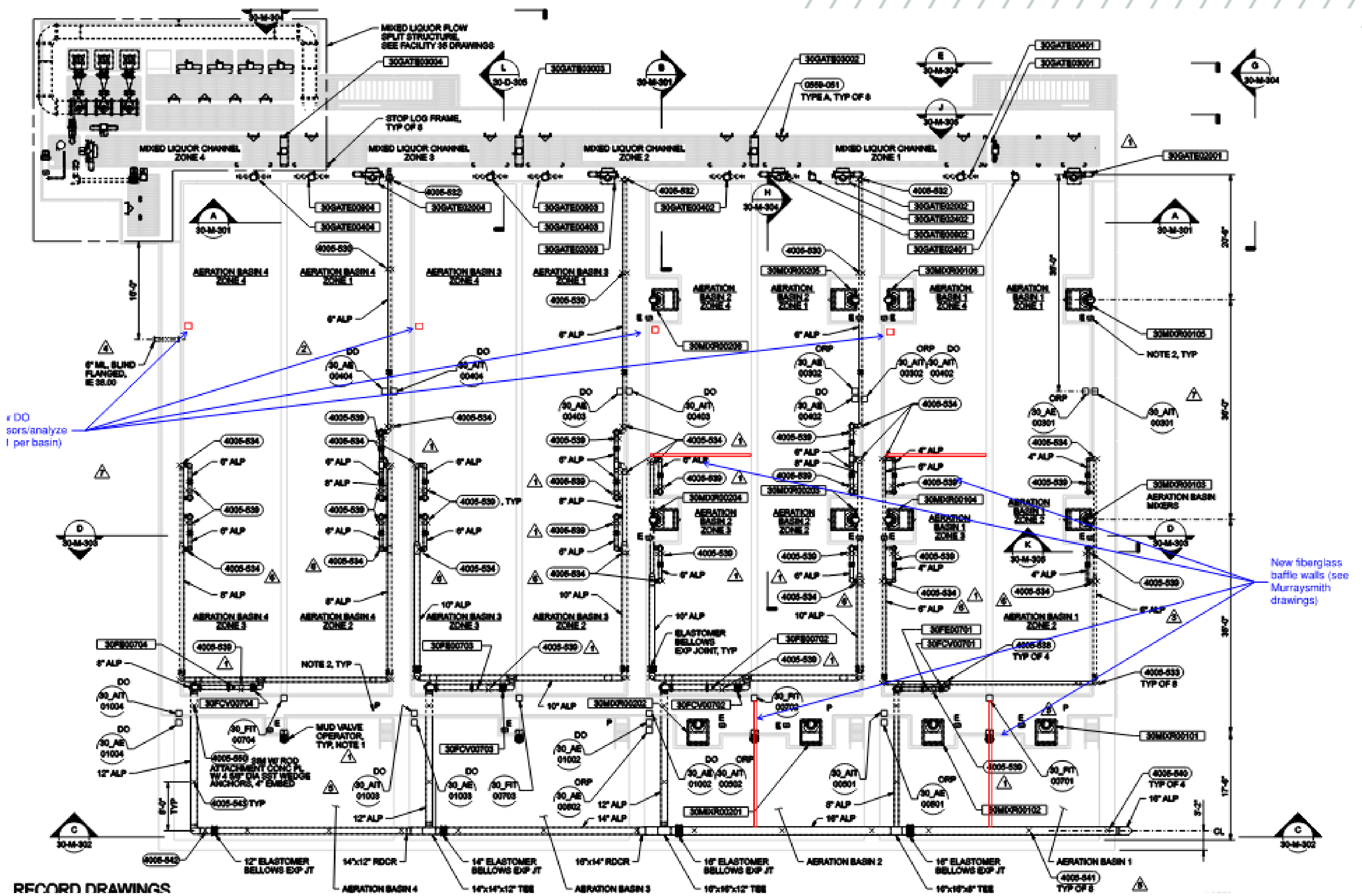

MIXED LIQUOR CHANNEL ZONE 4
MIXED LIQUOR CHANNEL ZONE 3
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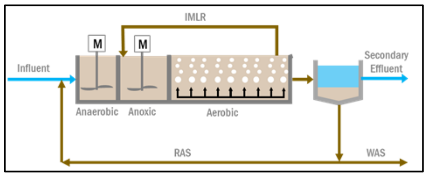
MIXED LIQUOR CHANNEL ZONE 1
AERATION BASIN 4 ZONE 4
AERATION BASIN 4 ZONE 1
AERATION BASIN 3 ZONE 4
AERATION BASIN 3 ZONE 1
AERATION BASIN 4 ZONE 3
AERATION BASIN 4 ZONE 2
AERATION BASIN 3 ZONE 3
AERATION BASIN 3 ZONE 2
AERATION BASIN 1 ZONE 2
New fiberglass baffle walls (see Murraysmith drawings)
RECORD DRAWINGS

A2O



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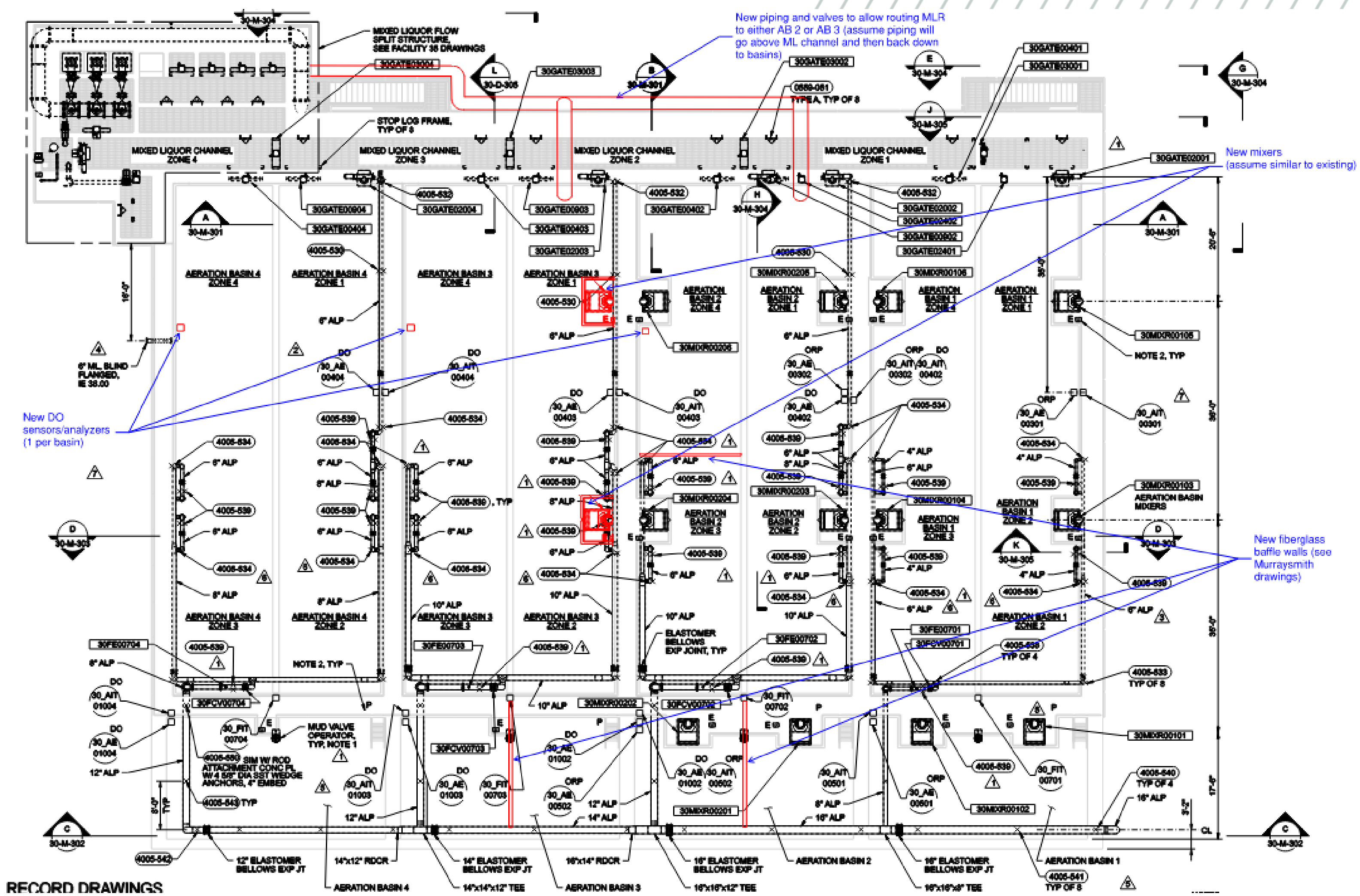

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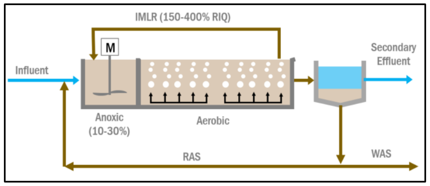
AERATION BASIN 2
AERATION BASIN 1
RECORD DRAWINGS

SND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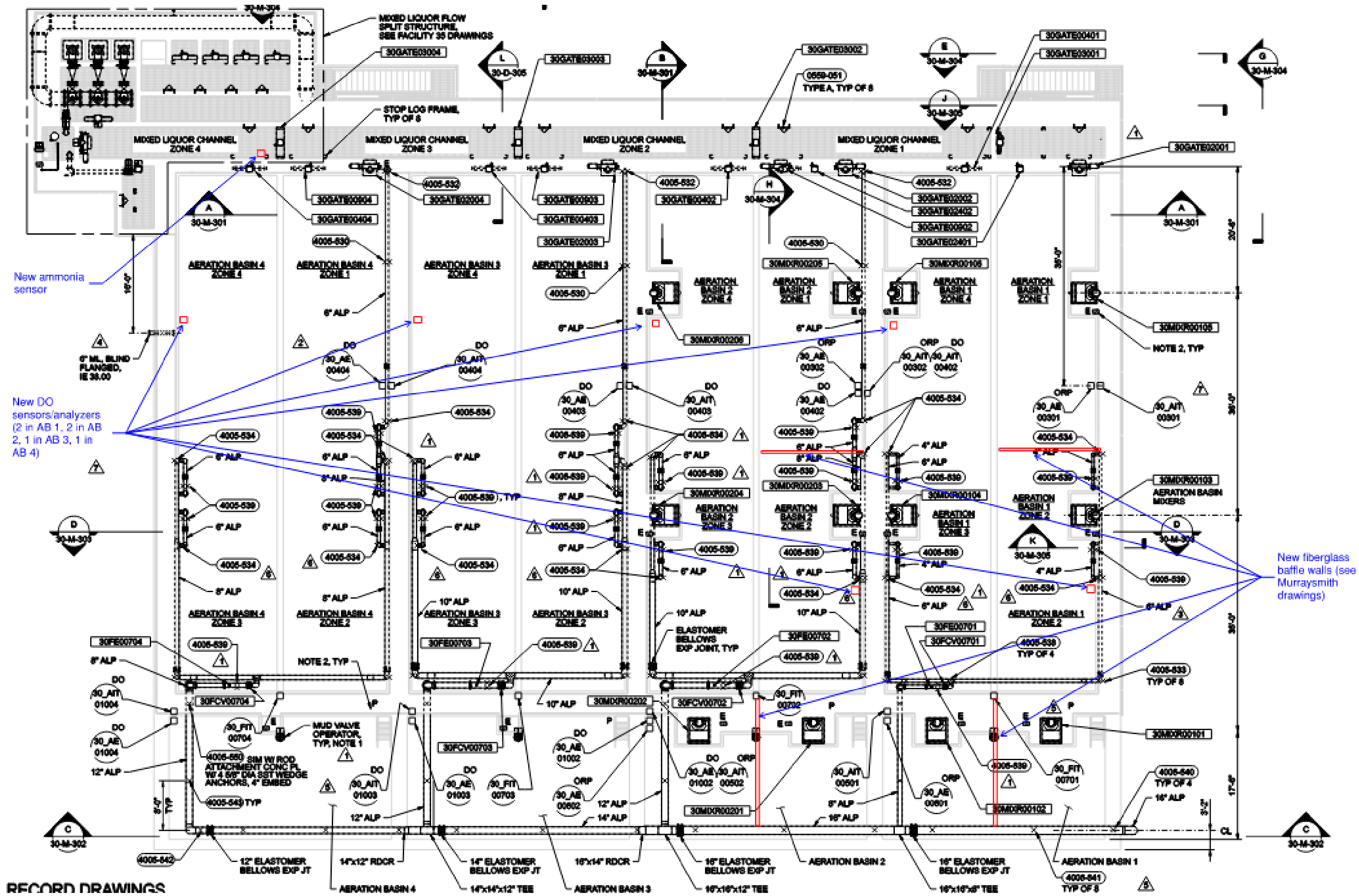
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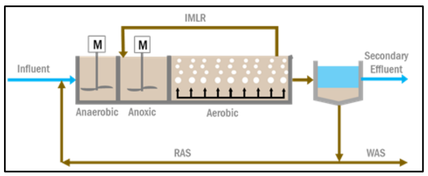
STOP LOG FRAME, TYP OF 8
AERATION BASIN 4 ZONE 4
AERATION BASIN 4 ZONE 1
AERATION BASIN 3 ZONE 4
AERATION BASIN 3 ZONE 1
AERATION BASIN 4 ZONE 3
AERATION BASIN 4 ZONE 2
AERATION BASIN 3 ZONE 3
AERATION BASIN 3 ZONE 2
AERATION BASIN 1 ZONE 2
AERATION BASIN MIXERS
MUD VALVE OPERATOR, TYP, NOTE 1
ELASTOMER BELLOWS EXP JOINT, TYP
AERATION BASIN 4
AERATION BASIN 3
AERATION BASIN 2
AERATION BASIN 1
RECORD DRAWINGS

SND/A2O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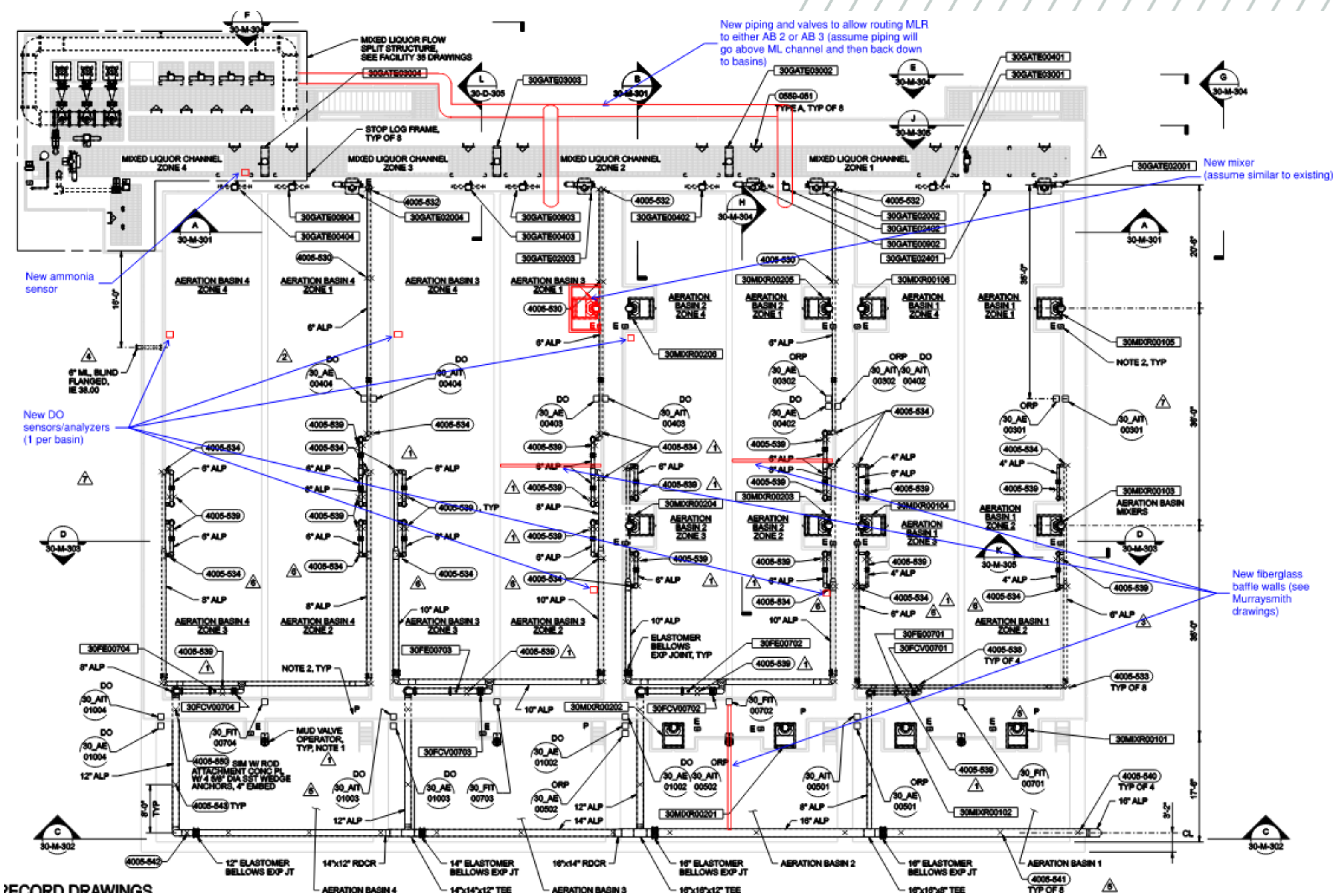
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AERATION BASIN 4 ZONE 2
AERATION BASIN 3 ZONE 3
AERATION BASIN 3 ZONE 2
AERATION BASIN 1 ZONE 2
RECORD DRAWINGS

Secondary System Alternatives Comparison

Alternatives	MLE	A2O	SND	SND/A2O
AB modifications	• New baffle walls, DO sensors, air flow meters/control valves, diffusers	• New baffle walls, DO sensors, air flow meters/control valves, diffusers, mixers • Re-route IMLR • New IMLR pumps	• New baffle walls, DO sensors, NH3 sensor, air flow meters/ control valves, diffusers	• New baffle walls, DO sensors, NH3 sensor, air flow meters/ control valves, diffusers, mixers • Re-route IMLR • New IMLR pumps
Chemical addition	• Alum for P removal • Caustic for pH control (max month)	• Alum for P removal (if limit < 2 mg/L) • Caustic for pH control (max month)	• Alum for P removal	• Alum for P removal (if limit < 1 mg/L)
AB requirements	• 2 (dry weather) • 3 (wet weather)	• 3 (dry weather) • 4 (wet weather)	• 2 (dry weather) • 3 (wet weather)	• 3 (dry weather) • 4 (wet weather)
Secondary clarifier requirements	• 3 (dry weather) • 4 (wet weather)	• 3 (dry weather) • 4 (wet weather) (≈capacity at max mo)	• 3 (dry weather) • 4 (wet weather)	• 3 (dry weather) • 4 (wet weather) (≈capacity at max mo)
Effluent quality	• Meets NH3-N criterion • PO4-P ≥ 2 mg/L	• Meets NH3-N criterion • PO4-P ≤ 2.5 mg/L	• Meets NH3-N criterion • PO4-P ≥ 2 mg/L	• Meets NH3-N criterion • Meets TP criterion
Average air flow	• 2300 - 2500 scfm	• 2300 – 2600 scfm	• 1800 – 2000 scfm	• 1900 – 2100 scfm

Secondary System Alternatives Cost Comparison

Alternatives	MLE	A2O	SND	SND/A2O
Construction Cost [a] (2022$)	$1,116,000	$2,212,000	$1,047,000	$1,903.000
Annual Operating Costs [b] (2022$, for 2032)	Power: $32,000 Labor: $200,000 Chemical: $129,000 Total: $361,000	Power: $33,000 Labor: $200,000 Chemical: $34,000 Total: $267,000	Power: $26,000 Labor: $200,000 Chemical: $120,000 Total: $346,000	Power: $27,000 Labor: $133,000 Chemical: - Total: $160,000
NPV (2022$) [c]	$12,097,000	$10,668,000	$11,567,000	$7,078,000

Notes:

a. Class 5 estimate, with a range from -50% to +100%, unescalated, undiscounted.

b. Operating costs include power costs for aeration, additional labor costs, and chemical costs (caustic and alum), unescalated, undiscounted. Unit power cost of $0.045/kWh and labor cost of $133,133/FTE/yr assumed.

c. Net present value assuming design and construction in 2029 to 2031, operating costs from 2032 to 2052, 5% escalation rate, and 3.4% discount rate.

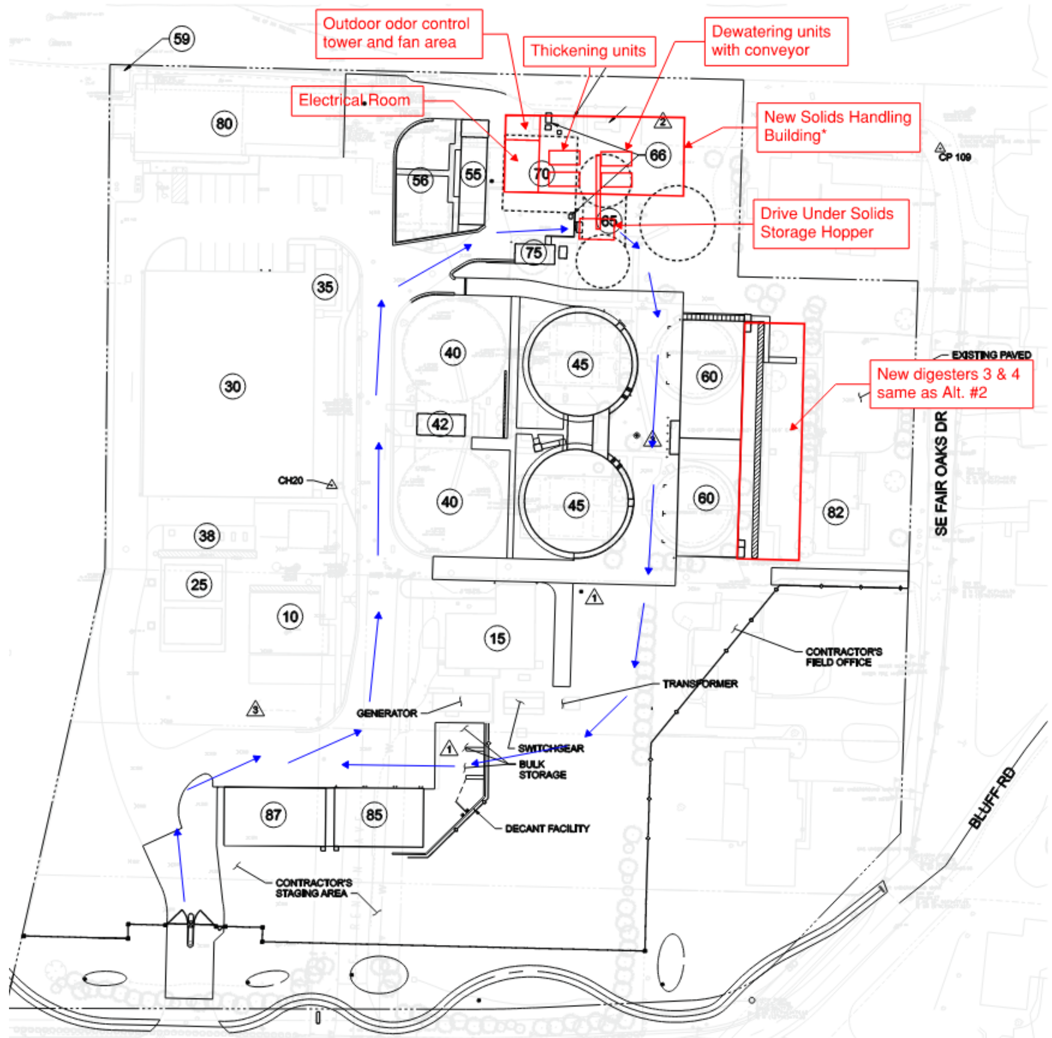
Recommendations for Secondary Treatment

- Implement SND for energy savings and improved alkalinity recovery
- Design diffuser grids and baffles to allow conversion to SND/A2O
- Leave space for chemical feed system
- Convert to A2O in the future as needed when nutrient limits are known

Solids Treatment Alternatives Analysis Update

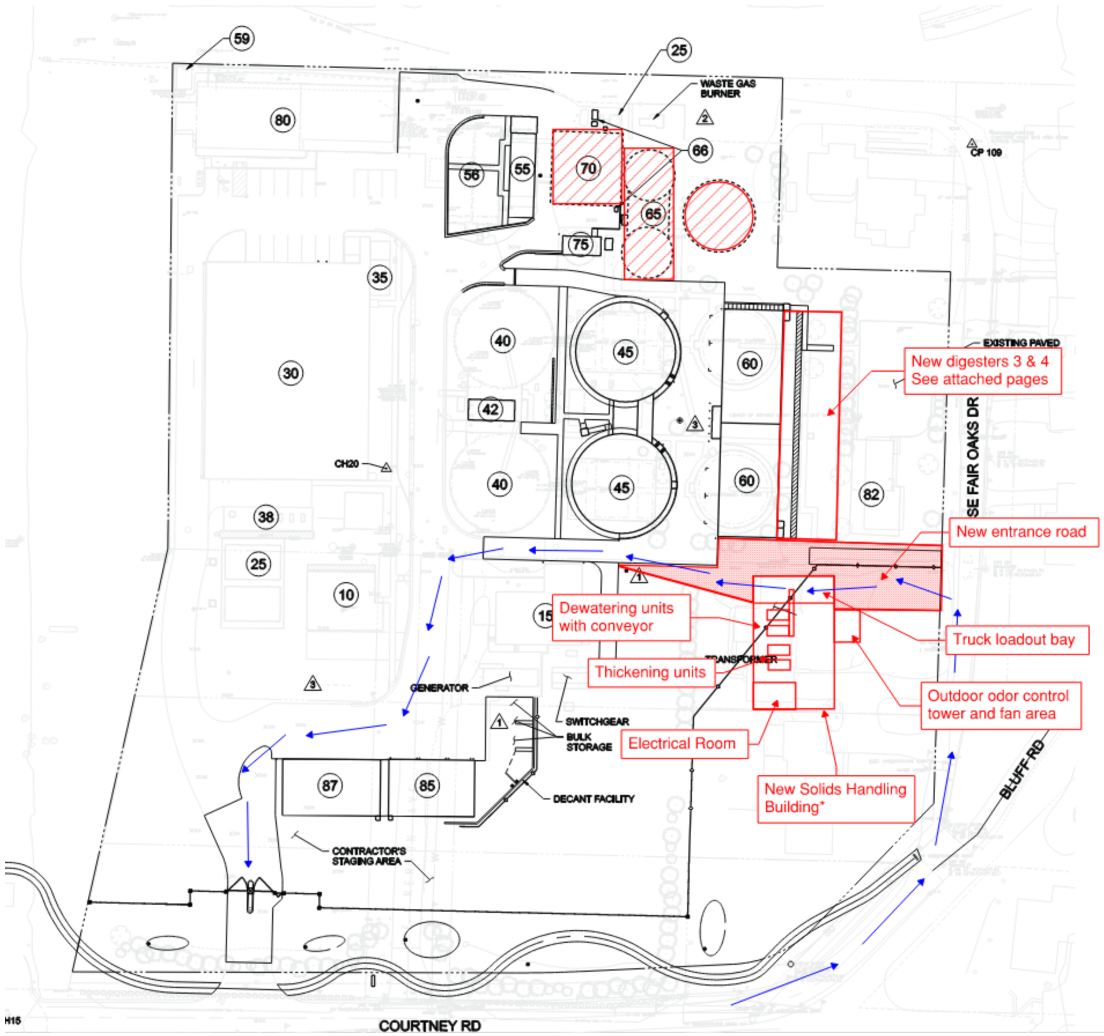
Alternative 1

- New Digesters 3 & 4 east of 1 & 2 and new Solids Handling Building in existing location.
- New building would include redundant thickening and dewatering units and all appurtenant equipment. Layouts and cost estimates assume RDTs and BFPs.
- Odor control fan and scrubber would be located outside the building similar to existing.
- There would be a drive through sludge storage hopper and truck access as shown with blue arrows. (Operations staff indicate this route would not be possible.)
- Temporary dewatering, and possibly thickening facilities would be needed during construction of the new building after Digesters 3 & 4 are constructed.



Alternative 2

- New Digesters 3 & 4 east of 1 & 2 and new Solids Handling Building located south of digesters.
- New building would include redundant thickening and dewatering units and all appurtenant equipment. Layouts and cost estimates assume RDTs and BFPs.
- Odor control fan and scrubber would be located outside the building.
- There would be a drive through truck bay connected to the building with a new entrance road on the east side. Truck traffic would be as shown in blue arrows.



Alternative 3

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- New Solids Handling Building would be constructed south of Digesters 1 and 2 and include redundant thickening and dewatering units and all appurtenant equipment. Layouts and cost estimates assume RDTs and BFPs.
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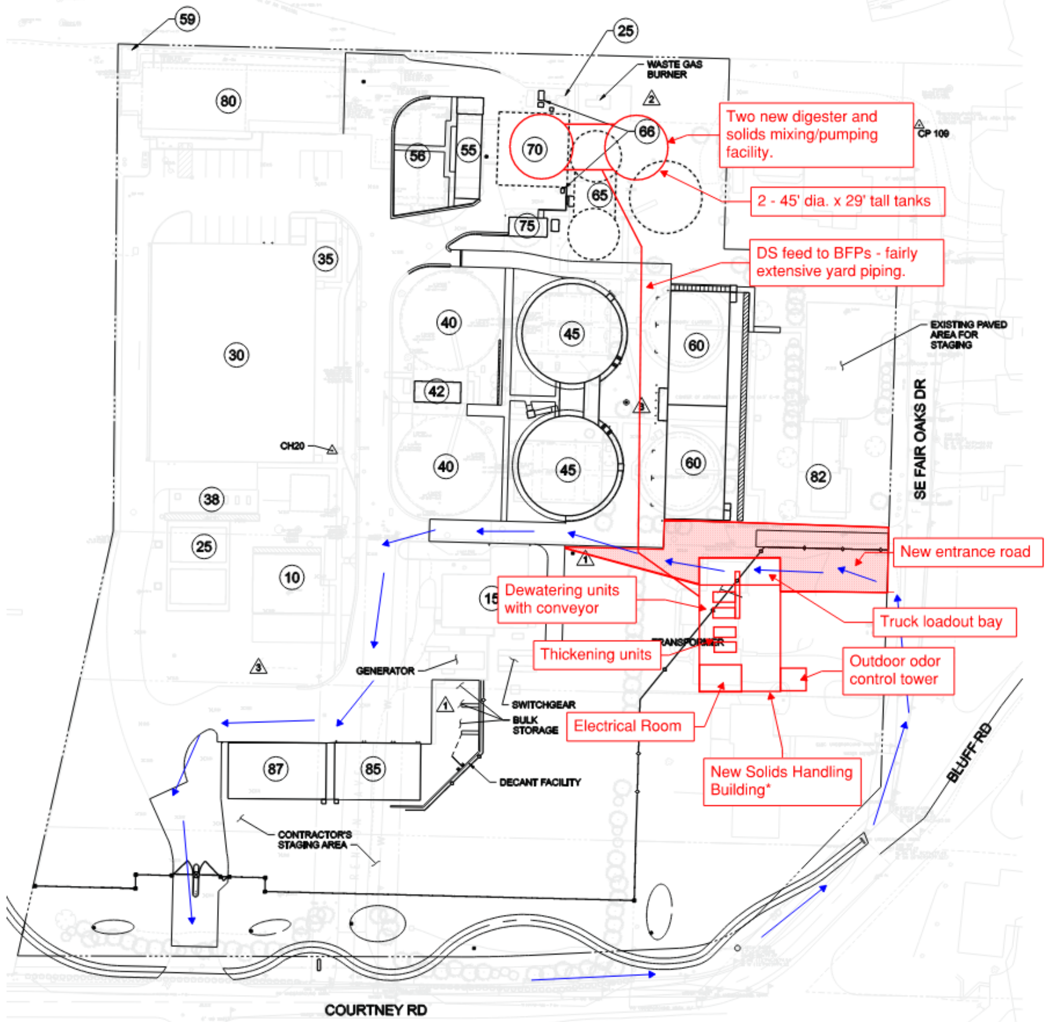

Solids Treatment Alternatives Comparison

Alternative	Advantages	Disadvantages
Alternative 1	• Would make use of the existing plant site and not require expansion into the current "park" area.	• Plant ops has stated that the truck access as shown would not be possible. • Temporary dewatering, and thickening facilities would be needed for ~15 to 18 months during demo of the existing building and construction of new one.
Alternative 2 - Likely preferred alternative	• Truck access to the solids loading bay as part of the new building would seemingly be easier. • Provides space for future storage or treatment processes in area of existing building and digesters.	• Expansion into the "park" area south of Digesters 1 and 2 may require permitting and community acceptance.
Alternative 3	• Truck access to the solids loading bay as part of the new building would seemingly be easier. • Provides space for future storage or treatment processes in area of existing building and digesters.	• Expansion into the "park" area south of Digesters 1 and 2may require permitting and community acceptance • Extensive yard piping through a likely congested area to pump digested sludge from new Digesters 3 and 4 to the new building.

Solids Alternatives Estimated Project Costs

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

- Estimated costs for all three alternatives are essentially the same.
- It is also assumed O&M costs for all 3 alternatives would be essentially the same.
- Based on this, cost will not be a large factor in the alternative selection.
- Other factors, such as truck access, ability to expand into the current “park” area, constructability, and ease of operation and maintenance will have a much larger impact on alternative selection.
- A more thorough business case evaluation should be performed when it becomes closer to the time to perform the Solids Handling Upgrade.

CIP Discussion

Appendix K CIP Project Cost Opinions

K

<u>Opinion of Probable Construction Cost</u>
Project C-1: Lift Station 5 Basin RDII Reduction Pilot
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
Pre-Rehabilitation Work					
1	Smoke Testing	35,000	LF	$ 0.71	$ 25,000.00
2	Pre-Rehabilitation Flow Meters	5	EA	$ 9,400.00	$ 47,000.00
3	Pre-Rehabilitation Flow Meter Analysis	1	LS	$ 29,000.00	$ 29,000.00
				Subtotal	*$ 101,000.00*
Rehabilitation Work					
4	Mobilization	1	LS	$ 88,000.00	$ 88,000.00
5	Insurance	1	LS	$ 44,000.00	$ 44,000.00
6	Survey	1	LS	$ 15,000.00	$ 15,000.00
7	Site Clearing	1	LS	$ 15,000.00	$ 15,000.00
8	Erosion and Sediment Control Plan	1	LS	$ 4,000.00	$ 4,000.00
9	Traffic Control	1	LS	$ 26,000.00	$ 26,000.00
10	Cleaning & Pre-Construction CCTV	8,783	LF	$ 6.03	$ 53,000.00
11	6" CIPP	173	LF	$ 63.58	$ 11,000.00
12	8" CIPP	5,839	LF	$ 65.08	$ 380,000.00
13	10" CIPP	2,556	LF	$ 70.03	$ 179,000.00
14	12" CIPP	215	LF	$ 74.42	$ 16,000.00
15	Reinstate Service Laterals	138	EA	$ 115.94	$ 16,000.00
16	Full Lateral Rehabilitation	138	EA	$ 5,500.00	$ 759,000.00
17	Post-Construction CCTV	8,921	LF	$ 2.91	$ 26,000.00
18	Manhole Rehabilitation	63	VF	$ 571.43	$ 36,000.00
				Construction Subtotal	*$ 1,668,000.00*
				Construction Contingency (30%)	$ 501,000.00
				Construction Total	$ 2,169,000.00
				Project Development & Implementation (30%)	$ 651,000.00
				Rehabilitation Project Cost	$ 2,820,000.00
Post-Rehabilitation Work					
19	Post-Rehabilitation Flow Metering	5	EA	$ 9,400.00	$ 47,000.00
20	Post-Rehabilitation Flow Meter Analysis	1	LS	$ 30,000.00	$ 30,000.00
				Subtotal	$ 77,000.00
				Construction Contingency (30%)	$ 23,000.00
				Construction Total	$ 100,000.00
				Total Project Cost	**$ 3,021,000.00**

<u>Opinion of Probable Construction Cost</u>

Project C-2: Lift Station 2 Basin RDII Reduction Program

Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
Pre-Rehabilitation Work					
1	Smoke Testing	165,414	LF	$ 0.71	$ 117,000.00
2	Pre-Rehabilitation Flow Meters	17	EA	$ 7,764.71	$ 132,000.00
3	Pre-Rehabilitation Flow Meter Analysis	1	LS	$ 39,000.00	$ 39,000.00
				Subtotal	*$ 288,000.00*
				Construction Contingency (30%)	*$ 86,000.00*
				Construction Total	*$ 374,000.00*
Rehabilitation Work					
4	Mobilization	1	LS	$ 136,000.00	$ 136,000.00
5	Insurance	1	LS	$ 68,000.00	$ 68,000.00
6	Survey	1	LS	$ 23,000.00	$ 23,000.00
7	Site Clearing	1	LS	$ 23,000.00	$ 23,000.00
8	Erosion and Sediment Control Plan	1	LS	$ 7,000.00	$ 7,000.00
9	Traffic Control	1	LS	$ 42,000.00	$ 42,000.00
10	Cleaning & Pre-Construction CCTV	12,794	LF	$ 6.02	$ 77,000.00
11	8" CIPP	11,145	LF	$ 64.96	$ 724,000.00
12	12" CIPP	304	LF	$ 75.63	$ 23,000.00
13	14" CIPP	4	LF	$ 263.16	$ 1,000.00
14	18" CIPP	251	LF	$ 151.39	$ 38,000.00
15	20" CIPP	752	LF	$ 195.48	$ 147,000.00
16	21" CIPP	338	LF	$ 195.44	$ 66,000.00
17	Reinstate Service Laterals	198	EA	$ 116.16	$ 23,000.00
18	Full Lateral Rehabilitation	198	EA	$ 5,500.00	$ 1,089,000.00
19	Post-Construction CCTV	12,794	LF	$ 2.97	$ 38,000.00
20	Manhole Rehabilitation	95	VF	$ 568.42	$ 54,000.00
				Construction Subtotal	*$ 2,579,000.00*
				Construction Contingency (30%)	$ 774,000.00
				Construction Total	$ 3,353,000.00
				Project Development & Implementation (30%)	$ 1,006,000.00
				Rehabilitation Project Cost	$ 4,359,000.00
Post-Rehabilitation Work					
21	Post-Rehabilitation Flow Metering	17	EA	$ 7,705.88	$ 131,000.00
22	Post-Rehabilitation Flow Meter Analysis	1	LS	$ 39,000.00	$ 39,000.00
				Subtotal	$ 170,000.00
				Construction Contingency (30%)	$ 51,000.00
				Construction Total	$ 221,000.00
				Total Project Cost	**$ 4,954,000.00**

Opinion of Probable Construction Cost
Project C-3: Lift Station 6 Basin RDII Reduction Program
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
Pre-Rehabilitation Work					
1	Smoke Testing	6,846	LF	$ 0.73	$ 5,000.00
2	Pre-Rehabilitation Flow Meters	2	EA	$ 9,500.00	$ 19,000.00
3	Pre-Rehabilitation Flow Meter Analysis	1	LS	$ 21,000.00	$ 21,000.00
				Subtotal	*$ 45,000.00*
				Construction Contingency (30%)	*$ 14,000.00*
				Construction Total	*$ 59,000.00*
Rehabilitation Work					
4	Mobilization	1	LS	$ 12,000.00	$ 12,000.00
5	Insurance	1	LS	$ 6,000.00	$ 6,000.00
6	Survey	1	LS	$ 2,000.00	$ 2,000.00
7	Site Clearing	1	LS	$ 2,000.00	$ 2,000.00
8	Erosion and Sediment Control Plan	1	LS	$ 500.00	$ 500.00
9	Traffic Control	1	LS	$ 500.00	$ 500.00
10	Cleaning & Pre-Construction CCTV	171	LF	$ 5.85	$ 1,000.00
11	8" CIPP	171	LF	$ 64.33	$ 11,000.00
12	Reinstate Service Laterals	33	EA	$ 121.21	$ 4,000.00
13	Full Lateral Rehabilitation	33	EA	$ 5,500.00	$ 181,500.00
14	Post-Construction CCTV	171	LF	$ 2.92	$ 500.00
15	Manhole Rehabilitation	11	VF	$ 545.45	$ 6,000.00
				Construction Subtotal	*$ 227,000.00*
				Construction Contingency (30%)	$ 68,000.00
				Construction Total	$ 295,000.00
				Project Development & Implementation (30%)	$ 89,000.00
				Rehabilitation Project Cost	$ 384,000.00
Post-Rehabilitation Work					
16	Post-Rehabilitation Flow Metering	2	EA	$ 9,500.00	$ 19,000.00
17	Post-Rehabilitation Flow Meter Analysis	1	LS	$ 21,000.00	$ 21,000.00
				Subtotal	$ 40,000.00
				Construction Contingency (30%)	$ 12,000.00
				Construction Total	$ 52,000.00
				Total Project Cost	**$ 495,000.00**

<u>Opinion of Probable Construction Cost</u>
Project C-4: Influent Lift Station Basin RDII Reduction Program
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
Pre-Rehabilitation Work					
1	Smoke Testing	207,931	LF	$ 0.71	$ 148,000.00
2	Pre-Rehabilitation Flow Meters	21	EA	$ 7,714.29	$ 162,000.00
3	Pre-Rehabilitation Flow Meter Analysis	1	LS	$ 42,000.00	$ 42,000.00
				Subtotal	*$ 352,000.00*
				Construction Contingency (30%)	*$ 106,000.00*
				Construction Total	*$ 458,000.00*
Rehabilitation Work					
4	Mobilization	1	LS	$ 201,000.00	$ 201,000.00
5	Insurance	1	LS	$ 101,000.00	$ 101,000.00
6	Survey	1	LS	$ 34,000.00	$ 34,000.00
7	Site Clearing	1	LS	$ 34,000.00	$ 34,000.00
8	Erosion and Sediment Control Plan	1	LS	$ 12,000.00	$ 12,000.00
9	Traffic Control	1	LS	$ 74,000.00	$ 74,000.00
10	Cleaning & Pre-Construction CCTV	171	LF	$ 877.19	$ 150,000.00
11	6" CIPP	270	LF		$ 18,000.00
12	8" CIPP	12,724	LF	$ 65.00	$ 827,000.00
13	10" CIPP	503	LF		$ 35,000.00
14	12" CIPP	250	LF		$ 19,000.00
15	15" CIPP	247	LF		$ 23,000.00
16	21" CIPP	1,428	LF		$ 278,000.00
17	Reinstate Service Laterals	326	EA	$ 113.50	$ 37,000.00
18	Full Lateral Rehabilitation	326	EA		$ 1,793,000.00
19	Post-Construction CCTV	24,693	LF	$ 3.00	$ 74,000.00
20	Manhole Rehabilitation	179	VF	$ 569.83	$ 102,000.00
				Construction Subtotal	*$ 3,812,000.00*
				Construction Contingency (30%)	$ 1,144,000.00
				Construction Total	$ 4,956,000.00
				Project Development & Implementation (30%)	$ 1,487,000.00
				Rehabilitation Project Cost	$ 6,443,000.00
Post-Rehabilitation Work					
21	Post-Rehabilitation Flow Metering	2	EA	$ 9,500.00	$ 19,000.00
22	Post-Rehabilitation Flow Meter Analysis	1	LS	$ 21,000.00	$ 21,000.00
				Subtotal	$ 40,000.00
				Construction Contingency (30%)	$ 12,000.00
				Construction Total	$ 52,000.00
				Total Project Cost	**$ 6,953,000.00**

Opinion of Probable Construction Cost
Project C-5: Lift Station 4 Basin RDII Reduction Program
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
Pre-Rehabilitation Work					
1	Smoke Testing	2,335	LF	$ 0.64	$ 1,500.00
2	Pre-Rehabilitation Flow Meters	1	EA	$ 9,000.00	$ 9,000.00
3	Pre-Rehabilitation Flow Meter Analysis	1	LS	$ 20,500.00	$ 20,500.00
				Subtotal	*$ 31,000.00*
				Construction Contingency (30%)	*$ 10,000.00*
				Construction Total	*$ 41,000.00*
Rehabilitation Work					
4	Mobilization	1	LS	$ 4,000.00	$ 4,000.00
5	Insurance	1	LS	$ 2,000.00	$ 2,000.00
6	Survey	1	LS	$ 1,000.00	$ 1,000.00
7	Site Clearing	1	LS	$ 1,000.00	$ 1,000.00
8	Erosion and Sediment Control Plan	1	LS	$ 500.00	$ 500.00
9	Traffic Control	1	LS	$ 1,000.00	$ 1,000.00
10	Cleaning & Pre-Construction CCTV	491	LF	$ 6.11	$ 3,000.00
11	8" CIPP	491	LF	$ 65.17	$ 32,000.00
12	Reinstate Service Laterals	4	EA	$ 125.00	$ 500.00
13	Full Lateral Rehabilitation	4	EA	$ 5,500.00	$ 22,000.00
14	Post-Construction CCTV	491	LF	$ 2.04	$ 1,000.00
15	Manhole Rehabilitation	11	VF	$ 545.45	$ 6,000.00
				Construction Subtotal	*$ 74,000.00*
				Construction Contingency (30%)	$ 22,000.00
				Construction Total	$ 96,000.00
				Project Development & Implementation (30%)	$ 29,000.00
				Rehabilitation Project Cost	$ 125,000.00
Post-Rehabilitation Work					
16	Post-Rehabilitation Flow Metering	1	EA	$ 9,000.00	$ 9,000.00
17	Post-Rehabilitation Flow Meter Analysis	1	LS	$ 21,000.00	$ 21,000.00
				Subtotal	$ 30,000.00
				Construction Contingency (30%)	$ 9,000.00
				Construction Total	$ 39,000.00
				Total Project Cost	**$ 205,000.00**

<u>Opinion of Probable Construction Cost</u>
Project C-6: Lift Station 3 Basin RDII Reduction Program
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
Pre-Rehabilitation Work					
1	Smoke Testing	51,309	LF	$ 0.70	$ 36,000.00
2	Pre-Rehabilitation Flow Meters	5	EA	$ 9,400.00	$ 47,000.00
3	Pre-Rehabilitation Flow Meter Analysis	1	LS	$ 24,000.00	$ 24,000.00
				Subtotal	*$ 107,000.00*
				Construction Contingency (30%)	*$ 32,000.00*
				Construction Total	*$ 139,000.00*
Rehabilitation Work					
4	Mobilization	1	LS	$ 256,000.00	$ 256,000.00
5	Insurance	1	LS	$ 128,000.00	$ 128,000.00
6	Survey	1	LS	$ 43,000.00	$ 43,000.00
7	Site Clearing	1	LS	$ 43,000.00	$ 43,000.00
8	Erosion and Sediment Control Plan	1	LS	$ 10,000.00	$ 10,000.00
9	Traffic Control	1	LS	$ 59,000.00	$ 59,000.00
10	Cleaning & Pre-Construction CCTV	23,297	LF	$ 6.01	$ 140,000.00
11	8" CIPP	19,504	LF	$ 65.01	$ 1,268,000.00
12	10" CIPP	1,009	LF	$ 70.37	$ 71,000.00
13	12" CIPP	1,788	LF	$ 74.94	$ 134,000.00
14	15" CIPP	996	LF	$ 94.38	$ 94,000.00
15	Reinstate Service Laterals	428	EA	$ 114.49	$ 49,000.00
16	Full Lateral Rehabilitation	428	EA	$ 5,500.00	$ 2,354,000.00
17	Post-Construction CCTV	23,297	LF	$ 3.00	$ 70,000.00
18	Manhole Rehabilitation	168	VF	$ 571.43	$ 96,000.00
				Construction Subtotal	*$ 4,815,000.00*
				Construction Contingency (30%)	$ 1,444,000.00
				Construction Total	$ 6,259,000.00
				Project Development & Implementation (30%)	$ 1,878,000.00
				Rehabilitation Project Cost	$ 8,137,000.00
Post-Rehabilitation Work					
19	Post-Rehabilitation Flow Metering	5	EA	$ 9,400.00	$ 47,000.00
20	Post-Rehabilitation Flow Meter Analysis	1	LS	$ 24,000.00	$ 24,000.00
				Subtotal	$ 71,000.00
				Construction Contingency (30%)	$ 21,000.00
				Construction Total	$ 92,000.00
				Total Project Cost	**$ 8,368,000.00**

<u>Opinion of Probable Construction Cost</u>

Project C-7: Annual Condition Rehabilitation

Oak Lodge Water Services

The following quantities are based off rehabilitation work over a 10-year period

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization	1	LS	$ 397,000.00	$ 397,000.00
2	Insurance	1	LS	$ 198,000.00	$ 198,000.00
3	Survey	1	LS	$ 66,000.00	$ 66,000.00
4	Site Clearing	1	LS	$ 66,000.00	$ 66,000.00
5	Erosion and Sediment Control Plan	1	LS	$ 35,000.00	$ 35,000.00
6	Traffic Control	1	LS	$ 213,000.00	$ 213,000.00
7	Cleaning & Pre-Construction CCTV	70,918	LF	$ 6.01	$ 426,000.00
8	CIPP (Size Varies)	70,918	LF	$ 82.45	$ 5,847,000.00
9	Reinstate Service Laterals	1127	EA	$ 115.35	$ 130,000.00
10	Post-Construction CCTV	70,918	LF	$ 3.00	$ 213,000.00
				Construction Subtotal	*$ 7,591,000.00*
				Construction Contingency (30%)	$ 2,277,000.00
				Construction Total	$ 9,868,000.00
				Project Development & Implementation (30%)	$ 2,961,000.00
				Project Cost (10-year)	$ 12,829,000.00
				Project Time Frame (Years)	10
				Annual Cost (Per Year)	$ 1,282,900.00
				Total Time Frame (Years)	20
				Total Project Cost (20-years)	$ 25,658,000.00

Opinion of Probable Construction Cost
Project C-8: Trunk A Upsizing
Oak Lodge Water Services

WSC

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization	1	LS	$ 370,000.00	$ 370,000.00
2	Insurance	1	LS	$ 186,000.00	$ 186,000.00
3	Survey	1	LS	$ 62,000.00	$ 62,000.00
4	Site Clearing	1	LS	$ 62,000.00	$ 62,000.00
5	Erosion and Sediment Control Plan	1	LS	$ 17,000.00	$ 17,000.00
6	Traffic Control	1	LS	$ 124,000.00	$ 124,000.00
7	24" Sewer Main, <10 ft deep	1,092	LF	$ 650.18	$ 710,000.00
8	24" Sewer Main, 10-15 ft deep	2,671	LF	$ 700.11	$ 1,870,000.00
	27" Sewer Main, <10 ft deep	721	LF		$ 505,000.00
9	27" Sewer Main, 10-15 ft deep	240	LF	$ 750.00	$ 180,000.00
	27" Sewer Main, 15-20 ft deep	333	LF		$ 266,000.00
10	30" Sewer Main, <10 ft deep	1,639	LF	$ 749.85	$ 1,229,000.00
11	30" Sewer Main, 10-15 ft deep	507	LF	$ 800.79	$ 406,000.00
12	30" Sewer Main, 15-20 ft deep	835	LF	$ 850.30	$ 710,000.00
13	30" Sewer Main, 25-30 ft deep	220	LF	$ 900.00	$ 198,000.00
14	Connect to Lateral	59	EA	$ 2,000.00	$ 118,000.00
				Construction Subtotal	*$ 7,013,000.00*
				Construction Contingency (30%)	$ 2,104,000.00
				Construction Total	$ 9,117,000.00
				Project Development & Implementation (30%)	$ 2,735,000.00
				Total Project Cost	$ 11,852,000.00

Opinion of Probable Construction Cost
Project C-9: Trunk Main B Upsizing
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization	1	LS	$ 324,000.00	$ 324,000.00
2	Insurance	1	LS	$ 162,000.00	$ 162,000.00
3	Survey	1	LS	$ 54,000.00	$ 54,000.00
4	Site Clearing	1	LS	$ 54,000.00	$ 54,000.00
5	Erosion and Sediment Control Plan	1	LS	$ 17,000.00	$ 17,000.00
6	Traffic Control	1	LS	$ 130,000.00	$ 130,000.00
7	15" Sewer Main, <10 ft deep	362	LF	$ 248.69	$ 90,000.00
8	18" Sewer Main, <10 ft deep	583	LF	$ 349.97	$ 204,000.00
9	18" Sewer Main, 10-15 ft deep	2,773	LF	$ 450.09	$ 1,248,000.00
10	18" Sewer Main, 15-20 ft deep	554	LF	$ 649.58	$ 360,000.00
11	18" Sewer Main, 20-25 ft deep	690	LF	$ 750.62	$ 518,000.00
12	24" Sewer Main, <10 ft deep	823	LF	$ 649.82	$ 535,000.00
13	24" Sewer Main, 10-15 ft deep	418	LF	$ 699.40	$ 292,000.00
14	24" Sewer Main, 15-20 ft deep	1,521	LF	$ 750.12	$ 1,141,000.00
15	24" Sewer Main, 20-25 ft deep	330	LF	$ 799.03	$ 264,000.00
16	24" Sewer Main, 25-30 ft deep	637	LF	$ 849.56	$ 541,000.00
17	Connect to Lateral	99	EA	$ 2,000.00	$ 198,000.00
				Construction Subtotal	*$ 6,132,000.00*
				Construction Contingency (30%)	$ 1,840,000.00
				Construction Total	$ 7,972,000.00
				Project Development & Implementation (30%)	$ 2,392,000.00
				Total Project Cost	$ 10,364,000.00

Opinion of Probable Construction Cost
Project C-10: Trunk Main 2A Upsizing
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization	1	LS	$ 61,000.00	$ 61,000.00
2	Insurance	1	LS	$ 30,000.00	$ 30,000.00
3	Survey	1	LS	$ 10,000.00	$ 10,000.00
4	Site Clearing	1	LS	$ 10,000.00	$ 10,000.00
5	Erosion and Sediment Control Plan	1	LS	$ 4,000.00	$ 4,000.00
6	Traffic Control	1	LS	$ 30,000.00	$ 30,000.00
7	15" Sewer Main, 10-15 ft deep	322	LF	$ 350.93	$ 113,000.00
8	18" Sewer Main, 10-15 ft deep	1,099	LF	$ 449.50	$ 494,000.00
9	18" Sewer Main, 15-20 ft deep	600	LF	$ 650.00	$ 390,000.00
10	Connect to Lateral	4	EA	$ 2,000.00	$ 8,000.00
				Construction Subtotal	*$ 1,150,000.00*
				Construction Contingency (30%)	$ 345,000.00
				Construction Total	$ 1,495,000.00
				Project Development & Implementation (30%)	$ 448,000.00
				Total Project Cost	$ 1,943,000.00

<u>Opinion of Probable Construction Cost</u>
Project C-11: Trunk Main C Upsizing
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization	1	LS	$ 4,000.00	$ 4,000.00
2	Insurance	1	LS	$ 2,000.00	$ 2,000.00
3	Survey	1	LS	$ 1,000.00	$ 1,000.00
4	Site Clearing	1	LS	$ 1,000.00	$ 1,000.00
5	Erosion and Sediment Control Plan	1	LS	$ 1,000.00	$ 1,000.00
6	Traffic Control	1	LS	$ 4,000.00	$ 4,000.00
7	10" Sewer Main, 10-15 ft deep	289	LF	$ 249.13	$ 72,000.00
				Construction Subtotal	*$ 85,000.00*
				Construction Contingency (30%)	$ 26,000.00
				Construction Total	$ 111,000.00
				Project Development & Implementation (30%)	$ 33,000.00
				Total Project Cost	$ 144,000.00

Opinion of Probable Construction Cost
Project C-19: Lift Station 4 Rehabilitation
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization (8%)	1	LS	$ 11,000.00	$ 11,000.00
2	Erosion Control	1	LS	$ 4,000.00	$ 4,000.00
3	Bypass Pumping	4	WK	$ 2,000.00	$ 8,000.00
4	Demolition	1	LS	$ 15,000.00	$ 15,000.00
5	Electrical and Control Kiosk	1	LS	$ 20,000.00	$ 20,000.00
6	Electrical Service, Main Breaker, and MTS	1	LS	$ 8,000.00	$ 8,000.00
7	Site Electrical	1	LS	$ 50,000.00	$ 50,000.00
8	Lift Station Pipe, Valves, & Fittings	1	LS	$ 4,000.00	$ 4,000.00
9	Gravel Borrow Fill	350	CY	$ 51.43	$ 18,000.00
10	Gravel Surfacing	160	SY	$ 12.50	$ 2,000.00
11	Operations & Maintenance Manual	1	LS	$ 2,000.00	$ 2,000.00
				Construction Subtotal	*$ 142,000.00*
				Construction Contingency (30%)	$ 42,000.00
				Construction Total	$ 184,000.00
				Project Development & Implementation (30%)	$ 55,000.00
				Total Project Cost	$ 239,000.00

Opinion of Probable Construction Cost
Project C-20: Lift Station 6 Rehabilitation
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization (8%)	1	LS	$ 34,000.00	$ 34,000.00
2	Erosion Control	1	LS	$ 4,000.00	$ 4,000.00
3	Bypass Pumping	6	WK	$ 3,500.00	$ 21,000.00
4	Demolition	1	LS	$ 30,000.00	$ 30,000.00
5	Pump Station Structural Modifications	1	LS	$ 50,000.00	$ 50,000.00
6	Electrical and Control Kiosk	1	LS	$ 8,000.00	$ 8,000.00
7	Epoxy Coating Wetwell & Discharge Man	1700	SF	$ 31.76	$ 54,000.00
8	Lift Station Pipe, Valves, & Fittings	2	EA	$ 14,000.00	$ 28,000.00
9	Chain Link Fence & Gate	300	LF	$ 56.67	$ 17,000.00
10	Electrical Service, Main Breaker, and MTS	1	LS	$ 15,000.00	$ 15,000.00
11	Instruments	1	LS	$ 10,000.00	$ 10,000.00
12	Pump Control Panel & Starters	1	LS	$ 80,000.00	$ 80,000.00
13	Pump Disconnection Pane	1	LS	$ 20,000.00	$ 20,000.00
14	Site Electrical	1	LS	$ 70,000.00	$ 70,000.00
15	Startup	1	LS	$ 8,000.00	$ 8,000.00
16	Gravel Surfacing	427	SY	$ 9.37	$ 4,000.00
17	Operations & Maintenance Manual	1	LS	$ 2,000.00	$ 2,000.00
				Construction Subtotal	*$ 455,000.00*
				Construction Contingency (30%)	$ 137,000.00
				Construction Total	$ 592,000.00
				Project Development & Implementation (30%)	$ 177,000.00
				Total Project Cost	$ 769,000.00

Opinion of Probable Construction Cost
Project P-1: Wastewater Master Plan Update
Oak Lodge Water Services

Bid Item	Description	Quantity	Unit	Unit Price	Cost
1	2027 Wastewater Master Plan Update	1	LS	$370,000.00	$ 370,000.00
2	2032 Wastewater Master Plan Update	1	LS	$370,000.00	$ 370,000.00
3	2037 Wastewater Master Plan Update	1	LS	$370,000.00	$ 370,000.00
4	2042 Wastewater Master Plan Update	1	LS	$370,000.00	$ 370,000.00
5	2047 Wastewater Master Plan Update	1	LS	$370,000.00	$ 370,000.00
6	2052 Wastewater Master Plan Update	1	LS	$370,000.00	$ 370,000.00
				Project Cost	*$ 2,220,000.00*

Appendix L CIP Project Map

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OAK LODGE WATER SERVICES

Collection System
CIP Projects

WSC

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0 0.13 0.25 0.5 Miles