DECEMBER 2022

City of Lynnwood

WWTP FACILITY PLAN

PREPARED BY RH2 ENGINEERING, INC.

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City of Lynnwood WWTP Facility Plan

DECEMBER 2022

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CERTIFICATION

This Wastewater Treatment Plant Facility Plan for the City of Lynnwood was prepared under the direction of the following professional engineers registered in the State of Washington.

12/02/2022

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Chapter 7, Section 8.6

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TABLES

CHARTS

FIGURES

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EXECUTIVE SUMMARY

The City of Lynnwood (City) Wastewater Water Treatment Plant (WWTP) provides treatment of sanitary wastewater from the City prior to discharging to Puget Sound. The most recent major expansions of the WWTP occurred in the 1980s, through which primary treatment was expanded and secondary treatment was added to the facility in two projects. Since these projects, lesser improvements have been made, although the major processes and tankage has not been changed. The purpose of this WWTP Facility Plan (Plan) is to review the overall condition of the facility and its capability to meet capacity needs and regulatory requirements through the planning period. This Plan documents these analyses and recommendations, and meets both the Engineering Report and Facility Plan requirements as described herein. The City's 2022 *General Sewer Plan* (2022 GSP) was completed concurrently with this Plan and acts as a companion to this document.

The following summaries are the essential considerations that are fundamental to the planning for this facility.

Service Area Growth

The capacity of the WWTP has not been significantly expanded or altered in over 30 years. However, the collection system population has grown significantly and is poised to grow further as planned redevelopment will densify areas within the City. The flow and loading to the WWTP associated with the projected population growth will exceed the capacity of the existing facility and an expansion of the WWTP will be necessary to support the projected growth.

Age and Condition of Existing Facility

Due to the age of the facility, major improvements are warranted to rectify the current conditions of the equipment and structures needed to perform vital treatment functions. The conditions-based needs are widespread throughout the facility. The aging incinerator is one example of a process unit necessitating replacement as it incurs high operations and maintenance costs, and it periodically violates emissions requirements. During the drafting of this Plan, the City was completing improvements to decommission the incinerator and proceed with landfill disposal of sludge as an interim measure.

New Regulations

New regulatory requirements for the WWTP are expected during the planning period. The most significant of these relate to stringent total inorganic nitrogen removal limits that are anticipated for WWTPs discharging to Puget Sound. The capacity of the WWTP secondary treatment system will be exceeded during the planning period regardless of new nitrogen removal limitations; however, the addition of these limits is a significant consideration in configuring improvements and expansion to the secondary treatment.

Peak Wet Weather Flows

In addition to the projected growth in flow and loading, a major planning element for this facility is the high peak flows that are a result of infiltration and inflow (I/I) that occurs during storm events. While the WWTP currently experiences average flows of approximately 4 million gallons per day

(MGD), peak hour flows over 20 MGD are common at the WWTP. Especially during October and April, the peak hour, daily, and weekly flows greatly exceed the average flows and impact treatment performance. Peak flows are a major consideration for both the hydraulic capacity of the WWTP and the secondary treatment system capacity necessary to meet cold weather nitrogen limits.

Site Constraints

The location and configuration of the WWTP presents significant physical constraints to expanding the WWTP. The topography of the surrounding ravine and the proximity to adjacent property lines limit the space that can be used for improvements. It should be noted that the 2022 GSP reviewed potential off-site improvements, such as construction of a new WWTP at an alternate location. However, the costs of any equivalent greenfield improvements at an alternate site within the City were found to greatly exceed improvements to the existing WWTP, and as such, this Plan focused its attention on configuring on-site WWTP improvements within the constraints of the existing site.

Current Facility Configuration and Operation

The hydraulic profile of the WWTP includes preliminary and primary treatment downhill from secondary treatment. This configuration is non-desirable as it requires pumping all primary effluent up to secondary treatment. Reconfiguration of the facility to provide the gravity flow through the main liquid stream process units is highly desirable, but such reconfiguration is further complicated by the need to maintain the operability of the existing facility during construction of any improvements. Both treatment technologies and construction phasing thoroughly considered these constraints.

Alternative Treatment Technologies

This Plan analyzed available treatment alternatives to verify the applicability to meet the requirements of all the essential planning considerations, as well as other factors described in detail in subsequent chapters. To meet the variety of drivers and constraints, technologies that provide densification of secondary treatment will be necessary and each is closely analyzed for applicability at this site. The chosen approach must utilize the latest technology and understanding of activated sludge treatment. This approach is also the most cost-effective, robust, and sustainable method to meet the City’s needs given the variety of factors analyzed in this Plan.

Recommended Approach to Improvements

This Plan details the recommended improvements with the goal of maximizing the future capacity of the facility available at the existing site as there likely will be insufficient space to make a future expansion to the WWTP footprint within the ravine. The proposed improvements are configured in a manner that intends to meet the City’s needs during the planning period as cost effectively as possible. The steps for implementing the proposed improvements are provided in detail in this Plan.

An expanded summary of the major analyses and findings from each chapter of this Plan follows.

SUMMARY OF KEY FINDINGS

Service Area and Population

The City's sewer system currently includes the majority of the City limits and serves approximately 5,900 acres. The City's sewer collection system currently includes approximately 104 miles of gravity main, 6 miles of lift station force mains, 7 lift stations, and the WWTP. Small portions of the City limits are served by the City of Mountlake Terrace or the Alderwood Water and Wastewater District.

Population forecasts were estimated by the Puget Sound Regional Council for each service area using the Land Use Vision Regional model. For the purposes of population analysis, the sewer service area was divided into four subareas. Area A consists of the area within the City of Lynnwood, Area B consists of the area within the City of Edmonds, Area C consists of the Alderwood Mall Area, and Area D consists of the Lynnwood City Center. The technical memorandum *Population and Flow Projections* prepared by BHC Consultants (BHC) (included in **Appendix D**) provides the establishment of these areas.

The sewered population served by the City was estimated by BHC using the population minus the number of residences served by a septic system and multiplying by an average of 2.59 residents per connection. The City's 2022 GSP (BHC) provides the basis for the projected growth in the collection system used in this Plan to establish projected flow and loading for the purposes of identifying future treatment needs. This Plan is intended to accompany the 2022 GSP and provide the detailed analysis and recommendations for the WWTP. **Table E-1** provides a summary of the projected population use in this Plan.

Table E-1. Baseline and Projected for Residential and Employee Populations

Population and Employment in Sewer Service Area					
Parameter	Existing (2019)	Projected 2026	Projected 2030	Projected 2040	Projected 2050
Population	42,707	49,696	53,951	64,771	74,431
Sewered Population	42,093				
Employees	29,233	32,317	32,257	45,242	49,882

1. It was assumed that all residents on septic systems will be connected to the City's sewer system by 2026.

Regulations for Surface Water Discharge

Wastewater flow and loading into the WWTP and treated plant effluent discharged to the Puget Sound are regulated through the City's National Pollutant Discharge Elimination System (NPDES) Permit, which is enforced by Ecology. The City's current revised NPDES Permit has an effective date of March 1, 2019, and an expiration date of February 29, 2024. The permitted flow and loading design criteria for the WWTP are included in **Table E-2**.

Table E-2. WWTP Permitted Flow and Loading Design Criteria

Parameter	Design Quantity
Maximum Month Design Flow (MMDF)	7.4 MGD
BOD_5 Influent Loading for Maximum Month	15,120 lb/d
TSS Influent Loading for Maximum Month	15,120 lb/d

FUTURE REGULATORY CHANGES

Ecology also has been modeling the Puget Sound to understand the nutrients contributing to the low and decreasing dissolved oxygen levels throughout Puget Sound. As a result, Ecology believes discharges of nutrients to Puget Sound from domestic WWTPs are significantly contributing to the problem, with nitrogen identified as the limiting nutrient, and inorganic nitrogen (consisting of nitrate-nitrite and ammonia) as the “biologically available” form. The City’s WWTP is included in the modeling as one of the WWTPs with an outfall to the Puget Sound.

In January 2021, Ecology released a preliminary draft of the Puget Sound Nutrient General Permit (PSNGP) for public comment, and a formal version became effective on January 1, 2022, and expires on December 31, 2026. In response, the City has filed a Notice of Intent for coverage under the PSNGP and is submitting Daily Monitoring Reports as required by the PSNGP.

In addition, the City must submit an annual Nitrogen Optimization Plan to Ecology, regardless of whether action levels are exceeded or not. All domestic WWTPs covered by the PSNGP will have individualized action levels. The City’s Total Inorganic Nitrogen (TIN) action level is 340,000 pounds per year. If the City determines that the action level has been exceeded, steps must be taken to identify possible factors, to identify modifications that can be made to improve performance, to assess different strategies that may provide better process improvements, and to document any changes made while completing correction action requirements.

Regulations for Biosolids

Chapter 173-308 WAC is the basis for the state-wide biosolids management program. Facilities that are subject to the permit program apply for coverage under the existing state-wide general permit. The City is covered under the general permit, but the program does not regulate the City’s current solids handling method of incineration. Until a new solids handling system is constructed capable of meeting the requirements of Chapter 173-308 WAC for land application, the City will dispose of dewatered sludge via landfill.

Regulations for Air Emissions

The Puget Sound Clean Air Agency (PSCAA) has jurisdiction over air emissions from the City’s WWTP. The most significant emissions requirements for the existing facility are posed by the sewage sludge incinerator. PSCAA was consulted during the analysis for this Plan, and the recommendations for compliance with air quality requirements are outlined in **Chapter 9**.

Wastewater Flow and Loading

Current flow and loading was analyzed to determine if the existing WWTP can provide adequate service to its existing customers. The projected flow and load analysis is used to identify if capacity is sufficient for future conditions.

Historical flow values are summarized in **Table E-3**.

Table E-3. Historical WWTP Flow Summary (2015-2020)

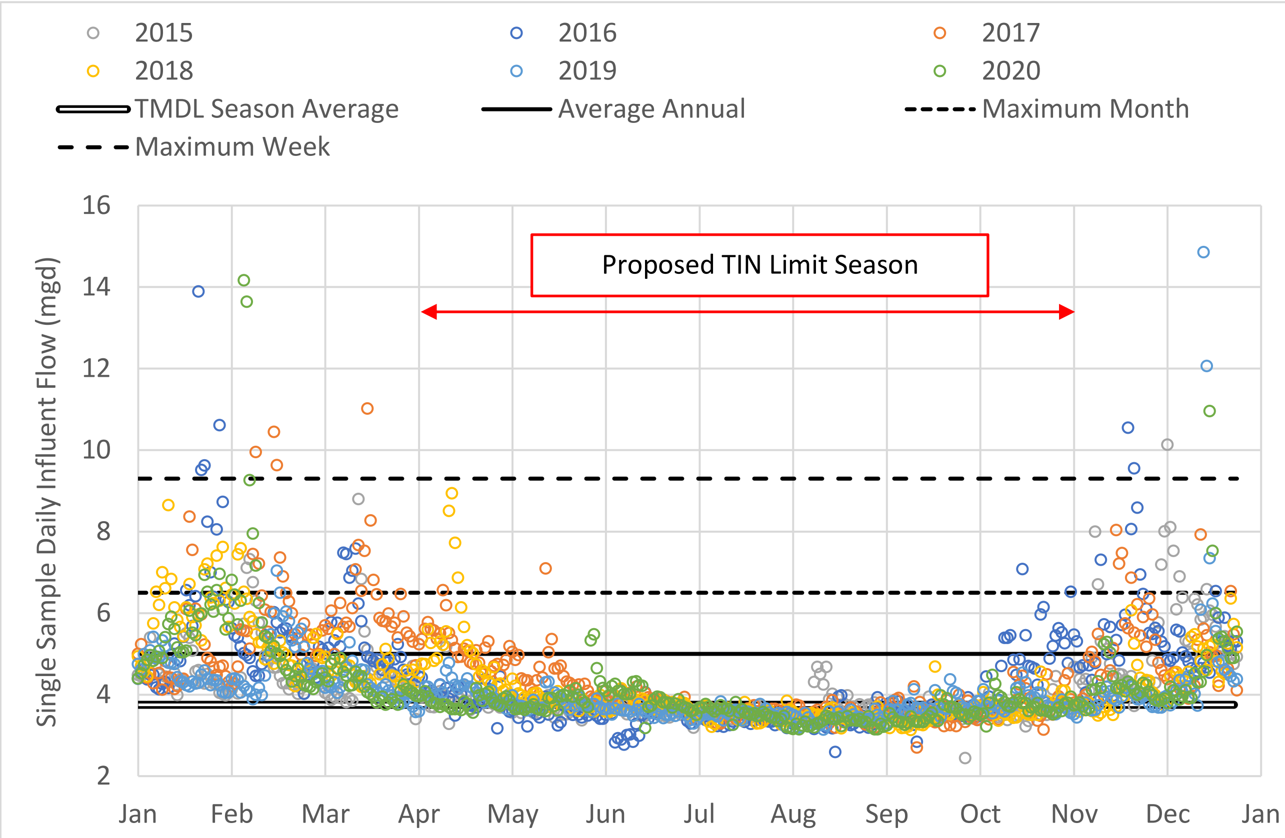
Year	Sewer System Pop.	Sewer System Employees	AA Flow (MGD)	AA Flow per Capita per Day (ppcd)	MM Flow (MGD)	Max. Month Average Flow per Capita per Day (ppcd)	Percent of NPDES Permit Max. Month Limit	Flow MM/AA Peaking Factor
2015	39,900	29,233	4.17	105	5.91	148	80%	1.42
2016	40,108	29,233	4.47	112	6.22	155	84%	1.39
2017	40,483	29,233	4.60	114	6.24	154	84%	1.36
2018	41,060	29,233	4.32	105	6.14	150	83%	1.42
2019	42,093	29,233	4.04	96	5.01	119	68%	1.24
2020	42,093	29,233	4.20	100	5.98	142	81%	1.42
2015 to 2019 Average			**4.32**	**106**	**5.90**	**145**	**---**	**1.37**

1. 2020 values are not included in the historical average due to the COVID pandemic.
2. Flow values are shown exactly as reported in the City's DMRs.
3. Projected population, employee, and flow values were calculated by BHC (Tech Memo dated November 10, 2020).

The WWTP experiences high peak flow events during periods of heavy precipitation due to high I/I in the collection system. During wet weather events, the WWTP has experienced peak hour flow events up to 20 MGD. For the purposes of planning preliminary treatment improvements, this Plan conservatively projects future peak hour flows in excess of 20 MGD.

Significant secondary treatment system improvements will be needed to meet the regulatory requirements for nitrogen reduction as a result of the PSNGP with the proposed seasonal average limit of 3 milligrams per liter (mg/L) from April 1st through October 31st. **Chart E-1** shows the historical individual daily WWTP flow values on a year over year basis for comparison to the proposed seasonal TIN limit period. As seen in the chart, the months of April and October pose potentially higher flows driven by wet weather events.

Chart E-1 – WWTP Daily Flow Values (2015-2020)



Historical loading trends for influent 5-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) were analyzed for the past 6 years (2015 through 2020) as shown in **Tables E-4** and **E-5**. The onset of the COVID-19 pandemic significantly altered the population routines in the City, and as such, the loading data from 2020 is shown for informational purposes only.

Table E-4. Historical WWTP Influent BOD_5 Loading Summary

Year	Sewer System Pop.	Sewer System Employees	AA BOD_5 (mg/L)	AA BOD_5 (lb/d)	AA BOD_5 per Capita per Day (ppcd)	MM BOD_5 (mg/L)	MM BOD_5 (lb/d)	BOD_5 MM/AA Peaking Factor
2015	39,900	29,233	241	8,188	0.21	283	8,757	1.07
2016	40,108	29,233	241	8,510	0.21	293	9,211	1.08
2017	40,483	29,233	245	8,911	0.22	299	9,694	1.09
2018	41,060	29,233	249	8,632	0.21	296	9,336	1.08
2019	42,093	29,233	279	9,177	0.22	321	9,702	1.06
2020	42,093	29,233	259	8,675	0.21	313	9,630	1.11
2015 to 2019 Average			**251**	**8,684**	**0.21**	**298**	**9,340**	**1.08**

1. 2020 values are not included in the historical average due to the COVID pandemic.
2. Population values established for 2019 also were used for 2020.
3. Employment values established for 2019 also were used for 2015 through 2020.

Table E-5. Historical WWTP Influent TSS Loading Summary

Year	Sewer System Pop.	Sewer System Employees	AA TSS (mg/L)	AA TSS (lb/d)	AA TSS per Capita per Day (ppcd)	MM TSS (mg/L)	MM TSS (lb/d)	TSS MM/AA Peaking Factor
2015	39,900	29,233	212	7,175	0.18	249	7,740	1.08
2016	40,108	29,233	206	7,299	0.18	245	7,923	1.09
2017	40,483	29,233	206	7,512	0.19	252	7,958	1.06
2018	41,060	29,233	211	7,288	0.18	249	7,605	1.04
2019	42,093	29,233	227	7,452	0.18	265	7,998	1.07
2020	42,093	29,233	214	7,172	0.17	258	7,952	1.11
2015 to 2019 Average			**212**	**7,345**	**0.18**	**252**	**7,844**	**1.07**

1. 2020 values are not included in the historical average due to the COVID pandemic.
2. Population values established for 2019 also were used for 2020.
3. Employment values established for 2019 also were used for 2015 through 2020.

From 2015 through 2020, annual average influent BOD_5 and TSS loadings show an overall moderate increase over this period. The WWTP currently has a permitted influent loading limit of 15,120 pounds per day (lb/d) for both BOD_5 and TSS per the NPDES Permit. This permit also stipulates that the City shall submit a plan and schedule for continuing to maintain capacity when the loading reaches 85 percent or more of the permitted loading values for 3 consecutive months. Over the past 6 years, the City has not exceeded this planning threshold for BOD_5 or TSS.

HISTORICAL NITROGEN LOADING DATA

With the impending PSNGP regulations, the City began monitoring influent and effluent nitrogen in 2021. Average influent nitrogen concentration and loading values for 2021 are shown in **Table E-6**.

Table E-6. Lynnwood WWTP Influent Nitrogen Loading in 2021

Quarter of 2021	Avg Flow (MGD)	Avg NH_3 (mg/L)	Avg NO_2 + NO_3 (mg/L)	Avg TIN (mg/L)	Avg TIN (lb/d)	Avg TKN (mg/L)	Avg TKN (lb/d)
Q1	4.7	16.9	3.1	20.1	779	25.2	971
Q2	3.6	25.0	3.5	28.5	851	36.7	1,094
Q3	3.3	30.9	1.4	32.3	893	41.6	1,181
Q4	4.8	23.8	1.8	25.6	972	N/A	N/A

1. NO_2 is nitrite and NO_3 is nitrate

The influent data suggests that nitrogen enters the WWTP primarily in ammonia (NH_3) form. TIN, the sum of ammonia, nitrite, and nitrate forms of nitrogen, mostly consists of ammonia. Total Kjeldahl Nitrogen (TKN) (the sum of ammonia and organic nitrogen) consists primarily of ammonia, but the data also suggests that a significant fraction of organic nitrogen is present in the influent.

For reference, average effluent nitrogen concentration and loading values during 2021 are shown quarterly in **Table E-7**.

Table E-7. Lynnwood WWTP Effluent Nitrogen Loading in 2021

Quarter of 2021	Avg Flow (MGD)	Avg NH3 (mg/L)	Avg NO2 + NO3 (mg/L)	Avg TIN (mg/L)	Avg TIN (lb/d)	Average TIN Reduction (%)
Q1	4.7	20.8	0.4	21.2	804.1	-0.03
Q2	3.6	26.8	1.0	27.8	830.1	0.02
Q3	3.3	21.4	3.6	25.0	691.8	0.23
Q4	4.8	24.2	0.4	24.6	945.5	0.03

The limited data suggests that nitrification does not reliably occur at the WWTP during cold weather months. During the warmest portion of the year, exhibited by Quarter 3, a significant drop in ammonia nitrogen occurs from influent to effluent. TIN also is reduced on average by 23 percent during this period, suggesting that some denitrification must occur.

Projected Flow and Loading

Projected flow values were calculated using the 2012 *Wastewater Comprehensive Plan Update* (referred to as the 2012 GSP in this Plan) per capita and employee rates (50 gallons per day (gpd) per capita for residential, 31 gpd per employee) for the projected 2026, 2030, 2040, and 2050 populations (refer to **Chapter 2** for a summary of population projections). The same I/I rate (300 gallons per acre per day (gpad)) also was applied to the projected future sewer service areas. A summary of the loading projections based on the population projections and per capita loading rates are summarized in **Table E-8**.

Table E-8. Flow, BOD_5 and TSS Loading Projections at WWTP

Population and Employment in Sewer Service Area					
	Existing (2019)	Projected 2026	Projected 2030	Projected 2040	Projected 2050
Population	42,093	49,696	53,951	64,771	74,431
Employees	29,233	32,317	32,257	45,242	49,882
Flow					
Annual Average Day (MGD)	4.04	5.19	5.49	6.34	6.97
Maximum Month Avg. Day (MGD)	5.01	6.64	7.03	8.12	8.92
Maximum Week Average Day (MGD)	9.25	8.80	9.31	10.75	11.81
Maximum Day (MGD)	16.53	15.72	16.64	19.21	21.11
Peak Hour (MGD)	20.13	22.20	23.50	27.14	29.82
BOD_5					
Annual Average Day (lb/d)	9,177	10,500	11,400	13,700	15,700
Concentration (mg/L)	*279*	*243*	*249*	*259*	*270*
Maximum Month Average Day (lb/d)	9,702	11,400	12,400	14,800	17,000
Concentration (mg/L)	*321*	*206*	*211*	*219*	*229*
Maximum Week Average Day (lb/d)	11,500	13,600	14,800	17,700	20,400
Concentration (mg/L)	*149*	*185*	*191*	*197*	*207*
Maximum Day (lb/d)	14,000	16,600	18,000	21,600	24,800
Concentration (mg/L)	*102*	*127*	*130*	*135*	*141*
TSS					
Annual Average Day (lb/d)	7,452	9,000	9,800	11,700	13,400
Concentration (mg/L)	*227*	*208*	*214*	*221*	*231*
Maximum Month Average Day (lb/d)	7,998	9,700	10,500	12,600	14,400
Concentration (mg/L)	*265*	*175*	*179*	*186*	*194*
Maximum Week Average Day (lb/d)	9,500	11,300	12,200	14,700	16,800
Concentration (mg/L)	*123*	*154*	*157*	*164*	*171*
Maximum Day (lb/d)	12,500	14,800	16,100	19,300	22,200
Concentration (mg/L)	*91*	*113*	*116*	*120*	*126*
TKN					
Annual Average Day (lb/d)	1,480	1,740	1,890	2,270	2,610
Concentration (mg/L)	*44*	*40*	*41*	*43*	*45*
Maximum Month Average Day (lb/d)	1,570	1,890	2,060	2,460	2,830
Concentration (mg/L)	*38*	*34*	*35*	*36*	*38*

1. Highlighted values exceed the WWTP design criteria as listed in the NPDES permit and noted in **Chapter 3**.
2. Projected population and employees were calculated by BHC (Tech Memo dated November 10, 2020).
3. All projected BOD and TSS loads have been rounded up to the nearest 100 pounds. TKN load values are rounded to the nearest 10 pounds.
4. All concentrations have been calculated from the flow and load values.
5. A conservative estimate of TKN is provided in this table based on a 6:1 ratio of influent BOD:TKN.

WWTP improvements are needed in the near term to expand and accommodate projected flow and loads. The maximum month flow is projected to exceed 85 percent of the design criteria listed in the NPDES by 2030 and 100 percent of the design criteria by 2040. The maximum month BOD_5 loading is projected to exceed 85 percent of the design criteria by 2040 and 100 percent of the design criteria by 2050.

Evaluation of Existing Facilities

Individual WWTP processes were analyzed in this Plan based on a general conditions assessment, including integrity, age, and useful life, and their capacity to pass or treat the current and projected flow and loading established in **Chapter 4**.

The current WWTP provides treatment of raw wastewater from the City's collection system and select areas of the City of Edmond's collection system prior to discharging treated effluent to Puget Sound. The WWTP consists of primary treatment, secondary treatment, disinfection, and solids incineration.

LIQUID STREAM ANALYSES

Preliminary Treatment

1. The influent pipe through Bertola Road is aging and should be evaluated for replacement where impacted by future improvements.
2. The location of the existing Parshall flume does not allow accurate influent flow measurement.
3. The existing headworks does not provide sufficient hydraulic capacity for projected peak flow conditions.
4. The existing headworks is undersized to provide sufficient space for mechanical equipment redundancy.
5. The mechanical equipment is aging and will require replacement during the planning period.

Primary Treatment

1. The primary clarifiers do not provide sufficient capacity to allow for redundancy during current or future peak flow conditions. If the WWTP remains as configured through the planning period, additional primary clarifier area or other improvements are necessary.
2. If the primary clarifier mechanisms are to remain in use through the planning period, budgeting for full replacement of the existing mechanisms is recommended.

Bypass Overflow Structure and Primary Effluent

Flows above 14 MGD bypass secondary treatment due to the capacity limitations of the secondary treatment process. While this functions satisfactorily with the current permit conditions, to meet future nutrient limits, the secondary treatment system will need to treat all flow as discussed in **Chapter 6**. The existing system is not expected to require improvements prior to the major secondary treatment system upgrade.

Main Plant Pump Station (MPPS)

The MPPS is not sufficiently sized to provide capacity for primary effluent flow higher than 14 MGD. While the MPPS functions satisfactorily with the current permit conditions, to meet future nutrient limits, the MPPS will need to be abandoned or reconfigured to allow all flow to be conveyed to the secondary treatment system. In the interim, the MPPS is not expected to require improvements prior to the major secondary treatment system upgrade.

Aeration Basins and Blowers

The future requirements for nitrogen reduction will require significant changes to the aeration basins and associated systems as discussed in **Chapter 6** and **Chapter 8**.

In the near term, the remaining centrifugal blowers will be replaced with a combination of automatically controlled screw and turbo blowers in the existing Blower Room. This work is expected to be complete in 2023.

Secondary Clarifiers and RAS

1. Replace the older removable covers with aluminum Hallsten covers (to be handled as part of the WWTP operations and maintenance (O&M) program and budget and recommended to be performed by 2030).
2. Replace components for all four cross screw sludge collector mechanisms (to be handled as part of the WWTP O&M program and budget and recommended to be performed by 2026).

Secondary Effluent Disinfection System

1. The hydraulic and treatment capacity of the chlorine contact tank will be exceeded during the planning period, necessitating expansion or replacement of the existing effluent disinfection system.
2. Replacement of the automatic composite sampler will be necessary during the planning period and will be completed as part of the normal WWTP O&M program and budget.

Chlorination and Dechlorination Systems

The chlorination and dechlorination systems function satisfactorily and provide sufficient dosing capacity. However, the systems are aging, and if they are to be maintained for usage through the planning period, they should likely be upgraded to ensure reliability and improve safety. However, WWTP staff have expressed interest in other effluent disinfection systems to reduce the handling of chlorine at the WWTP.

Plant Effluent Outfall

As a condition of the NPDES Permit, the submerged outfall pipe must be inspected each permit cycle. The existing outfall pipe and diffuser were inspected on August 16, 2021, and the recommended repairs were completed on August 31, 2021. No major concerns are noted with the outfall at this time.

SOLIDS HANDLING SYSTEM ANALYSES

Primary Sludge Conveyance

The primary sludge system is expected to be decommissioned or largely reconfigured as part of the future secondary treatment system improvements described in **Chapter 6** and **Chapter 8**.

WAS Thickening

The waste activated sludge (WAS) thickening system is expected to be decommissioned or largely reconfigured as part of the future secondary treatment system improvements described in **Chapter 6** and **Chapter 8**.

Dewatering

1. Replace the thickened sludge feed grinder, pumps (both), variable frequency drives (both), and flow meter (recommended to be performed by 2026).
2. Replace the dewatering system equipment and dewatered sludge conveyor (recommended to be performed between 2031 and 2040).
3. Analyze options and design improvements to replace the weight scales to provide accurate weight measurement of stored neat polymer (recommended to be performed by 2026).

Scum Concentrating

WWTP staff have determined through operation of the process that the scum collection basin, scum chopper pump, and scum concentrator do not have sufficient capacity. Improvements to this equipment are necessary to provide sufficient capacity and should include replacement of the scum hopper and concentrated scum pump.

Incineration System

Due to the historically high O&M costs associated with the incinerator and routine issues with meeting air quality standards, an analysis performed by Murraysmith concluded that it is more cost effective for the City to suspend incineration and proceed with hauling of dewatered sludge until a new solids handling system can be constructed. The Murraysmith report is included in **Appendix F**.

ELECTRICAL AND CONTROL SYSTEM ANALYSES

A detailed analysis of the electrical system downstream of the electrical service and standby power equipment is not provided in this Plan, as the significant WWTP improvements necessary to rectify other needs identified in the Plan are likely to completely reconfigure or replace the WWTP electrical systems. The supervisory control and data acquisition (SCADA) computer system is using software that is still relevant, and the overall computer system and network has been well maintained by both the City and SCADA consultants. Continued maintenance and updates are recommended for this system.

WWTP SITE CONSIDERATIONS

An expansion of the WWTP will be necessary to meet the needs identified in this Plan. The two most restrictive constraints for future expansion include the necessity to maintain existing WWTP operation during construction of new improvements and the physical constraints of the site that limit the developable area for new processes, as discussed in **Chapters 6** and **8**.

Evaluation of WWTP Liquid Stream Alternatives

SECONDARY TREATMENT

The analyses of the secondary treatment system are based on a PSNGP effluent TIN limit of 3 mg/L. Three technologies feasible for the WWTP were evaluated: integrated fixed film activated sludge (IFAS), membrane aerated biofilm reactor (MABR), and continuous flow reactor configured to achieve densified activated sludge (CFR-DAS). CFR-DAS was determined to have the lowest cost and the highest likelihood of success in achieving the future capacity needs and nutrient limits. It is the recommended approach for mainstream secondary treatment at the WWTP and is further developed for implementation in **Chapter 8**.

PRELIMINARY TREATMENT

As discussed in **Chapter 5**, the existing headworks is limited in hydraulic capacity to pass future peak hour flow events. It is recommended a new headworks with mechanical screening and grit removal system redundancy is constructed uphill of the existing secondary clarifiers.

Influent metering will be necessary upstream of the proposed headworks location. Influent sewer pipe can be routed in a manner that dissipates energy from the influent and aligns the flow to allow for use of an open channel meter upstream of the screening channels, outside of the proposed Headworks Building.

The future screening system must be sized to pass the projected 2050 peak hour flow of approximately 30 MGD. The existing screening system consists of a single multi-rake screen with ¼-inch bar spacing with a capacity limitation of approximately 14 MGD. The City desires a higher level of screening with the future system in addition to the increased capacity. Two-dimensional perforated plate screening would provide significantly increased screenings removal compared to the current one-dimensional bar screen. A CFR-DAS system would be adequately protected by perforated plate screenings with 6 to 9 mm openings.

The existing grit removal system consists of a single 12-foot-diameter grit chamber, grit pump, and classifier. Similar to the screening system, the future grit removal system must provide significantly increased capacity, as well as redundancy in equipment. For the peak flows experienced at the City, vortex-style grit removal in concrete channels is a standard and proven approach to grit removal and is recommended.

EFFLUENT DISINFECTION

The existing effluent disinfection system consists of a chlorine gas system and a liquid sodium bisulfate dechlorination system. The existing chlorination system is aging, and the City desires to change to an alternate disinfection system to avoid the future use of chlorine gas, which bears high costs and risks associated with the transport, storage, and handling of a hazardous material. The City considered other disinfection alternatives and settled on ultraviolet (UV) disinfection. This Plan recommends the City budget for an enclosed vessel UV system.

Evaluation of WWTP Solids Handling Alternatives

The City considered five solids handling process alternatives: enhanced anaerobic digestion; vapor recompression drying; gasification; heat drying; and autothermal thermophilic aerobic digestion (ATAD). These alternatives were evaluated against capital cost, footprint, nutrient side stream, truck traffic, 30-year O&M cost, regulatory, proven technology, staffing, process complexity, carbon dioxide generation, and total energy use.

Vapor recompression drying and heat drying were scored the highest due to their relatively compact footprint, low truck traffic, and lowest capital costs. These two technologies warranted further in-depth evaluation reviewing specific equipment, considering new criteria such as Inlet DS Concentration Sensitivity, Dewatering Requirement, and Pyrolysis Integration. Four manufacturers were considered for heat drying and one manufacturer was considered for vapor recompression drying. The Komline-Sanderson paddle wheel dryer scored the highest due to its competitive capital and O&M costs, small footprint requirement, and minimal odor control requirements and is the recommended solids handling alternative. The total 2021 US Dollar equipment cost for this recommended alternative is $7.9M, with an annual 2021 US Dollar O&M cost of $1.7M, and a total 30-year life-cycle cost of $41.0M. The recommended process, sized to meet the 2050 maximum month conditions with 85 percent uptime (310 days per year), will fit in the confined footprint at the site with fully redundant systems upstream of the dryer process.

Recommended Improvements

The recommended improvements for the City’s WWTP include:

- Replacement of the existing preliminary treatment system with a new headworks located uphill from the existing secondary clarifiers;
- Removal of the primary treatment;
- New first and second stage aeration basins;
- Improvements to the existing aeration basins and secondary clarifiers;
- Replacement of the existing solids handling system with a facility, including an indirect dryer system; and
- Replacement of the existing effluent chlorination system with a new UV disinfection system.

WWTP UPPER SITE PREPARATION

To accommodate a new headworks and additional aeration basins, the WWTP footprint will need to be expanded uphill. This will require significant clearing and grading, realignment of the existing access road and influent gravity sewer piping, and rerouting of Outfall Creek piping. The site expansion is discussed in more detail in **Chapter 8**, and the planning-level capital cost is estimated to be $19,360,000.

PRELIMINARY TREATMENT IMPROVEMENTS

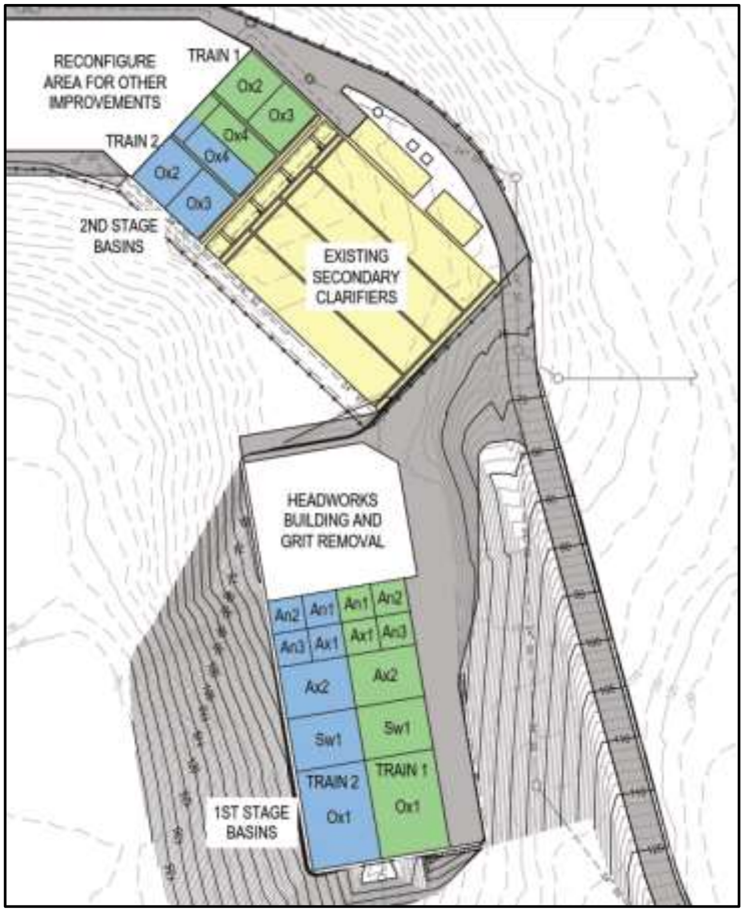
The headworks infrastructure will be designed to provide capacity for the 2050 peak hour flow of 30 MGD. The proposed headworks will be housed in a two-floor concrete building. The proposed preliminary treatment improvements are designed to have complete redundancy at the 2050 peak hour flow condition. The screening system, grit chamber, screenings washer/compactors, grit pumps, and classifiers are all sized to handle this flow with identical equipment providing 100-percent online redundancy. The planning-level cost estimate for the planning, design, permitting, and construction of the future preliminary treatment system is estimated to be $26,482,000.

SECONDARY TREATMENT IMPROVEMENTS

The secondary treatment improvements will remove the existing primary clarifiers and expand the aeration basin tankage, coupled with process control elements to facilitate CFR-DAS, and were determined to have the highest likelihood of meeting the 2050 capacity and TIN reduction requirements. For the purposes of this Plan, the proposed secondary treatment system is expected to provide capacity for secondary treatment to conventional standards (BOD and TSS) for the projected 2040 conditions and beyond.

A basic layout of the new secondary treatment system is shown in **Figure E-1**, which shows two identical trains consisting of anaerobic (Ax), anoxic (Ax), and aerobic or oxic (Ox) zones in the first stage, and activated sludge aeration basins and latter aerobic zones in the second stage. A swing (Sw) zone is also shown, which can be operated as aerobic or anoxic. The new headworks and the existing secondary clarifiers will be between the two stages of aeration basins. A new RAS system will support the proposed secondary treatment system.

Figure E-1 – Proposed Secondary Treatment System



The planning-level cost estimate for the planning, design, permitting, and construction of the future secondary treatment system is estimated to be $88,080,000.

EFFLUENT DISINFECTION IMPROVEMENTS

Enclosed vessel UV disinfection was selected over open-channel UV disinfection since an enclosed vessel UV system has siting flexibility and the enclosure of the outfall system. The enclosed UV disinfection system will be installed in either a new building or within a portion of an existing building. The UV disinfection system was sized to treat the projected 2050 peak hour flow of 30 MGD. The planning-level cost estimate for the planning, design, permitting, and construction of the future effluent disinfection system is estimated to be $10,478,000.

SOLIDS HANDLING IMPROVEMENTS

The solids handling improvements will accomplish the City's goals of fitting the new process onsite while meeting 2050 maximum month solids production. This process also will allow the City to minimize biosolids hauling truck traffic to 2 to 3 trucks per week by reliably producing 90-percent Class A biosolids. The Solids Handling Building is intended to be slab-on-grade with a metal frame and siding construction on two stories. The solids handling process is sized to account for 85 percent uptime while providing full redundancy for aerobic storage mixing/aeration, WAS thickening, and dewatering. The planning-level cost for the planning, design, permitting, and construction of the solids handling process is estimated to be $63,290,000.

SUMMARY OF COSTS AND STAFFING

Table E-9 summarizes the expected capital costs for the recommended improvements discussed in this chapter.

Table E-9. Summary of Expected Capital Costs (in millions) for Recommended Improvements

	Upper WWTP Site Preparation	Preliminary Treatment	Secondary Treatment	Effluent Disinfection	Solids Handling	Total
Project Total	**$19.4**	**$27.1**	**$88.1**	**$9.9**	**$63.3**	**$207.7**

Table E-10 summarizes the expected O&M costs for the categories of recommended improvements discussed in this chapter.

Table E-10. Summary of Expected Annual O&M Costs for Recommended Improvements

	Preliminary Treatment	Secondary Treatment	Effluent Disinfection	Solids Handling	Total
Total O&M *(Rounded up to nearest $10,000)*	**$398,000**	**$1,159,000**	**$113,000**	**$1,689,000**	**$3,359,000**

While 7.5 full-time employees (FTEs) are recommended for the operations and maintenance of the recommended improvements, it is expected that 5 more FTEs are necessary for other WWTP functions. Therefore, at the 20-year condition, 12.5 FTEs would be necessary for the WWTP.

Implementation Plan

Major improvements to the WWTP must be phased in a manner that maintains the operation of the existing WWTP. The physical constraints of the existing site, as well as the complexity of the WWTP infrastructure, will challenge the implementation of significant improvements at this site. Proposed improvement may be constructed in three phases: upper site utility work; liquid stream improvements; and solids handling.

WWTP PERMITTING

The current draft of the NPDES permit for WWTP became effective on March 1, 2019. The City must apply for renewal by August 31, 2023. The proposed improvements to the WWTP will require review and approval of an engineering report in accordance with WAC 173-240-060. This Plan is intended to meet those requirements. Construction documents for the proposed improvements will require review and approval by Ecology prior to construction in accordance with Section G5 of the NPDES Permit.

The PSNGP requires that the City prepare a Nitrogen Optimization Plan and comply with intermediate milestones. The PSNGP also requires each treatment facility to conduct a Nutrient Reduction Evaluation (NRE) during the first permit cycle. The NRE is due by December 31, 2025.

The WWTP improvements will require air emissions permitting subject to PSCAA regulations. Further, to construct the proposed WWTP improvements, coordination with and permit approvals from several regulatory agencies will be required, including the City, Ecology, Washington State Department of Archaeology and Historic Preservation, Washington Department of Fish and Wildlife, and U.S. Army Corps of Engineers.

SCHEDULE

A conceptual estimate of the overall schedule for the three phases of improvements is shown in **Figure E-2**.

Figure E-2 – Conceptual Estimate of Overall Schedule for Improvements

Task	Year (Quarter)																					
	2022				2023				2024				2025				2026				2027-2028	2029-2031
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1-4	1-4
Planning																						
Facility Plan	■																					
GSP	■	■	■	■																		
Ecology Approval					■	■																
Design & Permitting																						
Survey/Geotech					■	■	■	■														
Permitting					■	■	■	■	■	■	■	■	■	■	■	■					■	
Phase 1 Design									■	■	■	■										
Phase 2 Design									■	■	■	■	■	■	■	■						
Phase 3 Design																					■	
Construction																						
Phase 1													■	■	■	■						
Phase 2																	■	■	■	■	■	
Phase 3																						■

1 | INTRODUCTION

1.1 AUTHORIZATION

The City of Lynnwood (City) authorized RH2 Engineering, Inc., (RH2) to prepare this Wastewater Treatment Plant (WWTP) Facility Plan (Plan). The Plan meets the requirements for an "engineering report" for a domestic wastewater facility in accordance with Washington Administrative Code (WAC) 173-240-060. The Plan is additionally intended to meet the requirements of a "facility plan" as identified in WAC 173-240-060(5) and Sections G1-2.5.1 (Engineering Reports/Facility Plans) and G1-4.1 (Engineering Report/Facility Plan) of the Washington State Department of Ecology's (Ecology) *Criteria for Sewage Works Design* (commonly known as the Orange Book).

1.2 PURPOSE OF THE PLAN

The purpose of this Plan is to identify existing and future needs or deficiencies of the WWTP and recommend improvements to remedy these items. The primary factors that will drive WWTP improvements are generally conditions, capacity, and/or regulatory based, and each are briefly introduced as follows.

1.2.1 WWTP Conditions

The WWTP solids handling system has relied on an incineration system since the 1960s. The current incinerator has become increasingly costly to operate due to its age, and it has difficulties meeting regulations for air emissions. Evaluation of the future of solids handling at the WWTP was a significant driver in this Plan.

The current configuration of the liquid stream treatment system at the WWTP was largely constructed through two projects in the 1980s. The first project expanded preliminary and primary treatment at the existing WWTP. The second project added secondary treatment uphill from the previously constructed preliminary and primary treatment systems. Smaller projects have since occurred to retrofit components of the WWTP, but the major liquid stream components of the WWTP are at least 30 years old and much of it warrants improvements due to age and condition.

1.2.2 WWTP Capacity

As the population of the City's sewer service area grows and densifies, the expected flow and loading to the WWTP will exceed its rated capacity during the planning period. No substantial improvements to the WWTP capacity have been made in over 30 years; to meet the demands of growth, an increase of WWTP capacity will be necessary.

1.2.3 Future Regulations

In December 2021, Ecology issued the Puget Sound Nutrient General Permit (PSNGP), which applies to all domestic WWTPs discharging to Puget Sound. The PSNGP is Ecology's first step in regulating the discharge of nitrogen from domestic WWTPs to Puget Sound to combat the low dissolved oxygen occurrences in the sound. The PSNGP proposed an initial seasonal limit of 3 milligrams per liter (mg/L) of Total Inorganic Nitrogen (TIN) from April 1st to October 31st. Outside of this window, WWTPs would be expected to apply all known and reasonable technologies (AKART) to reduce the discharge of nitrogen. While the final limits and compliance timeline have not been developed at this time, the impact of these potential regulatory requirements must be considered in WWTP planning.

In addition to the factors of age, capacity, and regulations, this Plan devotes significant effort to analyzing the constraints of the existing WWTP site, which significantly challenges any future improvements at this location. Potential alternatives for improvements are evaluated for their ability to not only remedy the identified deficiencies but also to be constructable within the constraints of the site while maintaining current WWTP operations. The recommended improvements are identified with overall phasing and implementation strategies.

Due to the complexity of implementing large scale projects at the current WWTP, potential off-site solutions are reviewed separately from this Plan with the intent of determining if such improvements can cost-effectively reduce the improvements necessary at the WWTP. These alternatives are analyzed separately in the City's 2022 *General Sewer Plan* (2022 GSP) completed by BHC Consultants, LLC (BHC) and RH2. This Plan is devoted to analyzing all potential on-site options for improvements to the WWTP to allow the facility to provide treatment while meeting regulations at its current location through the planning period.

For reference, the current National Pollutant Discharge Elimination System (NPDES) permit issued by Ecology for the City's WWTP is included in **Appendix A**. The current version of the PSNGP also is included in **Appendix A**. The process schematic, design criteria, and hydraulic profile for the major existing liquid stream components from the original contract documents are included in **Appendix B**. An aerial photo of the existing WWTP is provided in **Exhibit C-1 WWTP Aerial** in **Appendix C**.

1.3 RELATED DOCUMENTATION

The 2022 GSP provides the basis for the projected growth in the collection system used in this Plan to establish projected flow and loading for the purposes of identifying future treatment needs. This Plan is intended to accompany the 2022 GSP and provide the detailed analysis and recommendations for the WWTP. Other applicable background documentation and planning information relevant to this Plan are as follows:

- *Population and Flow Projections Technical Memorandum* prepared by BHC (included in **Appendix D**) is used for the basis of population projections included in the 2022 GSP.

1.4 SUMMARY OF PLAN CONTENTS

A summary of the content of the chapters in this Plan is as follows:

- **Chapter 1** introduces the reader to the objectives of the Plan, background information, and the overall organization of the Plan.
- **Chapter 2** presents the projected population growth of the sewer service area.

- **Chapter 3** presents the regulatory requirements and considerations that must be addressed with future improvements.
- **Chapter 4** identifies existing wastewater flow and loading rates and projects future flow and loading rates based on the population forecasts.
- **Chapter 5** presents a capacity- and conditions-based evaluation of the existing WWTP and unit processes to identify deficiencies.
- **Chapter 6** identifies and evaluates alternatives to rectify deficiencies or meet the needs of the major liquid stream components identified in previous chapters.
- **Chapter 7** identifies and evaluates alternatives to rectify deficiencies or meet the needs of the major solids handling components identified in previous chapters.
- **Chapter 8** summarizes the recommended improvements.
- **Chapter 9** provides guidance on implementation of the recommended improvements.

1.5 LIST OF ABBREVIATIONS

Table 1-1

Abbreviations

Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
AA	average annual
AACE International	Association for the Advancement of Cost Engineers
AKART	All known, available and reasonable technologies
AMSL	above mean sea level
AO	Approval Order issued by the Puget Sound Clean Air Agency. An Approval Order is the same as a permit to construct.
BOD or BOD_5	5-day biochemical oxygen demand
CBE	Chavond-Barry Engineering Corporation
CBOD or $CBOD_5$	5-day carbonaceous biochemical oxygen demand
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CFU	colony forming units
CFU/100 mL	colony forming units per 100 milliliters
CIP	Capital Improvement Plan
City	City of Lynnwood
Code	City Municipal Code
County	Snohomish County
CWA	Clean Water Act
DI	ductile iron
DMR	discharge monitoring reports
D.O.	dissolved oxygen

Abbreviation	Definition
Ecology	Washington State Department of Ecology
Emissions unit	Any part of the WWTP that emits or would have the potential to emit a regulated air pollutant.
EPA	U.S. Environmental Protection Agency
ERU	equivalent residential unit
gpm	gallons per minute
fps	feet per second
GMA	Growth Management Act
gpad	gallons per acre day
gpcd	gallons per capita per day
gpd	gallons per day
gpd/sf	gallons per day per square foot
gpm	gallons per minute
gpy	gallons per year
GSP	General Sewer Plan
HDPE	high-density polyethylene
hp	horsepower
I/I	infiltration and inflow
kW	kilowatts
lb/hr	pounds per hour
lb O_2/hr	pounds of oxygen per hour
lb/d or ppd	pounds per day
LS	Lift Station
MCC	motor control center
Metcalf & Eddy	Wastewater Engineering Treatment and Resource Recovery, 5th Edition
MD	maximum day
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
MH	manhole
MHI	median household income
mL	milliliters
MM	maximum month
MMBtuh	Millions of British Thermal Units per hour
MPPS	Main Plant Pump Station
MW	maximum week
NAVD	North American Vertical Datum
NO_2	nitrite
NO_3	nitrate
NOAA	National Oceanic and Atmospheric Administration
NOC	Notice of Construction

Abbreviation	Definition
NOP	Nitrogen Optimization Plan
NPDES	National Pollutant Discharge Elimination System
NRE	Nutrient Reduction Evaluation
NSPS	New Source Performance Standard
NSR	new source review
O&M	operations and maintenance
OFM	Washington State Office of Financial Management
Orange Book	Washington State Department of Ecology *Criteria for Sewage Works Design*
PARIS	Permitting and Reporting Information System
PH	peak hour
PHF	peak hour flow
Plan	WWTP Facility Plan
ppcd	pounds per capita per day
PSCAA	Puget Sound Clean Air Agency
psi or psig	pounds per square inch
PSNGP	Puget Sound Nutrient General Permit
PVC	polyvinyl chloride
RACT	Reasonably Available Control Technology
RAS	return activated sludge
Reg. 1	Puget Sound Clean Air Agency Regulation 1
RCW	Revised Code of Washington
RH2	RH2 Engineering, Inc.
SCADA	supervisory control and data acquisition
SCFM	standard cubic feet per minute
SEPA	State Environmental Policy Act
sf	square foot
SLR	solids loading rate
SRT	solids retention time (aerobic)
SSI	sewage sludge incinerator
TDH	total dynamic head
TIN	Total Inorganic Nitrogen
TKN	Total Kjeldahl Nitrogen
TMDL	total maximum daily load
TP	Total phosphorus
TSS	total suspended solids
TWAS	thickened WAS
UGA	Urban Growth Area
UV	ultraviolet
µg/L	Micrograms per liter

Abbreviation	Definition
$\mu W\text{-}sec/cm^2$	microwatt seconds per centimeter squared
VFD	variable frequency drive
WAC	Washington Administrative Code
WAS	waste activated sludge
WSP	Water System Plan
WWTP	wastewater treatment plant

2 | SERVICE AREA AND PLANNING INFORMATION

Chapter 2 presents summary information regarding the service area and collection system, as well as planning information. This information is mainly for reference purposes, and is more completely represented in the City of Lynnwood (City) *Sewer Comprehensive Plan* (BHC, 2022) (2022 SCP), which is a companion document to this Facility Plan.

2.1 PLANNING PERIOD

This Facility Plan (Plan) will evaluate the wastewater treatment plant (WWTP) improvements necessary to meet future regulatory requirements identified in **Chapter 3** and rectify conditions- and capacity-based needs identified in **Chapter 5**. To accomplish this, the projected service area population is established in this chapter, and the corresponding flow and loading is estimated from these projections in **Chapter 4**.

The technical memorandum *Population and Flow Projections* prepared by BHC Consultants (BHC) in November 2020 is included as **Appendix D** and provides population and flow projections for the years 2026, 2030, 2040, and 2050. These years were established to estimate both near- and long-term growth.

For the purposes of planning, year 2050 serves as the basis of alternatives analyses for major infrastructure improvements. Major tankage and building expansions will be sized based on the year 2050 flow and loading projections, and as such, the capital cost estimates necessary for comparing alternatives are based on the 2050 conditions.

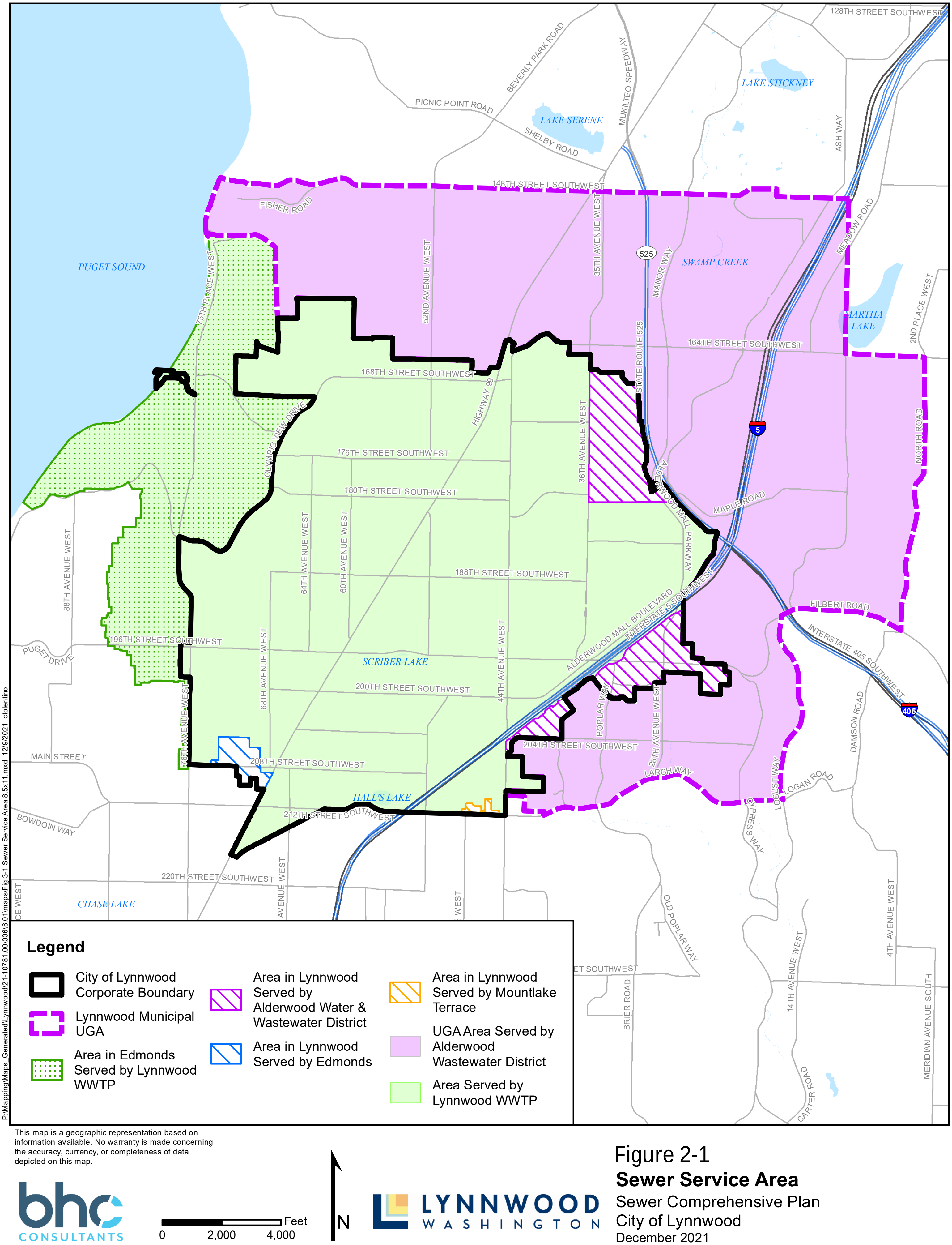
The recommended infrastructure improvements are analyzed at the 2040 condition for the purposes of estimating the design criteria necessary for sizing treatment equipment and other shorter-lived assets.

2.2 DESCRIPTION OF EXISTING SERVICE AREA AND COLLECTION SYSTEM

The City's sewer utility currently includes the majority of the City limits, and the WWTP serves approximately 5,900 acres. Small portions of the southeast sections of the City limits are served by the City of Mountlake Terrace and the Alderwood Water and Wastewater District. In addition, portions of the City of Edmonds that are outside of Lynnwood's Urban Growth Area (UGA) are served by the City's WWTP.

The Alderwood Water and Wastewater District provides sewer service in the City's UGA but outside of the City limits. The City also has a portion of its system in the southwest corner of the City limits that is conveyed and treated by the City of Edmonds. The City's Sewer Service Area map from the 2022 SCP is included as **Figure 2-1**.

The City's sewage collection system currently includes approximately 104 miles of gravity main, 6 miles of lift station force mains, 7 lift stations, and the WWTP. Wastewater is treated and disinfected at the WWTP before being discharged into the Puget Sound. The Sewer System Map from the 2022 SCP is attached as **Figure 2-2**.



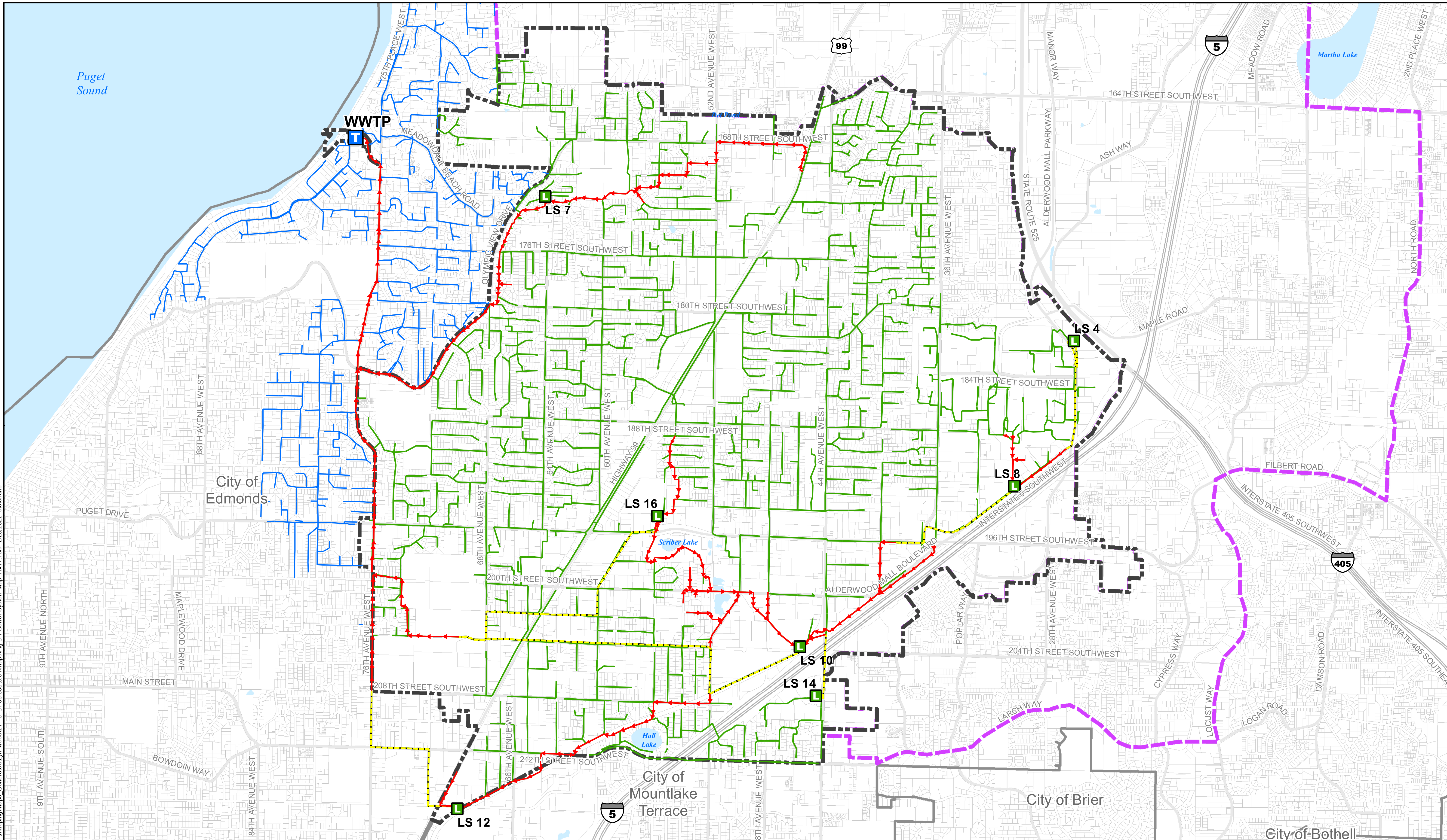
P:\Mapping\Maps_Generated\Lynnwood\21-10781.00\00616.01\maps\Fig 3-1 Sewer Service Area 8.5x11.mxd 12/9/2021 ctolentino

This map is a geographic representation based on information available. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.

bhc CONSULTANTS

LYNNWOOD WASHINGTON

Figure 2-1
Sewer Service Area
Sewer Comprehensive Plan
City of Lynnwood
December 2021



bhc CONSULTANTS

Sewer System: City of Lynnwood.
GIS Base Data: Snohomish County
This map is a geographic representation based on information available. No warranty is made concerning the accuracy, currency, or completeness of data depicted on this map.

Feet: 0 — 1,500 — 3,000

N

- T WWTP
- L Lift Station
- Force Main
- Sewer Pipes
- Edmonds Sewer Pipes
- Major Sewer Trunks
- Major Force Mains
- City of Lynnwood Corporate Boundary
- Lynnwood Municipal UGA
- Other City Boundaries

LYNNWOOD WASHINGTON

Figure 2-2
Sewer System Map
City of Lynnwood
Sewer Comprehensive Plan
February 2022

2.2.1 Existing Sewer Mains

The City's gravity main piping ranges in size from 8 inches to 36 inches in diameter, for a total of almost 104 miles. This total does not include any side sewers that are 6 inches or smaller. Gravity main materials include a majority of concrete pipes, with some polyvinyl chloride (PVC), high-density polyethylene (HDPE), ductile iron, and fiberglass reinforced plastic (FRP) pipes.

The existing lift station force mains cover almost 6 miles and range in size from 6-inch to 24-inch diameter.

2.2.2 Existing Lift Stations

The City's seven lift stations include two wet well/dry well stations, two vacuum-primed packaged stations, and three submersible stations, as follows:

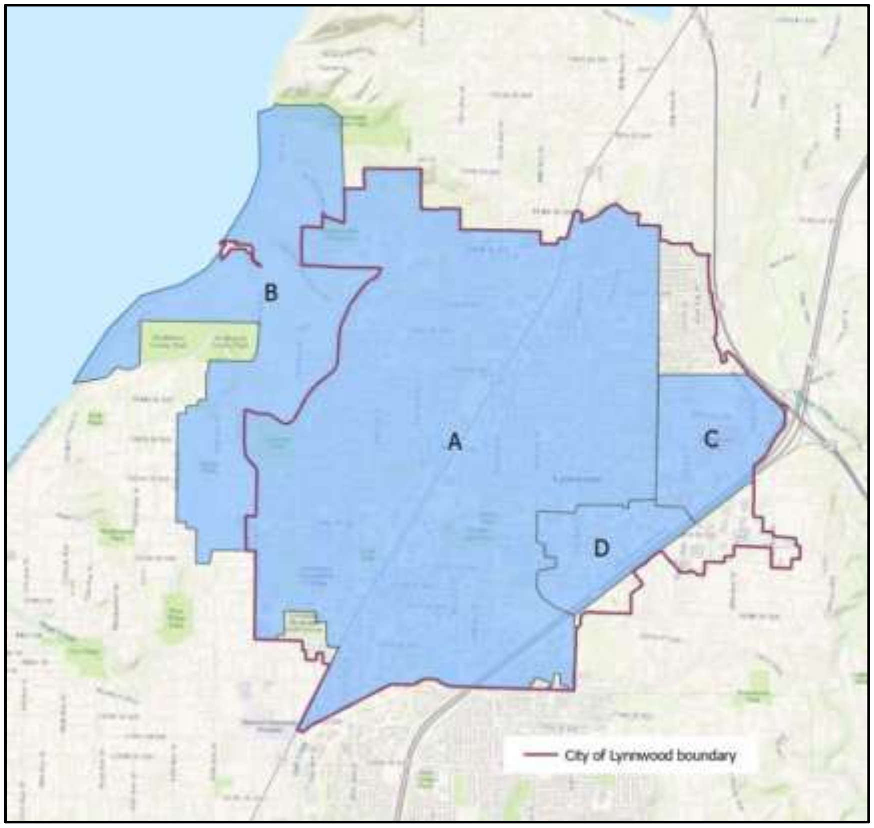
- Lift Station (LS) 4 is a two vacuum-primed packaged that is in the process of replacing aging equipment with 2 submersible Hidrostal pumps with a design capacity of 500 gallons per minute (gpm).
- LS 7 is a two vacuum-primed packaged station with a capacity of 125 gpm and 2 Smith and Loveless pumps.
- LS 8 is a submersible station that includes 4 Hidrostal pumps with a firm capacity of 3,000 gpm.
- LS 10 is a wet well/dry well type station with 4 Fairbanks Morse pumps with a capacity of 5,000 gpm.
- LS 12 is also a wet well/dry well type station with 4 Fairbanks Morse pumps. The design capacity of the station is 3,000 gpm.
- LS 14 is a two vacuum-primed packaged station with 2 Smith and Loveless pumps for a firm capacity of 210 gpm.
- LS 16 is a submersible lift station with 2 Hidrostal pumps and a firm capacity of 2,500 gpm.

2.3 POPULATION PROJECTIONS

2.3.1 Planning Area

The current sewer service area is defined in the 2022 SCP and is hatched in blue in **Figure 2-3**.

Figure 2-3 – Sewer Service Area and Planning Subareas



Courtesy of technical memorandum Population and Flow Projections prepared by BHC.

For the purposes of population analysis, the sewer service area was divided into four subareas. Area A consists of the area within the City of Lynnwood, Area B consists of the area within the City of Edmonds, Area C consists of the Alderwood Mall Area, and Area D consists of the Lynnwood City Center. **Appendix D** provides detail on the establishment of these areas and population analyses within each.

2.3.2 Historical Population Trends

Historical and baseline populations were estimated by Washington State Office of Financial Management's (OFM) Small Area Estimates Program. OFM's calculations show a steady rise in population over the period that was analyzed (2015 through 2019). The baseline population (in 2019) was estimated to be 42,707. As discussed in **Appendix D**, this is considered the most accurate estimate available until the results of the latest Census are published. The baseline employee population (in 2019) was provided by the Puget Sound Regional Council (PSRC) and was estimated to be 29,233. For the purposes of this Plan, it was assumed that the employee population has remained the same for the years 2015 through 2019.

The sewered population served by the City was estimated by BHC using the population minus the number of residences served by a septic system and multiplying by an average of 2.59 residents per connection. It was estimated that approximately 233 residences were served by septic systems for 2015 through 2018 and approximately 237 residences were served by septic systems in 2019. A summary of the historical population is shown in **Table 2-1**. For the purposes of this Plan, it was assumed that the residential and employee populations for 2020 were the same as 2019.

Table 2-1. Historical Residential and Employee Populations

Population and Employment in Sewer Service Area					
Parameter	2015	2016	2017	2018	2019 (Existing)
Population	40,503	40,711	41,086	41,663	42,707
Sewered Population	39,900	40,108	40,483	41,060	42,093
Employees	29,233	29,233	29,233	29,233	29,233

Table Notes:

1. Sewered population for 2019 was estimated from the 2019 population estimate minus the approximately 237 residences in the City's service area served by a septic system multiplied by an average of 2.59 residents per connection. Sewered population for 2015 through 2018 was estimated in a similar manner using the population from that year and the estimate of approximately 233 residences in the City's service area served by a septic system.

2.3.3 Population Projections

Population forecasts were estimated by PSRC for each service area using the Land Use Vision Regional Model. BHC modified some of these projections based on discussions with the City. It was assumed that all residents on septic systems will be connected to the City's sewer system by 2026. For more detail on the processes for establishing baseline and projected residential and employee populations, refer to **Appendix D**. A summary of the projected populations is shown in **Table 2-2**.

Table 2-2. Baseline and Projected for Residential and Employee Populations

Population and Employment in Sewer Service Area					
Parameter	Existing (2019)	Projected 2026	Projected 2030	Projected 2040	Projected 2050
Population	42,707	49,696	53,951	64,771	74,431
Sewered Population	42,093				
Employees	29,233	32,317	32,257	45,242	49,882

Table Notes:

1. It was assumed that all residents on septic systems will be connected to the City's sewer system by 2026.

3 | REGULATORY REQUIREMENTS

This chapter describes the current and anticipated future regulatory requirements for the City of Lynnwood's (City) Wastewater Treatment Plant (WWTP). The intent of this chapter is to outline regulatory requirements that can affect WWTP design criteria, the approach to treatment, and other factors to consider in long range planning for the WWTP.

3.1 REGULATIONS FOR SURFACE WATER DISCHARGE

Wastewater flow and loading into the WWTP and treated plant effluent water discharged to Browns Bay in Puget Sound are regulated through the City's National Pollutant Discharge Elimination System (NPDES) Permit.

The federal Clean Water Act (CWA, 1972, and later modifications, 1977, 1981, and 1987) established water quality goals for the navigable (surface) waters of the United States: "The objective of the CWA is the restoration and maintenance of the chemical, physical, and biological integrity of the country's water." The CWA grants individual authority to each state to define the water quality standards (within the limits set by the water quality goals) within its jurisdiction and enforce them. Water quality standards for surface waters in Washington State have been established (Chapter 173-201A Washington Administrative Code (WAC)) and are enforced by the Washington State Department of Ecology (Ecology) (Chapter 90.48 Revised Code of Washington (RCW)). The purpose of the water quality standards is to provide "public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife." Each surface water in the state is identified as fresh water or marine water and designated for one or more uses, which then determines the specific water quality standards that apply to that water.

The state also has established a permit program for implementation of the NPDES Permit Program created by the CWA. The program requires a discharge permit for any point source, such as a domestic wastewater treatment plant, and discharge of pollutants to surface waters of the state for the purpose of maintaining the water quality standards. Each permit is renewed on roughly a 5-year cycle. The permit and accompanying fact sheet include information on discharge limits, monitoring schedule, and general and special conditions that apply to the applicable point source.

The state requires that all laboratories reporting data to comply with NPDES permits must be accredited (Chapter 173-50 WAC). The WWTP on-site laboratory currently is accredited (Accreditation ID 654) for determination of the following parameters: total suspended solids; total chlorine (residual); pH; dissolved oxygen; biochemical oxygen demand; carbonaceous biochemical oxygen demand; and fecal coliform (SM 9221 E2+C and SM 9222 D).

In the future, the WWTP on-site laboratory will need to be accredited for determination of *E. coli*. Refer to the **Future Bacterial Indicator Effluent Limits** section in this chapter for the related change from fecal coliform to *E. coli* as the bacterial indicator.

The City's current revised NPDES Permit (Permit No. WA0024031) has an effective date of March 1, 2019, and expiration date of February 29, 2024. Copies of the permit and accompanying fact sheet are included as **Appendix A**. The following sections present the facility design criteria and effluent limits from the permit.

3.1.1 Facility Design Criteria

The permitted facility flow and loading design criteria for the WWTP is included in **Table 3-1**.

Table 3-1. WWTP Permitted Flow and Loading Design Criteria

Parameter	Design Quantity
Maximum Month Design Flow (MMDF)	7.4 MGD
BOD_5 Influent Loading for Maximum Month	15,120 lb/d
TSS Influent Loading for Maximum Month	15,120 lb/d

MGD = million gallons per day

3.1.2 Effluent Limits

Treated plant effluent water is discharged to Browns Bay in the Puget Sound through a piped outfall, which is designated as Outfall No. 001 in the NPDES Permit. Surface water quality standards are outlined in Chapter 173-201A WAC to protect existing water quality and preserve the beneficial uses of Washington's surface waters. This chapter outlines water quality based effluent limits and criteria specifying the maximum levels of pollutants allowed in receiving water to protect aquatic life and recreation, as well as criteria pertaining to the protection of human health. Chapter 173-221 WAC provides technology-based effluent limits for wastewater treatment plants. These regulations are performance standards that constitute all known, available, and reasonable technologies (AKART) for prevention, control, and treatment for domestic wastewater. When surface water quality based limits are more stringent than technology-based limits, the discharge must adhere to the water quality based limits. The effluent limits for Outfall No. 001, including whether the limit is water quality or technology-based, are shown in **Table 3-2**.

Table 3-2. NPDES Permit Effluent Limits

Effluent Limits for Outfall No. 001			
Parameter	**Basis of Limit**	**Average Monthly**	**Average Weekly**
Carbonaceous Biochemical Oxygen Demand (5-day) ($CBOD_5$)	Technology	25 mg/L 1,543 lb/d 85% removal of influent $CBOD_5$	40 mg/L 2,469 lb/d
Total Suspended Solids (TSS)	Technology	30 mg/L 1,851 lb/d 85% removal of influent TSS	45 mg/L 2,777 lb/d
Parameter	**Basis of Limit**	**Minimum**	**Maximum**
pH	Technology	6.0 standard units	9.0 standard units
Parameter	**Basis of Limit**	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria	Technology	200/100 mL	400/100 mL
Parameter	**Basis of Limit**	**Average Monthly**	**Maximum Daily**
Total Residual Chlorine	Water Quality	278 µg/L	728 µg/L

µg/L = micrograms per liter

3.1.3 Future Regulatory Changes

Ecology can change water quality standards or NPDES Permit effluent limits (the latter for the purpose of maintaining water quality standards). Known future changes to water quality standards and NPDES Permit effluent limits that are applicable to Outfall No. 001 at the WWTP are summarized in this section.

FUTURE BACTERIAL INDICATOR EFFLUENT LIMITS

The receiving water of the Browns Bay in Puget Sound at Outfall No. 001 is designated for Primary Contact Recreational Use (WAC 173-201A-612, Table 612). To protect water contact recreation in marine water, such as the receiving water, bacterial indicator criteria (standards) are defined (WAC 173-201A-210(3)(b)). Ecology is changing the bacterial indicator from fecal coliform to *E. coli* with an effective date of January 1, 2021. The *E. coli* and expiring fecal coliform bacterial indicator criteria are both defined in the current version of WAC 173-201A-210(3)(b).

The City's NPDES Permit has a fecal coliform bacteria effluent limit for Outfall No. 001. When the current permit expires, an *E. coli* bacteria effluent limit for Outfall No. 001 will be developed and become effective at the time of that permit renewal. Therefore, the fecal coliform bacteria effluent limit will remain effective until the permit expires.

PUGET SOUND NUTRIENT GENERAL PERMIT

Section 303(d) of the CWA establishes a process to identify and clean up surface waters that do not meet the applicable water quality standards. Every few years, Ecology performs a water quality assessment using collected data to determine whether water quality of the surface waters meets the standards. Based on the assessment, each surface water is placed into one of five categories that describes the status of the water quality and ranges from meeting the standards (Category 1) to impaired (i.e. polluted) and requiring a water improvement project (Category 5). Surface waters placed into Category 5 are listed on the state's 303(d) list of polluted waters, which is named after the referenced section of the CWA.

At certain times of the year, dissolved oxygen levels in a large number of locations throughout Puget Sound do not meet the applicable water quality standards, and in many other locations show evidence of not meeting the standards in the future. The surface waters within Puget Sound that are not meeting the dissolved oxygen standards are listed in the state's 303(d) list. Ecology initiated the Puget Sound Nutrient Reduction Project (Project) in the spring of 2017 to address the problem of human sources of nutrients contributing to the low and decreasing dissolved oxygen levels throughout Puget Sound. As a result of modeling, Ecology believes discharges of nutrients to Puget Sound from domestic wastewater treatment plants are significantly contributing to the problem. The goal of the Project is to develop a nutrient source reduction strategy, which includes reducing nutrient levels discharged from domestic wastewater treatment plants.

Ecology has been utilizing a model of Puget Sound to understand the problem and simulate potential improvements. Ecology has identified nitrogen as the limiting nutrient, with inorganic nitrogen, consisting of nitrate-nitrite and ammonia, as the "biologically available" form. Ecology is performing additional modeling for optimization scenarios; however, results from completed modeling are being used to determine effluent nitrogen permit limits for domestic wastewater treatment plants with outfalls to Puget Sound (identified as marine sources), which includes the City's WWTP. Individual NPDES permits for the same treatment plants will continue independently of, but in conjunction with, the general permit and may be modified as necessary to include facility-specific nutrient-related requirements.

In January 2021, Ecology released a preliminary draft of the Puget Sound Nutrient General Permit (PSNGP) for public comment. The public comment period ended on March 15, 2021, and Ecology has proceeded with developing a formal version, which became effective January 1, 2022 and expires December 31, 2026. The following descriptions summarize the final PSNGP, including anticipated permit limits specific to the City's WWTP.

Notice of Intent

The City has filed a Notice of Intent for coverage under the PSNGP and has started submitting Daily Monitoring Reports (DMR) as required by the General Permit and discussed below.

Optimization Requirements

Regardless of whether action levels are exceeded or not, the City must submit an annual Nitrogen Optimization Plan (NOP) to Ecology. Optimization refers to short-term actions (low cost controls and process changes) focused on improving existing performance. Optimization processes do not include large scale capital investments. The City must begin optimization immediately upon coverage under the PSNGP.

The NOP must improve the following components:

1. Treatment Process Performance Assessment

   Assess the nitrogen removal potential of the current treatment process and identify viable optimization strategies prior to implementation.

   a. Treatment Assessment. Develop a method to evaluate potential optimization approaches for the existing treatment process. This will include an evaluation of current (pre-optimization) process performance to determine the existing Total Inorganic Nitrogen (TIN) removal performance for the WWTP. The assessment must also include a list of potential optimization strategies capable of meeting the action level at the WWTP prior to starting optimization. Update the assessment and list of options as necessary with each Annual Report.

   b. Identify and Evaluate Optimization Strategies. From the list of options, identify viable optimization strategies. Prioritize and update this list as necessary to continuously maintain a working set of strategies for meeting the action level with the existing treatment processes. Any optimization strategy from the initial list that was considered but found to exceed a reasonable implementation cost or timeframe may be excluded. Documentation must include an explanation of the rationale and financial criteria used in the exclusion determination. If no viable optimization strategies exist for the current treatment processes, the City must immediately proceed to the identification of a corrective action.

c. Initial Selection. The City must select at least one optimization strategy no later than July 1, 2022. The expected performance (i.e. % TIN removal or a calculated reduction in effluent load or concentration) for the initial optimization strategy must be documented prior to implementation.

2. Optimization Implementation

   The City must document implementation of the selected optimization strategy, which includes the following:

   a. Strategy Implementation. Describe the initial implementation costs, length of time to implement (include starting date), adaptive management necessary for refining implementation, anticipated and unanticipated challenges, and impacts to overall treatment processes due to optimization process changes.

   b. Discharge Evaluation. By March 31st of each year (beginning in 2023), the City must review effluent data to determine average annual TIN concentration, load, and the TIN removal rate of the WWTP. Annual loads exceeding the action level will require corrective actions.

3. Influent Nitrogen Reduction Measures/Source Control

   The City must include documentation of investigation into opportunities to reduce influent TIN loads. Investigations must include a review of non-residential sources of nitrogen and the identification of pretreatment opportunities, as well as potential strategies for reducing TIN from new multi-family/dense residential developments and commercial buildings.

Action Levels

All domestic wastewater treatment plants covered by the PSNGP will have individualized action levels. These action levels represent TIN mass loading thresholds, which will require action from the City if they are exceeded.

Ecology took a minimum of 3 years' worth of TIN loading data and sampled it using a method called "bootstrapping." Bootstrapping means a data point is randomly selected from a set of data and "put back" into the set (i.e. data points might be selected more than once). This random selection is performed N times, where N is the total number of data points. A single "bootstrap sample" is a set of N randomly selected samples. Ecology performed a large number of bootstrap samples, took the average value of each bootstrap, and arranged these averages from smallest to largest. The chosen action level is equal to the 99th percentile of this set of averages. This means, if a treatment plant continues its pattern of historical nutrient loading, there is theoretically only a 1-percent chance that the nutrient loading of a future year exceeds the action level.

Ecology calculated the following action level values for the City:

Lynnwood TIN Action Level = **340,000 pounds per year**.

If the City determines in the Annual Report that the action level has been exceeded, the following steps must be taken:

1. Identify possible factors that caused the exceedance.
2. Identify whether modifications to the optimization strategy can improve performance.
3. Assess whether different strategies may provide better process improvements.

4. Document any changes to the optimization strategy made while completing corrective action requirements. New strategies will include a detailed description of the modified strategy and an implementation schedule. If no changes are made to the optimization strategy, the City must justify the rationale for not making changes.

With the subsequent Annual Report, the City would then need to prepare an engineering report or technical memorandum outlining the proposed approach for reducing the annual effluent load below the action level (unless Ecology has already approved a design document with a proposed solution). The engineering document must include:

1. A brief summary of alternatives considered and why the chosen alternative was selected. Alternatives analysis should include cost estimates for operation and maintenance;
2. Basic design information, including influent characterization;
3. A description of the proposed treatment approach and operation, including updates to the WWTP's process flow diagram;
4. Anticipated results from the proposed approach, including expected effluent quality; and
5. Certification by a licensed professional engineer.

If the City were to exceed the action level 2 years in a row, or for a third year during the permit term, it would be required to begin reducing nitrogen loads by implementing the proposed approach outlined in the engineering document. Updates to the WWTP Operation and Maintenance Manual would need to be submitted within 6 months following implementation.

Nutrient Reduction Evaluation

Treatment plants also will be required to conduct a Nutrient Reduction Evaluation (NRE) during the first permit cycle, which will build on the NOP. However, if the City maintains an annual average TIN concentration below 10 milligrams per liter (mg/L), it may submit a truncated NRE. If the City maintains an annual average below 10 mg/L and a seasonal (October through April) average below 3 mg/L, it will not have to submit an NRE. The NRE is due by December 31, 2025.

The NRE must include an analysis of AKART alternatives capable of reducing TIN. The analysis must select an alternative that has the greatest potential for TIN reduction and is reasonably feasible to implement. Main stream treatment plant upgrades, applicability of side stream treatment opportunities, alternative effluent management options, viability of satellite treatment, and nutrient reduction options that could lower final effluent TIN concentration below 3 mg/L must be assessed. The analysis must be sufficiently complete that an engineering report may be developed for the preferred AKART alternative and the preferred alternatives to reach 3 mg/L TIN seasonally, without substantial alterations of concept or basic considerations. The final report must contain appropriate requirements as described in Ecology's *Criteria for Sewage Works Design* (Orange Book) (2019) and *Reclaimed Water Facilities Manual: The Purple Book* (2019).

The NRE analysis must include the following:

1. Wastewater Characterization – Current flow rates, growth trends, and influent/effluent quality.
2. Treatment Technology Analysis

   a. Description of current treatment processes, including any modifications made for optimization or due to corrective actions.
   b. Description of site limitations, constraints, or other treatment implementation challenges that exist.
   c. Identification and screening of potential treatment technologies for meeting two different levels of treatment: AKART for nitrogen removal (annual basis); and 3 mg/L TIN (or equivalent load) as a seasonal average (April through October).
3. Economic Evaluation
   a. Develop capital, operation, and maintenance costs and 20-year net present value using the real discount rate for each technology alternative evaluated.
   b. Provide cost per pound of nitrogen removed.
   c. Provide details on basis for current wastewater utility rate structure, including how utilities allocate and recover costs from customers, how frequently rate structures are reviewed, the last time rates were adjusted, and the reason for adjustment.
   d. Provide impact to current rate structure for each alternative assessed.
4. Environmental Justice Review
   a. Evaluate the demographics within the sewer service area to identify communities of color, Tribes, indigenous communities, and low income populations.
   b. Identify areas within the service area that exceed the median household income.
   c. Include an affordability assessment to identify how much overburdened communities can afford to pay for the wastewater utility.
   d. Propose alternative rate structures or measures that can be taken to prevent adverse effects of rate increases on populations with economic hardship.
   e. Provide information on how recreational and commercial opportunities may be improved for communities as a result of the treatment improvements identified.
5. Select the most reasonable treatment alternative based on the AKART assessment and the alternative for achieving an effluent concentration of 3 mg/L TIN (or equivalent load reduction) based on an April through October seasonal average.
6. Provide viable implementation timelines that include funding, design, and construction for meeting both the AKART and seasonal average 3 mg/L TIN preferred alternatives.

Monitoring Requirements

The PSNGP will create additional monitoring requirements for the City. These requirements do not replace any requirements stipulated in the City's NPDES Permit. The City will need to comply with both permits separately. Recorded monitoring data should be submitted monthly on the electronic DMR form to be provided by Ecology within the Water Quality Permitting Portal. The City may use the same sample for the NPDES Permit and the PSNGP, but it must still prepare two separate monthly DMR submittals (one for each permit). A summary of the anticipated monitoring requirements under the PSNGP and a comparison to the City's NPDES Permit can be found in **Tables 3-3** and **3-4**.

Table 3-3. Comparison of City NPDES Permit and PSNGP Monitoring Requirements for WWTP Influent

Parameter	Units and Speciation	Minimum Sampling Frequency (NPDES)	Minimum Sampling Frequency (PSNGP)	Sample Type
$CBOD_5$	*mg/L*	5/week	1/week	24-hour composite
Total Ammonia	*mg/L as N*	---	1/week	24-hour composite
Nitrate plus Nitrate	*mg/L as N*	---	1/week	24-hour composite
Total Kjeldal Nitrogen	*mg/L as N*	---	1/week	24-hour composite

Green shading indicates the more stringent of the two permit requirements

Table 3-4. Comparison of City NPDES Permit and PSNGP Monitoring Requirements for WWTP Effluent

Parameter	Units and Speciation	Minimum Sampling Frequency (NPDES)	Minimum Sampling Frequency (PSNGP)	Sample Type
Flow	*MGD*	**Continuous**	**Continuous**	Metered/recorded
Total Monthly Flow	*MG*	---	1/month	Metered/recorded
$CBOD_5$	*mg/L*	5/week	1/week	24-hour composite
Total Organic Carbon	*mg/L*	---	1/week	24-hour composite
Total Ammonia	*mg/L as N*	Quarterly	1/week	24-hour composite
Nitrate plus Nitrate	*mg/L as N*	Quarterly	1/week	24-hour composite
Total Kjeldal Nitrogen	*mg/L as N*	Quarterly	1/week	24-hour composite
Total Inorganic Nitrogen (TIN)	*mg/L as N*	---	1/week	Calculated
TIN	*ppd*	---	1/week	Calculated
Average Monthly TIN	*lbs*	---	1/month	Calculated
Annual TIN, year to date	*lbs*	---	1/month	Calculated

Green shading indicates the more stringent of the two permit requirements

The City must submit monthly monitoring data using Ecology's WQWebDMR program by the 15th day of the following month. Any pollutant monitoring data collected more frequently than the permit stipulates must be used in calculations and submitted in the DMR.

Annual reports will be due by March 31st of the following year and will be submitted using Ecology's Water Quality Permitting Portal. The report will include a description of the status of the permit requirements, attachments, including summaries, descriptions, and reports, and other applicable information. Additionally, the annual report must answer the questions listed in Appendix D of the PSNGP.

After 12 months of monitoring, the City may request a reduction in sampling frequency from Ecology if it can demonstrate that the distribution of concentrations can be accurately represented with a lower frequency.

Additional Requirements

The City must retain records of monitoring information or documentation pertaining to permit requirements for a minimum of 5 years following termination of permit coverage. If the City is unable to comply with the conditions of the permit, it must notify Ecology within 24 hours and submit a written report to Ecology via the WQWebPortal within 5 days describing the noncompliance event and duration, and how steps will be taken to correct it. The City must keep the following documentation onsite or within reasonable access to the site: permit coverage letter, PSNGP, DMRs, and attachments to the Annual Report and Nitrogen Optimization Plan.

3.2 REGULATIONS FOR BIOSOLIDS

Chapter 173-308 WAC is the basis for the state-wide biosolids management program. Facilities that are subject to the permit program apply for coverage under the existing state-wide general permit. The state biosolids program regulates facilities that produce, treat, or land apply sewage sludge or biosolids for beneficial use. The City is covered under the general permit, but the program does not regulate the City's current solids handling method of incineration. As discussed in subsequent chapters, the City intends to decommission its existing incineration system. Until a new solids handing system is constructed capable of meeting the requirements of Chapter 173-308 WAC for land application, the City will dispose of dewatered sludge via landfill.

Biosolids quality is measured using three parameters: pathogen reduction, vector attraction reduction, and pollutant concentration. Pathogen reduction uses accepted treatment processes or requires measurement of pathogen concentration to determine compliance. To receive classification as Class B biosolids, a two-log (99-percent) reduction of pathogens/indicator organisms is required, with additional site management/access restrictions being required if the biosolids are applied to the land. To receive classification as Class A biosolids, biosolids must go through a more rigorous process called a Process to Further Reduce Pathogens. This reduces pathogens below detectable limits. Operators must test all Class A biosolids for pathogens and indicator organisms.

Vector attraction is related to odor control, and can be thought of as the appeal that the biosolids present to organisms (e.g., flies) that may transmit pathogens, if pathogens were present in the biosolids. Reduction of vector attraction can be achieved through lime stabilization, reducing volatile solids content, or physical mixing processes.

Pollutant concentration refers to the pollutant limits established in WAC 173-308-160. This sets a ceiling concentration limit for each pollutant, meaning the maximum allowable concentration in biosolids. It also lists the pollutant concentration limit, which is lower than the ceiling limit. Biosolids with pollutants above the pollutant concentration limit are subject to cumulative loading limits on application sites.

The City's existing solids handling system is discussed in **Chapter 5**. Proposed solids handling improvements are discussed in **Chapters 7** and **8**.

3.3 REGULATIONS FOR AIR EMISSIONS

Puget Sound Clean Air Agency (PSCAA) has jurisdiction over air emissions from the existing facility. The most significant air emissions requirements for the existing facility are posed by the sewage sludge incinerator. Other more minor points of emission within the WWTP are also regulated. PSCAA was consulted during the analysis for this Plan and the recommendations for compliance with applicable air quality requirements for the improvements proposed in this Plan are outlined in **Chapter 9**.

3.4 PLANNING REQUIREMENTS AND OTHER CONSIDERATIONS

The existing facility is located within the City limits, which is a small, annexed portion of City of Lynnwood jurisdiction that is otherwise surrounded by the City of Edmonds. The facility is situated towards the bottom of a ravine that contains steep slopes and a regulated watercourse, Outfall Creek. The facility is adjacent to Puget Sound, which is regulated as a Shoreline of the State, and both a state and federally regulated waterbody. Improvements to and/or expansion of the existing facility may require coordination with the following agencies/stakeholders.

- City of Lynnwood
- City of Edmonds
- Washington Department of Fish and Wildlife
- Ecology
- Washington State Department of Archaeology and Historic Preservation
- Washington State Department of Natural Resources (DNR)
- US Army Corps of Engineers
- National Marine Fisheries Service and US Fish and Wildlife Service
- Tulalip Tribes and the Muckleshoot Indian Tribe

Exhibit C-2 Existing Site Overview in **Appendix C** provides the jurisdictional information and known geohazards and biological resources for the existing WWTP. The detailed evaluation of the permitting requirements associated with any future improvements are described in **Chapter 9**.

4 | WASTEWATER FLOW AND LOADING

A detailed analysis of flow and loading is crucial to the planning efforts of a sewer service provider. This Wastewater Treatment Plant (WWTP) Facility Plan (Plan) analyzes current flow and load to determine if the existing WWTP, can provide adequate service to its existing customers. The projected flow and load analysis is used to identify if the WWTP capacity is sufficient for future conditions. This chapter provides a high-level comparison of flow and loading to the existing WWTP design criteria as listed in the City of Lynnwood's (City) National Pollutant Discharge Elimination System (NPDES) Permit issued by the Washington State Department of Ecology (Ecology). **Chapter 5** includes an analysis of unit process capacities based on the flow and loading developed in this chapter.

Several different flow and load scenarios were analyzed in this chapter, including the following:

- Annual average day (AA) – The daily average of flow and loading values in a single year.
- Maximum month average day (MM) – The daily average of flow and loading values during the maximum month.
- Maximum week average day (MW) – The daily average of flow and loading values during the maximum week.
- Maximum (or peak) day (MD) – The flow and load values during the maximum day of each year.
- Peak hour flow (PHF) – The flow (load not analyzed at peak hour) during the peak hour of each year.

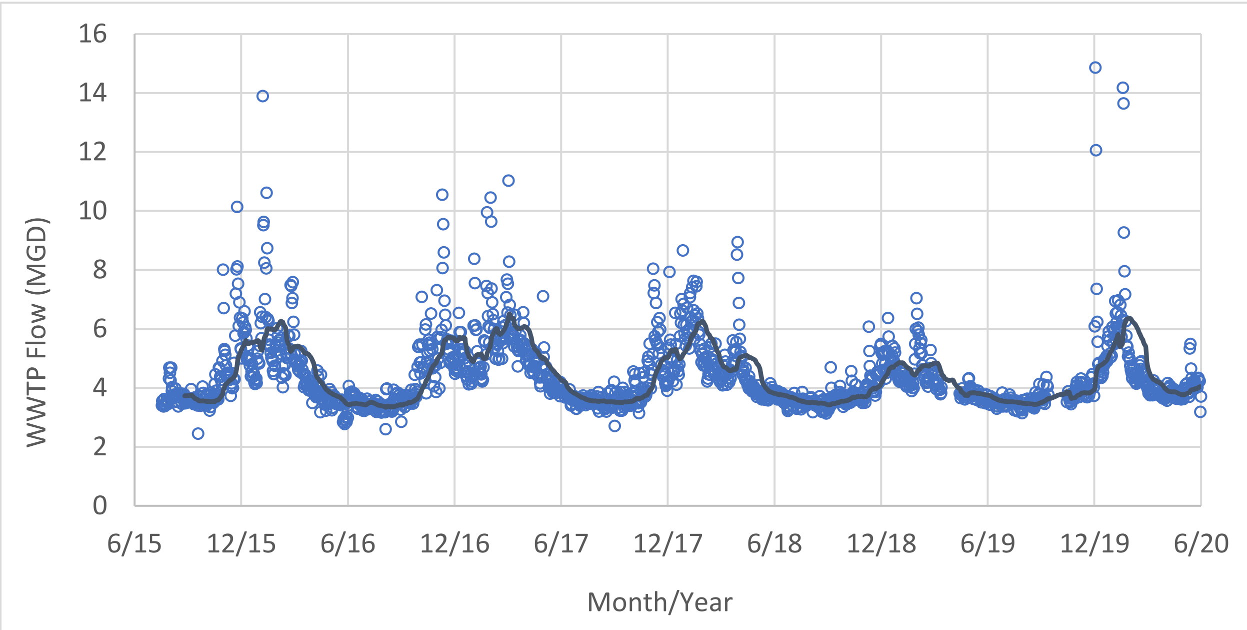
In this Plan, the 5-day biochemical oxygen demand (BOD_5) is used to estimate organic loading, total suspended solids (TSS) is used for solids loading, and total Kjeldahl nitrogen (TKN) is used for nitrogen loading. TKN includes organic and ammonia nitrogen, which are typically the largest components of influent total nitrogen.

4.1 HISTORICAL FLOW AND LOADING

4.1.1 Historical Flow

Chart 4-1 graphically displays the measured daily WWTP flow values from 2015 to 2020.

Chart 4-1 – Lynnwood WWTP Daily Flow Values (2015-2020)



As shown in the chart, the normal flow trend for the WWTP shows an increase in average flow during the wet weather period of October through April followed by dry weather flows from May through September. Wet weather flow events that are significantly above the normal flow trend occur approximately 10 to 20 days out of the year.

The historical WWTP flows are summarized in **Table 4-1**.

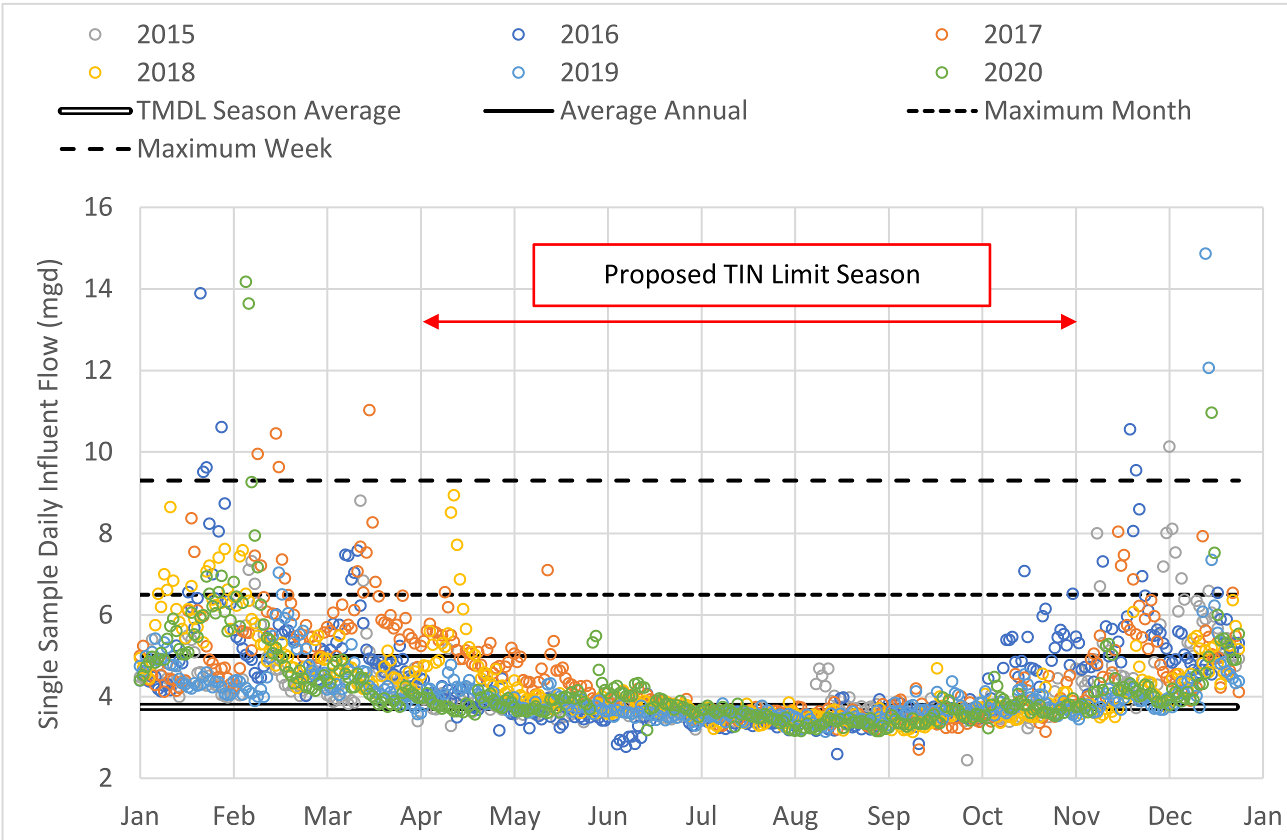
Table 4-1. Historical WWTP Flow Summary (2015-2020)

Year	Sewer System Pop.	Sewer System Employees	AA Flow (MGD)	AA Flow per Capita per Day (ppcd)	MM Flow (MGD)	Max. Month Average Flow per Capita per Day (ppcd)	Percent of NPDES Permit Max. Month Limit	Flow MM/AA Peaking Factor
2015	39,900	29,233	4.17	105	5.91	148	80%	1.42
2016	40,108	29,233	4.47	112	6.22	155	84%	1.39
2017	40,483	29,233	4.60	114	6.24	154	84%	1.36
2018	41,060	29,233	4.32	105	6.14	150	83%	1.42
2019	42,093	29,233	4.04	96	5.01	119	68%	1.24
2020	42,093	29,233	4.20	100	5.98	142	81%	1.42
2015 to 2019 Average			**4.32**	**106**	**5.90**	**145**	**---**	**1.37**

1. 2020 values are not included in the historical average due to the COVID pandemic.
2. Flow values are shown exactly as reported in the City's DMRs.
3. Projected population, employee, and flow values were calculated by BHC (Tech Memo dated November 10, 2020).

Significant secondary treatment system improvements will be needed to meet the regulatory requirements for nitrogen reduction discussed in **Chapter 3** with the proposed seasonal average limit of 3 milligrams per liter (mg/L) from April 1st through October 31st. The flow and loading in this period, as well as other parameters, will be critical to the analysis of secondary treatment improvements for nitrogen removal. **Chart 4-2** shows the historical individual daily WWTP flow values on a year over year basis for comparison to the proposed seasonal Total Inorganic Nitrogen (TIN) limit period.

Chart 4-2 – WWTP Daily Flow Values (2015-2020)



As is evident in the chart, the months of April and October pose potentially higher flows, driven by wet weather events, then the remainder of the proposed seasonal TIN limit. Also included are the approximate current baseline flows during the proposed seasonal TIN limit, as well as annual average, maximum month, and maximum week conditions.

Maximum day flows over 14 million gallons per day (MGD) have occurred infrequently as shown in the chart. Historical peak flow events are further analyzed in the following section

HISTORICAL PEAK FLOW ANALYSES

The WWTP experiences high peak flow events during periods of heavy precipitation due to high infiltration and inflow (I/I) in the collection system. **Table 4-2** tabulates the highest WWTP flow events, at various intervals from peak hour to peak week, for each year from 2016 to 2020.

Table 4-2. Lynnwood WWTP Peak Flow Events (2016-2020)

1-hr Flow (MGD)		3-hr Flow (MGD)		6-hr Flow (MGD)		12-hr Flow (MGD)		1-day Flow (MGD)		2-day Flow (MGD)		7-day Flow (MGD)	
> 15 MGD		> 12 MGD		> 10 MGD		> 10 MGD		> 8 MGD		> 8 MGD		> 8 MGD	
Date	MGD	Date	MGD	Date	MGD	Date	MGD	Date	Flow	Date	Flow	Date	Flow
2016													
1/21	17.9	1/21	17.6	1/21	17.1	1/21	16.2	1/22	14.0	1/23	11.8	1/28	9.0
2017													
3/18	15.1	3/18	14.8	3/18	14.4	3/18	13.2	2/16	11.9	2/17	10.3	-	-
2018													
-	-	-	-	4/15	10.5	4/15	10.0	4/15	9.8	4/16	8.9	-	-
2019													
12/21	18.9	12/21	18.6	12/21	18.1	12/21	17.3	12/21	16.6	12/22	13.5	12/26	8.2
2020													
2/5	19.6	2/5	19.1	2/5	18.4	2/6	16.8	2/6	16.2	2/7	14.0	2/12	9.3

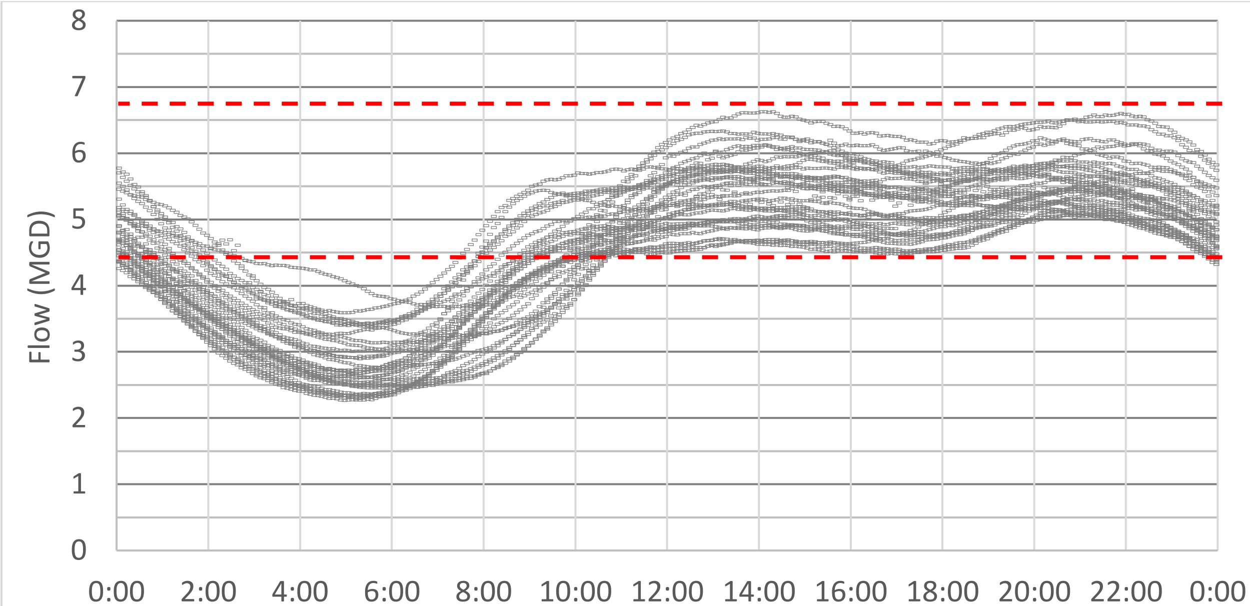
Note: If minimum peak flow threshold is not exceeded (i.e. >15 MGD for peak hour), no value is reported for that year (i.e. year 2018).

During wet weather events, the WWTP has witnessed peak hour flow events of approximately 20 MGD and experienced sustained peaks above 18 MGD for up to 6 hours. The peak flow events in 2018 and 2019 produced a WWTP peak hour flow of approximately 19 to 20 MGD. Further, this peak was maintained for approximately 3 hours before gradually declining. This may be indicative of inherent physical limits of the collection system to receive or pass flows substantially above 20 MGD. For the purposes of planning preliminary treatment improvements and other processes that are primarily sized for peak hydraulic events, this chapter conservatively projects future peak hour flows in excess of 20 MGD.

HISTORICAL WWTP DIURNAL CURVE

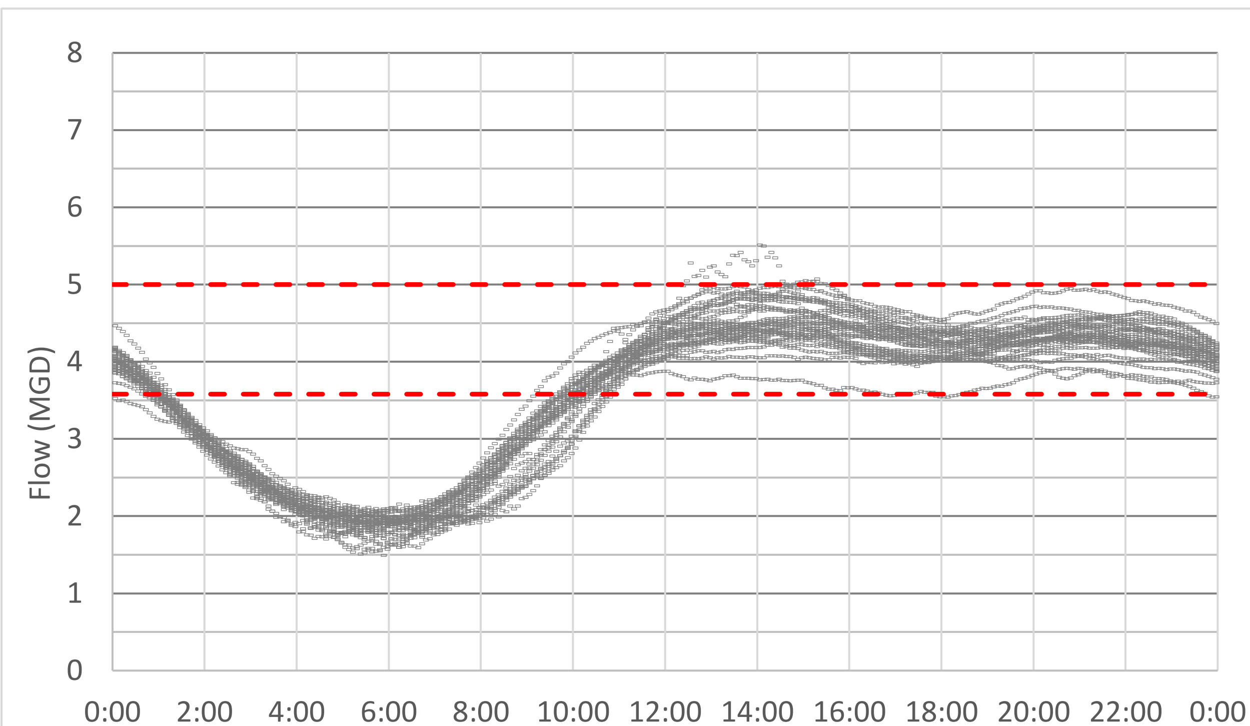
To perform analyses of secondary treatment systems in subsequent chapters, the typical diurnal curve for the WWTP must be developed to evaluate the typical intraday flow variations. WWTP flow is measured continually throughout the day, which allows for daily diurnal flow curves to be produced. Organic, solids, and nutrient loading is not measured on an intraday basis; therefore, the diurnal loading for these parameters is generally assumed to occur proportional to flow. **Chart 4-3** includes the 2-hour rolling average flow rate for each day in January 2019, and **Chart 4-4** includes the 2-hour rolling average flow rate for each day in August 2020.

Chart 4-3 – Lynnwood 2-Hour Rolling Average Flow Curves for Each Day of January 2019



Extracted from SCADA data on 5-minute intervals and averaged over 2 hours.

Chart 4-4 – Lynnwood 2-Hour Rolling Average Flow Curves for Each Day of August 2020



Extracted from SCADA data on 5-minute intervals and averaged over 2 hours.

These charts exhibit typically daily 2-hour average flow curves during the wet season and dry season, respectively. The average daily flow for January 2019 was 4.56 MGD, which is near to the current maximum month average day flow of 5 MGD. The 2-hour rolling average flow rate peaks at over 6.5 MGD, as shown in **Chart 4-3**. This represents a peak diurnal to average day factor of 1.42.

The average daily flow for July 2020 was 3.58 MGD. **Chart 4-4** shows the 2-hour rolling average flow rate peaks at approximately 5 MGD, except for one day in which it peaked near 5.5 MGD. To characterize the normal condition, the 2-hour rolling average peak of 5 MGD is used. This represents a peak diurnal to average day factor of 1.39.

To be conservative, a factor of 1.5 is used for planning to estimate the peak diurnal flow and loading condition compared to the average daily flow and loading.

4.1.2 Historical Organic and Solids Loading

RH2 Engineering, Inc., (RH2) analyzed the past 6 years (2015 through 2020) of data from the City's Discharge Monitoring Reports (DMRs) to establish historical loading trends for influent BOD_5 and TSS. This information, along with residential population and employment values from **Chapter 2**, are summarized in **Table 4-3** and **Table 4-4**, respectively. The onset of the COVID-19 pandemic significantly altered the population's routines, and as such, the loading data from 2020 is shown for informational purposes but is not used as a baseline for loading projections in this Plan.

Table 4-3. Historical WWTP Influent BOD_5 Loading Summary

Year	Sewer System Pop.	Sewer System Employees	AA BOD_5 (mg/L)	AA BOD_5 (lb/d)	AA BOD_5 per Capita per Day (ppcd)	MM BOD_5 (mg/L)	MM BOD_5 (lb/d)	BOD_5 MM/AA Peaking Factor
2015	39,900	29,233	241	8,188	0.21	283	8,757	1.07
2016	40,108	29,233	241	8,510	0.21	293	9,211	1.08
2017	40,483	29,233	245	8,911	0.22	299	9,694	1.09
2018	41,060	29,233	249	8,632	0.21	296	9,336	1.08
2019	42,093	29,233	279	9,177	0.22	321	9,702	1.06
2020	42,093	29,233	259	8,675	0.21	313	9,630	1.11
2015 to 2019 Average			**251**	**8,684**	**0.21**	**298**	**9,340**	**1.08**

1. 2020 values are not included in the historical average due to the COVID pandemic.
2. Population values established for 2019 also were used for 2020.
3. Employment values established for 2019 also were used for 2015 through 2020.

Table 4-4. Historical WWTP Influent TSS Loading Summary

Year	Sewer System Pop.	Sewer System Employees	AA TSS (mg/L)	AA TSS (lb/d)	AA TSS per Capita per Day (ppcd)	MM TSS (mg/L)	MM TSS (lb/d)	TSS MM/AA Peaking Factor
2015	39,900	29,233	212	7,175	0.18	249	7,740	1.08
2016	40,108	29,233	206	7,299	0.18	245	7,923	1.09
2017	40,483	29,233	206	7,512	0.19	252	7,958	1.06
2018	41,060	29,233	211	7,288	0.18	249	7,605	1.04
2019	42,093	29,233	227	7,452	0.18	265	7,998	1.07
2020	42,093	29,233	214	7,172	0.17	258	7,952	1.11
2015 to 2019 Average			**212**	**7,345**	**0.18**	**252**	**7,844**	**1.07**

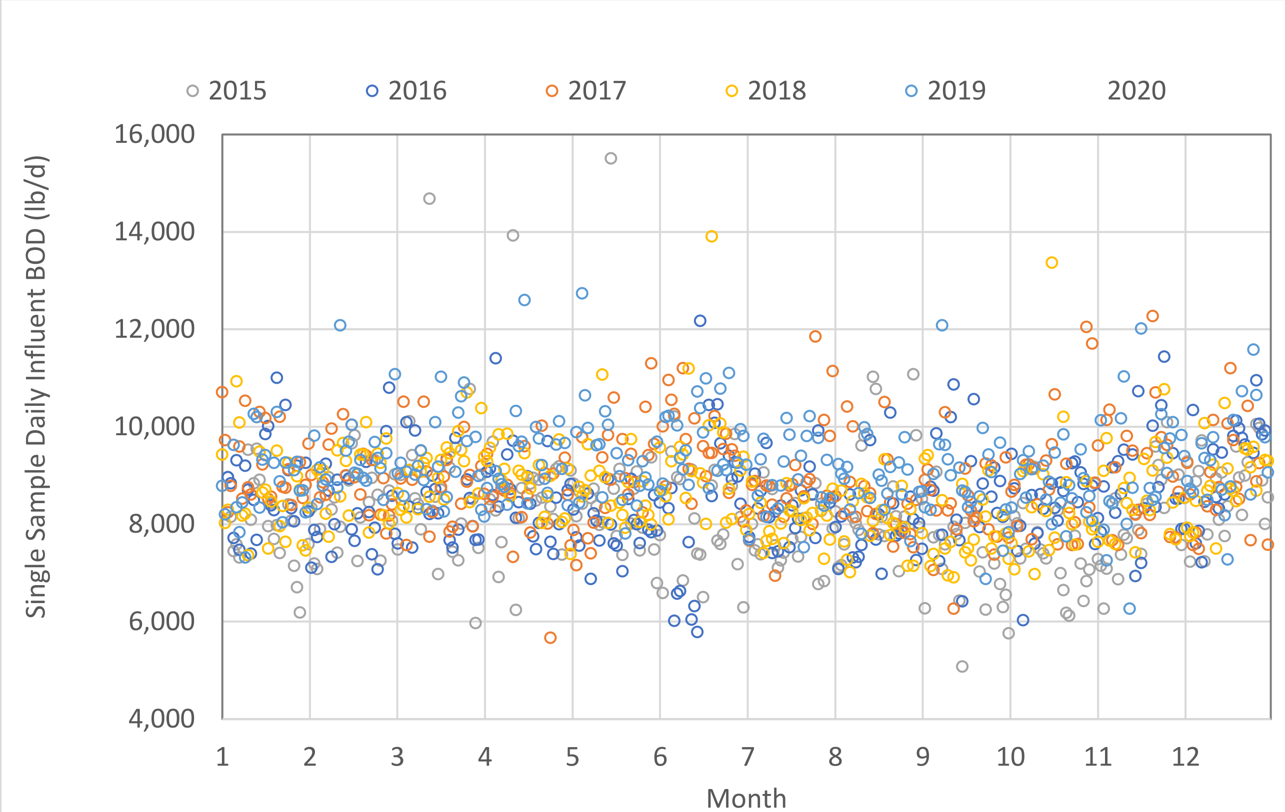
1. 2020 values are not included in the historical average due to the COVID pandemic.
2. Population values established for 2019 also were used for 2020.
3. Employment values established for 2019 also were used for 2015 through 2020.

In the period of 2015 through 2020, the annual average influent BOD_5 and TSS loadings show some fluctuations from year to year, but the overall trend shows a moderate increase in both BOD_5 and TSS loading over this period. Further, the tables demonstrate that the maximum month loading condition is typically around 7 percent above the annual average loading condition for both BOD_5 and TSS.

The WWTP currently has a permitted influent loading limit of 15,120 pounds per day (lb/d) for both BOD_5 and TSS per the City's NPDES Permit. This permit also stipulates that the City shall submit a plan and schedule for continuing to maintain capacity when the loading reaches 85 percent or more of the permitted loading values for 3 consecutive months. Over the past 6 years, the City has not exceeded this planning threshold for BOD_5 or TSS.

Chart 4-5 shows the individual daily influent BOD_5 loading to the WWTP from 2015 through 2020.

Chart 4-5 – Average Monthly Influent BOD Loading (2015-2020)



As shown in the chart, there is not a predictable seasonal variation in BOD loading. This is expected for a sewage system serving largely residential customers with recurring periods of I/I. This is of significance for modeling of future secondary treatment systems in later chapters.

4.1.3 Historical Nitrogen Loading Data

Frequent monitoring of influent nutrients has not historically been required by the City's NPDES Permit. However, given the impending Puget Sound Nutrient General Permit (PSNGP) regulations, the City began more frequent monitoring of influent and effluent nitrogen during 2021.

Average influent nitrogen concentration and loading values during 2021 are shown quarterly in **Table 4-5**. Note that influent TKN data was not provided from August 2021 onward.

Table 4-5. Lynnwood WWTP Influent Nitrogen Loading in 2021

Quarter of 2021	Avg Flow (MGD)	Avg NH_3 (mg/L)	Avg NO_2 + NO_3 (mg/L)	Avg TIN (mg/L)	Avg TIN (lb/d)	Avg TKN (mg/L)	Avg TKN (lb/d)
Q1	4.7	16.9	3.1	20.1	779	25.2	971
Q2	3.6	25.0	3.5	28.5	851	36.7	1,094
Q3	3.3	30.9	1.4	32.3	893	41.6	1,181
Q4	4.8	23.8	1.8	25.6	972	N/A	N/A

1. NO_2 is nitrite and NO_3 is nitrate

The influent data suggests that nitrogen enters the WWTP primarily in ammonia (NH_3) form. TIN, the sum of ammonia, nitrite, and nitrate forms of nitrogen, mostly consists of ammonia. TKN (the sum of ammonia and organic nitrogen) consists primarily of ammonia, but the data also suggests that a significant fraction of organic nitrogen is present in the influent.

The data also demonstrates that influent TKN concentration increases during the dry weather period, as expected. The average TKN load varies quarterly from 971 to 1,181 lb/d, but this range of approximately 20 percent seems high and is likely related to some sampling anomalies due to the limited amount of TKN sampling that has occurred. It is more likely that TKN variations are relatively small and proportional to the influent BOD.

The presence of some nitrate in the influent during summer months is evident in the 2021 data set. This loading is not analyzed in detail in this Plan, as the nitrate levels are not considered excessive but should be analyzed thoroughly in a future design for any potential impacts to proposed secondary treatment system improvements.

For reference, average effluent nitrogen concentration and loading values during 2021 are shown quarterly in **Table 4-6.**

Table 4-6. Lynnwood WWTP Effluent Nitrogen Loading in 2021

Quarter of 2021	Avg Flow (MGD)	Avg NH3 (mg/L)	Avg NO2 + NO3 (mg/L)	Avg TIN (mg/L)	Avg TIN (lb/d)	Average TIN Reduction (%)
Q1	4.7	20.8	0.4	21.2	804.1	-0.03
Q2	3.6	26.8	1.0	27.8	830.1	0.02
Q3	3.3	21.4	3.6	25.0	691.8	0.23
Q4	4.8	24.2	0.4	24.6	945.5	0.03

The limited influent and effluent TKN data for Quarters 1, 2, and 4 suggests that nitrification does not reliably occur at the WWTP during the cold weather months. During the warmest portion of the year, exhibited by Quarter 3, a significant drop in ammonia nitrogen occurs from influent to effluent. TIN also is reduced on average by 23 percent during this period, suggesting that some denitrification must occur.

4.2 PROJECTED FLOW AND LOADING

4.2.1 Flow Projections

The City's 2012 *Wastewater Comprehensive Plan Update* (referred to as the 2012 General Sewer Plan (GSP) in this Plan), which was prepared by BHC, provides a method of deriving the annual average daily flow from population values and service area. This method also was used by BHC as discussed in the technical memorandum *Population and Flow Projections*, which was prepared in November 2020 and is included as **Appendix D**. Per capita flows of 50 gallons per day (gpd) for residential population, 31 gpd per employee for commercial and/or industrial employees, and an average I/I rate of 300 gallons per acre day (gpad) were used in accordance with this methodology to determine a baseline annual average day flow using the current residential and employee population estimates and service area (refer to **Chapter 2** for a summary of population estimates and service area).

The baseline flow values (average day, maximum month, etc.) were compared to the historical data recorded by the City in DMRs for 2017 through 2019. The average daily flow determined by the 2012 GSP method is about 8.5 percent higher than the average of the historical data. BHC determined that these numbers represent an appropriately conservative methodology to use for future flow projections. Likewise, the peaking factors of the 2012 GSP were comparable to historical values for 2017 through 2019, and BHC recommended to continue using 2012 GSP peaking factors for flow projections. Peaking factors from the 2012 GSP were used to calculate flows for the average day of the maximum month, peak day, and peak hour flows. Further detail on the methodology for baseline flow and its comparison to historical data is discussed in **Appendix D**.

Projected flow values were calculated using the 2012 GSP per capita and employee rates (50 gpd per capita for residential, 31 gpd per employee) for the projected 2026, 2030, 2040, and 2050 populations (refer to **Chapter 2** for a summary of population projections). The same I/I rate (300 gpad) also was applied to the projected future sewer service areas. The projected average day, maximum month, peak day, and peak hour flows, along with residential population and employee values, are shown in **Table 4-7**.

Table 4-7. Flow Projections at WWTP

Population and Employment in Sewer Service Area					
	Existing (2019)	Projected 2026	Projected 2030	Projected 2040	Projected 2050
Population	42,093	49,696	53,951	64,771	74,431
Employees	29,233	32,317	32,257	45,242	49,882
Flow (MGD)					
Annual Average Day	4.04	5.19	5.49	6.34	6.97
Maximum Month Average Day	5.01	6.64	7.03	8.12	8.92
Maximum Week Average Day	9.25	8.80	9.31	10.75	11.81
Maximum Day	16.53	15.72	16.64	19.21	21.11
Peak Hour	20.13	22.20	23.50	27.14	29.82

1. Highlighted values exceed the WWTP design criteria as listed in the NPDES permit and noted in **Chapter 3**.
2. Projected population, employee, and flow values were calculated by BHC (Tech Memo dated November 10, 2020).

4.2.2 Loading Projections

Projected annual average BOD_5 and TSS loadings were estimated using the historical peaking factors and per capita loading rates. TKN loadings were estimated based on the 6:1 factor for BOD to TKN. This factor is typical of systems with moderate strength wastewater per *Wastewater Engineering Treatment and Resource Recovery, 5th Edition by Metcalf & Eddy* (Metcalf & Eddy) Table 8-1. Compared to the existing TKN measurements, this factor is conservative and is recommended for future TKN loading projections. The per capita loading rates are shown in **Table 4-8**.

Table 4-8. WWTP Loading Projections

Parameter	Peaking Factor	Per Capita Loading (lb/d)
BOD		
Annual Average	1.00	0.21
Maximum Month	1.08	0.23
Maximum Week	1.20	0.27
Maximum Day	1.22	0.33
TSS		
Annual Average	1.00	0.18
Maximum Month	1.07	0.19
Maximum Week	1.17	0.23
Maximum Day	1.32	0.30
TKN		
Annual Average	1.08	0.038
Maximum Month	1.00	0.035

1. Annual average used as basis for peaking factor ratio.

A summary of the loading projections based on the population projections from **Chapter 2** and per capita loading rates in **Table 4-8** are summarized in **Table 4-9**.

Table 4-9. BOD_5 and TSS Loading Projections at WWTP

Population and Employment in Sewer Service Area					
	Existing (2019)	Projected 2026	Projected 2030	Projected 2040	Projected 2050
Population	42,093	49,696	53,951	64,771	74,431
Employees	29,233	32,317	32,257	45,242	49,882
Flow					
Annual Average Day (MGD)	4.04	5.19	5.49	6.34	6.97
Maximum Month Avg. Day (MGD)	5.01	6.64	7.03	8.12	8.92
Maximum Week Average Day (MGD)	9.25	8.80	9.31	10.75	11.81
Maximum Day (MGD)	16.53	15.72	16.64	19.21	21.11
Peak Hour (MGD)	20.13	22.20	23.50	27.14	29.82
BOD_5					
Annual Average Day (lb/d)	9,177	10,500	11,400	13,700	15,700
Concentration (mg/L)	*279*	*243*	*249*	*259*	*270*
Maximum Month Average Day (lb/d)	9,702	11,400	12,400	14,800	17,000
Concentration (mg/L)	*321*	*206*	*211*	*219*	*229*
Maximum Week Average Day (lb/d)	11,500	13,600	14,800	17,700	20,400
Concentration (mg/L)	*149*	*185*	*191*	*197*	*207*
Maximum Day (lb/d)	14,000	16,600	18,000	21,600	24,800
Concentration (mg/L)	*102*	*127*	*130*	*135*	*141*
TSS					
Annual Average Day (lb/d)	7,452	9,000	9,800	11,700	13,400
Concentration (mg/L)	*227*	*208*	*214*	*221*	*231*
Maximum Month Average Day (lb/d)	7,998	9,700	10,500	12,600	14,400
Concentration (mg/L)	*265*	*175*	*179*	*186*	*194*
Maximum Week Average Day (lb/d)	9,500	11,300	12,200	14,700	16,800
Concentration (mg/L)	*123*	*154*	*157*	*164*	*171*
Maximum Day (lb/d)	12,500	14,800	16,100	19,300	22,200
Concentration (mg/L)	*91*	*113*	*116*	*120*	*126*
TKN					
Annual Average Day (lb/d)	1,480	1,740	1,890	2,270	2,610
Concentration (mg/L)	*44*	*40*	*41*	*43*	*45*
Maximum Month Average Day (lb/d)	1,570	1,890	2,060	2,460	2,830
Concentration (mg/L)	*38*	*34*	*35*	*36*	*38*

1. Highlighted values exceed the WWTP design criteria as listed in the NPDES permit and noted in **Chapter 3**.
2. Projected population and employees were calculated by BHC (Tech Memo dated November 10, 2020).
3. All projected BOD and TSS loads have been rounded up to the nearest 100 pounds. TKN load values are rounded to the nearest 10 pounds.
4. All concentrations have been calculated from the flow and load values.
5. A conservative estimate of TKN is provided in this table based on a 6:1 ratio of influent BOD:TKN.

4.3 SUMMARY

The maximum month flow is projected to exceed 85 percent of the design criteria listed in the NPDES by 2030 and 100 percent of the design criteria by 2040.

The maximum month BOD_5 loading is projected to exceed 85 percent of the design criteria by 2040 and 100 percent of the design criteria by 2050.

If three consecutive months exceed the design criteria, the City is required by permit to begin planning an upgrade to increase capacity, which will be a significant driver for improvements discussed in this Plan. These improvements will be evaluated in conjunction with analyses of the recommended improvements to meet the regulatory requirements identified in **Chapter 3** and the conditions-based needs and any unit process capacity issues identified in **Chapter 5**.

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5 | EVALUATION OF EXISTING FACILITIES

5.1 INTRODUCTION

This chapter presents an analysis of the existing wastewater treatment plant (WWTP) infrastructure. Individual WWTP processes were analyzed based on:

- A general conditions assessment, including integrity, age, and useful life; and
- Their capacity to pass or treat the current and projected flow and loading established in **Chapter 4**.

Potential deficiencies and necessary improvements are identified in this chapter. **Chapter 6** and **Chapter 7** provide a comparative analysis for major improvements with multiple alternatives for the liquid stream and solids handling systems, respectively. An aerial image of the existing WWTP is shown in **Exhibit C-1 WWTP Aerial** and the existing site plan is shown in **Exhibit C-2 WWTP Site Overview** in **Appendix C**.

5.2 EXISTING FACILITIES BACKGROUND

5.2.1 History

The City of Lynnwood's (City) original WWTP provided primary treatment and consisted of a sewage grinder and bar screen, a primary clarifier, an outfall to Browns Bay in Puget Sound, a sludge thickener, an incinerator, an operation building, and an office building. Since then, numerous expansions and upgrades to the WWTP have been completed. A visual overview of the current WWTP and a summary of the history are shown on **Exhibit C-3 WWTP Improvements History** in **Appendix C**.

The following is a historical projects list to identify the major additions and changes to the WWTP through 2012 (refer to the following section for more recent projects). The first project replaced a majority of the original WWTP except as noted.

1. Sewage Treatment Plant Expansion project (construction completed in 1984), which included:
    a. Plant influent and effluent flow measurement;
    b. Headworks screening and grit removal;
    c. Three rectangular primary clarifiers;
    d. Reuse of the existing circular primary clarifier;
    e. A chlorine (disinfection) chemical system;
    f. A chlorine disinfection contact tank;
    g. Reuse of the existing plant effluent outfall pipe and the addition of a diffuser;
    h. A plant drain lift station;
    i. Primary sludge thickening, including reuse of the existing sludge thickener;
    j. Reuse of the existing incinerator;
    k. Standby generator; and

   l. Office building and laboratory.
2. Wastewater Treatment Facility project (constructed in 1989), which included:
   a. Plant influent and effluent flow measurement improvements;
   b. Circular primary clarifier improvements;
   c. Addition of a Main Plant Pump Station (MPPS), three aeration basins, aeration blowers, and four secondary clarifiers;
   d. Chlorine disinfection contact tank improvements;
   e. Outfall diffuser improvements;
   f. Addition of waste activated sludge (WAS) thickening;
   g. Addition of dewatering;
   h. Addition of scum handling;
   i. Incineration and ash removal improvements; and
   j. Office building and laboratory improvements.
3. Lynnwood Wastewater Treatment Plant Improvements project (constructed in 1997), which included:
   a. Headworks screening improvements;
   b. Aeration blowers improvements;
   c. Primary sludge thickening improvements;
   d. WAS thickening improvements; and
   e. Addition of scum concentrating.
4. WWTP Secondary System Standby Generator project (constructed in 2010).

5.2.2 Projects Completed Since Previous Plan

The City's most recent *Wastewater Comprehensive Plan Update* was completed in November 2012. The following is a projects list to identify the major additions and changes to the WWTP since that plan was completed.

1. Process Blower project (constructed in 2013).
2. WWTP Energy Conservation Measures project (constructed in 2015), which included:
   a. Changes to the primary sludge process; and
   b. Dewatering improvements.
3. WWTF Chlorination and Headworks Screening Upgrades project (constructed in 2016), which included:
   a. Headworks screening improvements; and
   b. Chlorine (disinfection) chemical system improvements.
4. WAS Pump Station Improvements project (constructed in 2016).
5. WWTF Air Pollution Controls Improvements project (constructed in 2016).
6. ODS Pump Vault Upgrade project (constructed in 2016).
7. WWTF Headworks Motor Control Center Replacement project (constructed in 2016).

8. WWTF Activated Sludge System Process Improvements project (constructed in 2017).
9. Fluidizing Blower Variable Frequency Drive project (constructed in 2020).
10. WWTP Fuel System Replacement project (constructed in 2020).
11. WWTF Plant Drain Lift Station Variable Frequency Drive Replacement project.
12. Pre-concentration tank mechanism replacement (constructed in 2021).
13. Building No. 1, Building No. 2, and secondary treatment odor control project (constructed in 2021).
14. Rectangular primary clarifier improvements (chain, flight, scum troughs, effluent weirs, and drive system (Primary Clarifier No. 1 was completed in 2021 and Primary Clarifiers No. 2 and No. 3 should be completed in 2022).

The following is a list of active projects for major additions and changes at the WWTP that are currently being designed or constructed.

1. WWTF – West Electrical Service Equipment Replacement project (design).
2. WWTP Aeration Blowers Upgrade project (design).

5.2.3 System Overview

The current WWTP provides treatment of raw wastewater from the City's collection system and select areas of the City of Edmond's collection system prior to discharging treated effluent to Puget Sound. The WWTP consists of primary treatment, secondary treatment, disinfection, and solids incineration. The individual liquid stream and solids handling system processes are described in this chapter. Existing WWTP information is provided on the following figures in **Appendix B**:

- **Existing WWTP Process Schematic**
- **Existing WWTP Design Criteria**
- **Existing WWTP Hydraulic Profile**

Visual overviews of the existing WWTP and processes are shown on the following figures in **Appendix C**:

- **Exhibit C-2 Existing Site Overview**
- **Exhibit C-4 Existing Lower Site Plan**.

5.3 HISTORICAL EFFLUENT WATER QUALITY PERFORMANCE

As discussed in **Chapter 3**, the City's National Pollutant Discharge Elimination System (NDPES) Permit identifies effluent limits for WWTP treated effluent water discharged to Browns Bay in Puget Sound. A review of historical plant effluent water quality relative to the permit effluent limits is used to evaluate overall WWTP treatment performance. Recorded data in the City's WWTP daily monitoring reports (DMRs) for the 6 years of 2015 through 2020 has been reviewed, and the findings are summarized in this section.

5.3.1 CBOD

Historical plant effluent levels of 5-day carbonaceous biochemical oxygen demand ($CBOD_5$) are shown in the following charts. **Chart 5-1** shows measured concentrations in milligrams per liter (mg/L), and **Chart 5-2** shows calculated daily mass in pounds per day (lb/d). Both charts include the monthly (30-day) and weekly (7-day) permitted limits.

Chart 5-1 – Historical Plant Effluent $CBOD_5$ Concentration

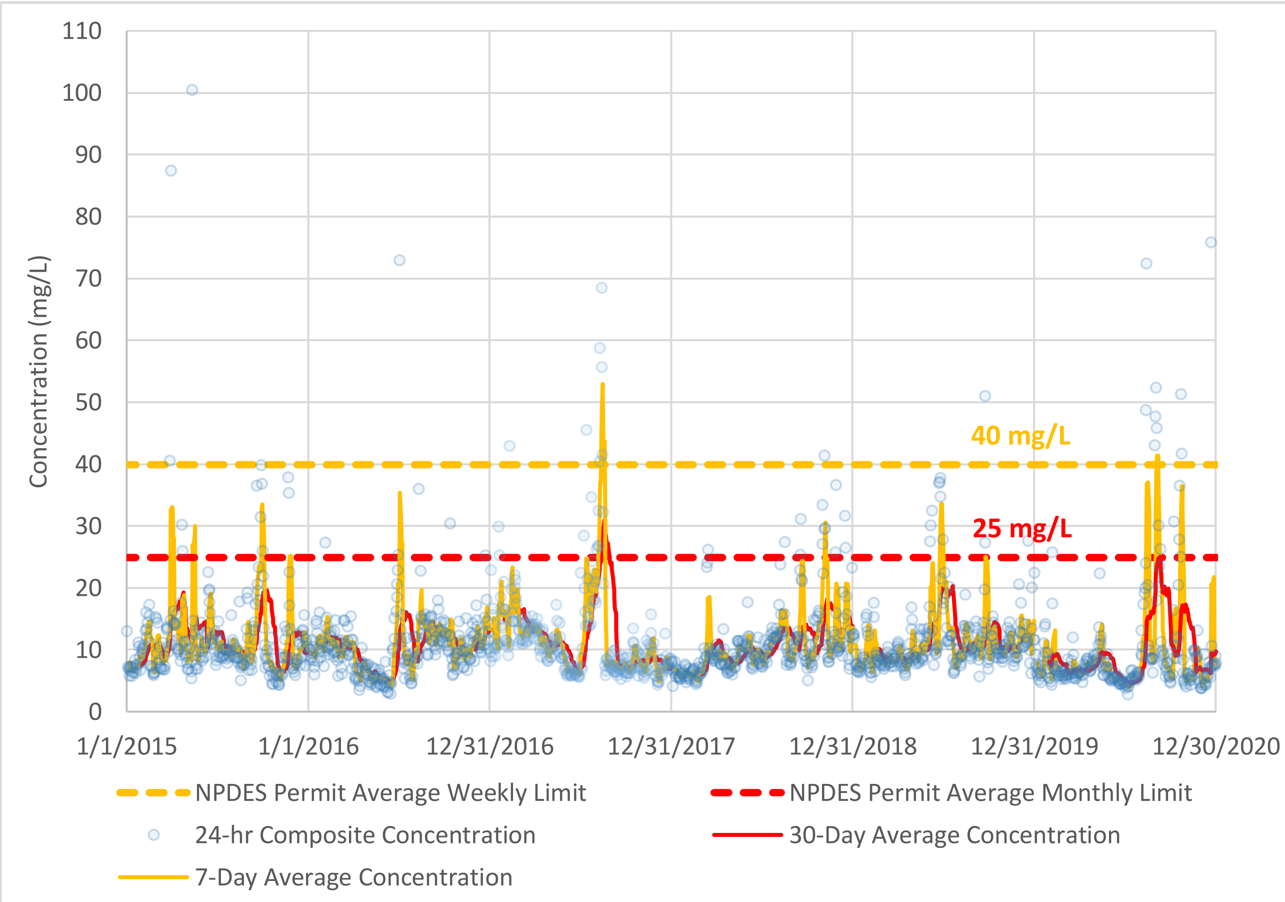
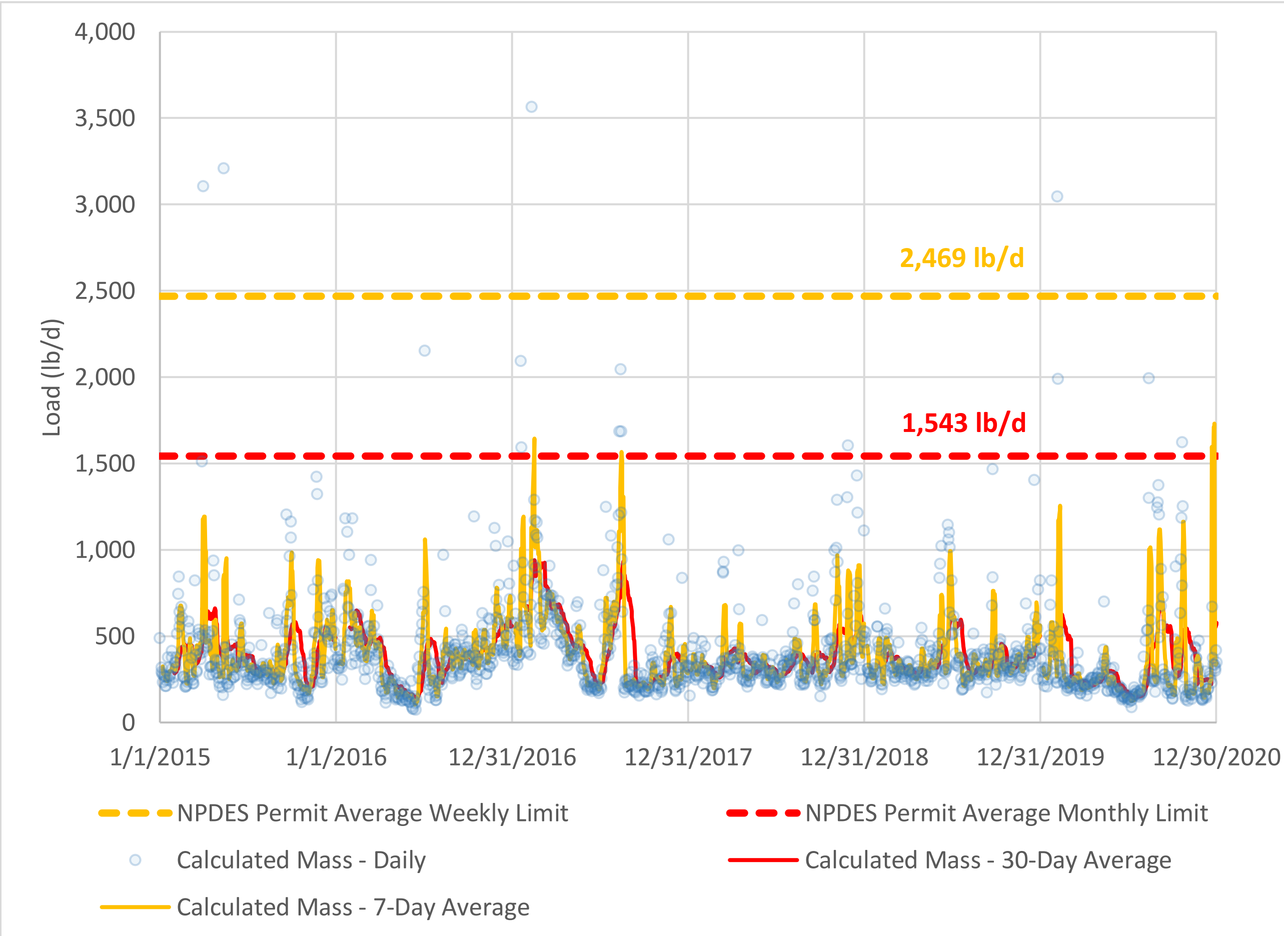


Chart 5-2 – Historical Plant Effluent $CBOD_5$ Mass Loading



No exceedances of the monthly effluent $CBOD_5$ concentration limit were reported in the last 6 years. A single occurrence of weekly effluent $CBOD_5$ concentration exceedance occurred in August of 2017.

5.3.2 TSS

Historical plant effluent levels of total suspended solids (TSS) are shown in the following charts. **Chart 5-3** shows measured concentrations and **Chart 5-4** shows calculated daily mass. Both charts include the monthly and weekly permitted limits.

Chart 5-3 – Historical Plant Effluent TSS Concentration

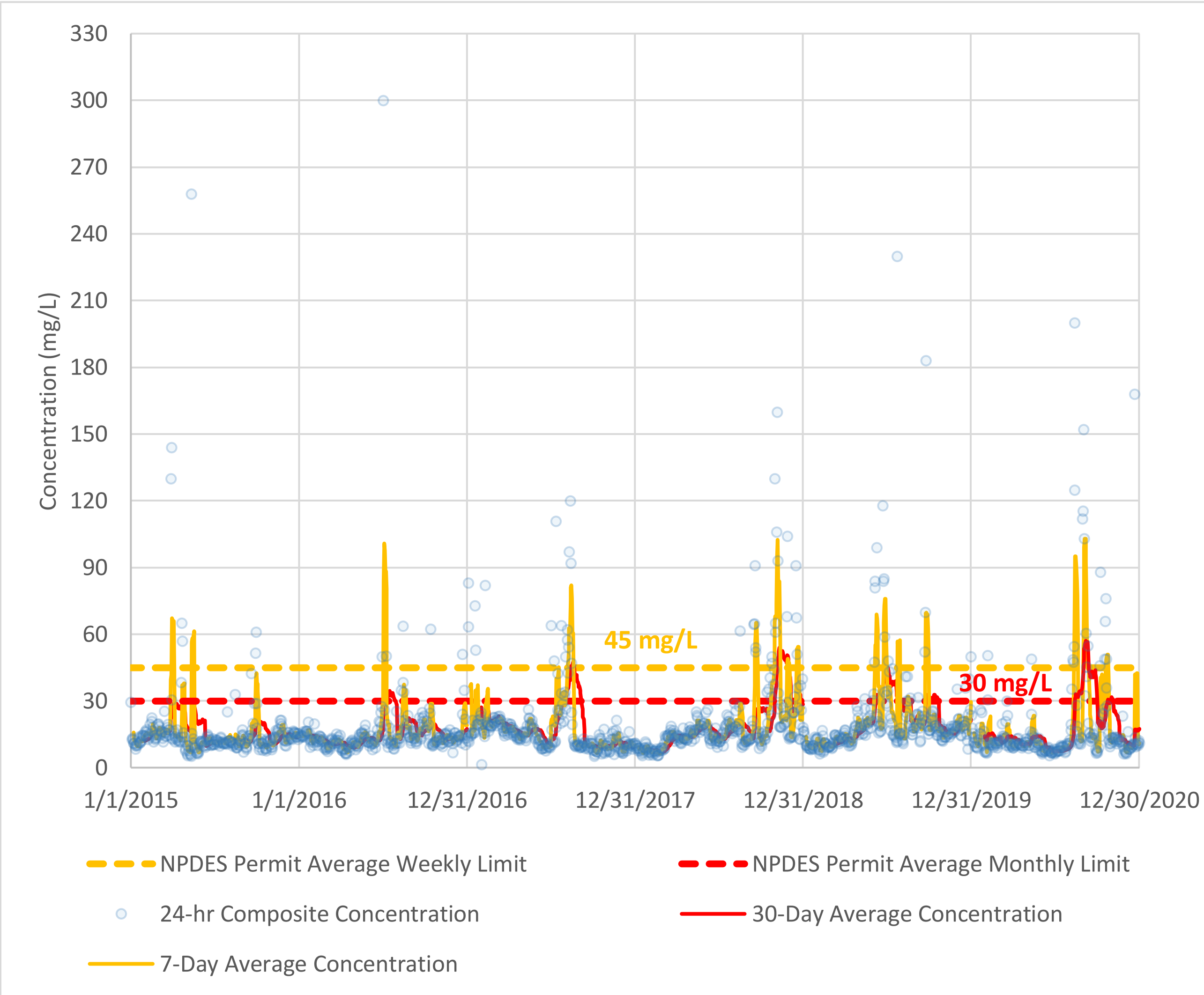
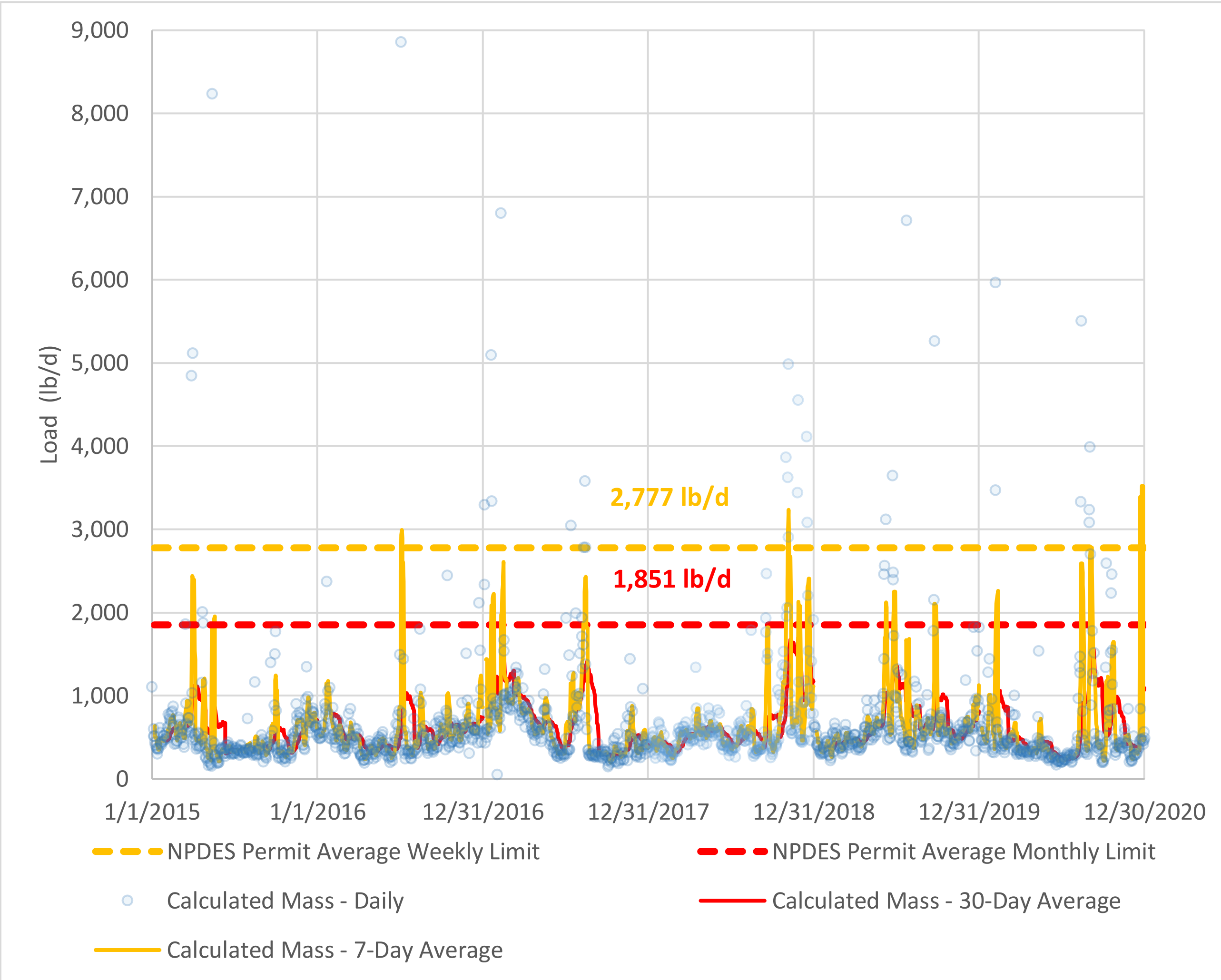


Chart 5-4 – Historical Plant Effluent TSS Mass Loading



Exceedances of the monthly effluent TSS concentration limit of 30 mg/L occurred twice in 2017, once in 2018, twice in 2019, and three times in 2020. Exceedances of the weekly effluent TSS concentration limit of 45 mg/L occurred in 2 of the months in 2015, once each in 2016 and 2017, 4 of the months in 2018, and 2 of the months in 2020. Infrequent single sample occurrences with concentrations exceeding 100 mg/L have occurred multiple times in the last 6 years.

5.3.3 pH

The reported historical plant effluent pH over the last 6 years has ranged from 6.1 to 7.9, with one sample outside of this range at 9.8 on January 31, 2019. This outlier sample is assumed to be erroneous. The average effluent pH over the last 6 years is 6.9. The minimum and maximum permitted levels are 6.0 and 9.0, respectively.

5.3.4 Fecal Coliform Bacteria

The reported historical plant effluent fecal coliform bacteria over the last 6 years have ranged from 4 to 140 per 100 milliliters (mL) on a monthly geometric mean basis. Counts have ranged from 12 to 360 per 100 mL on a weekly geometric mean basis. The permitted monthly and weekly limits are 200 and 400 per 100 mL, respectively.

5.3.5 Total Residual Chlorine

The reported historical plant effluent total chlorine residual average monthly values over the last 6 years have ranged from 6 to 155 micrograms per liter (µg/L). Maximum daily values have ranged from 40 to 700 µg/L. The permitted monthly average and maximum daily limits are 278 µg/L and 728 µg/L, respectively.

5.3.6 Summary of Evaluation

Effluent permit violations in the last 6 years have primarily been related to TSS exceedances. These exceedances are generally attributed to periods of decreased settleability of mixed liquor, or increased mixed liquor suspended solids due to wasting being decreased during outages of the incinerator. This issue is expected to be remedied with a future solids handling project that would provide redundancy in solids handling equipment to reduce the likelihood of outages as created by the incinerator. Additionally, improvements to mixed liquor settleability with future liquid stream improvements should reduce the likelihood of recurring effluent TSS violations.

5.4 LIQUID STREAM ANALYSES

5.4.1 Preliminary Treatment

OVERVIEW

All raw influent wastewater flows by gravity into WWTP. The piped influent from the City of Lynnwood is routed down Bertola Road from 76th Avenue West. The influent pipeline along Bertola Road is 24-inch diameter. The plant influent also includes raw wastewater flowing by gravity from three small areas of the City of Edmond's collection system that are adjacent to the WWTP site and flow in through separate pipes. Wastewater flow into the headworks also includes in-plant drainage and secondary clarifier scum that combine with raw influent directly upstream of the headworks. The headworks provides influent screening and grit removal.

A majority of the manholes and below-grade pipes conveying the raw wastewater into the WWTP site were installed with the original plant in 1962. The portion of manholes and pipes adjacent to the headworks has been replaced and modified in 1984 and 1989. In 1989, a Parshall flume was installed to measure plant influent flow into the headworks, replacing the previous flow measurement located within the headworks. The headworks concrete structure was constructed in 1984, along with Building No. 1, which encloses the headworks and adjacent rectangular primary clarifiers. Headworks screening and screenings handling equipment were replaced in 2016. The grit removal equipment is from 1989, with exception of the grit classifier, which has since been replaced in-kind.

Influent flows through a drop structure, pre-chlorination manhole, and Parshall flume before entering the headworks. An automatic composite sampler is housed in a small structure adjacent to the headworks and used to sample raw influent. All influent splits into two channels in the headworks: a primary screening channel and a backup channel, which are each isolated with manual slide gates. The primary channel houses an automatic mechanical bar screen and discharges to the grit removal system. The backup channel houses a manually cleaned bar screen and bypasses the grit removal system.

The grit removal system consists of a circular concrete grit chamber. The grit chamber includes a paddle drive system with the gearbox centered above the top of the chamber. Settled grit slurry is extracted from the chamber and discharged to an adjacent grit classifier by an integrated air lift system. Air is supplied to the system from the aeration basin blowers.

All wastewater discharging from the headworks combines to flow by gravity to the primary clarifiers.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing plant influent flow measurement, headworks screening, and headworks grit removal process components are provided in **Table 5-1**, **Table 5-2**, and **Table 5-3**.

Table 5-1. Design Criteria for Existing Plant Influent Flow Measurement

Parameter	Value	Units
Type	Parshall Flume	
Quantity	1	
Size (Throat Width)	30	*in*
Measurement Range	0.6 - 26.9	*MGD*

Table 5-2. Design Criteria for Existing Headworks Screening

Parameter	Value	Units
Screening Channels		
Configuration	Split channels, cast-in-place concrete	
Quantity	1 Primary, 1 Backup	
Channel Depth (each)	48	*in*
Primary Channel Screening		
Screen Type	In-channel mechanical bar screen	
Screen Quantity	1	
Screen Bar Spacing	0.25	*in*
Screen Width	45	*in*
Screen Height (in Vertical Plane)	48	*in*
Screen Angle (from Horizontal)	75	*degrees*
Primary Channel/Screen Peak Flow Rating (Screen with 30% blinding and 6 fps slot velocity)	13.6	*MGD*
Backup Channel Screening		
Screen Type	In-channel bar screen	
Screen Quantity	1	
Screen Bar Spacing	0.375	*in*
Screen Width	36	*in*
Screen Height (in Vertical Plane)	48	*in*
Screen Angle (from Horizontal)	50	*degrees*
Primary Channel Screenings Handling System		
System Type	Washer/compactor with sluice trough	
Sluice Trough Quantity	1	
Washer/Compactor Quantity	1	
Washer/Compactor Screw Diameter	8	*in*
System Throughput Capacity	70	*ft^3/hr*
Screenings Volume Reduction	60 - 70	*%*
Screenings Weight Reduction	60 - 70	*%*

fps = feet per second
ft^3/hr = cubic feet per hour

Table 5-3. Design Criteria for Existing Headworks Grit Removal

Parameter	Value	Units
Primary Channel Grit Removal		
Configuration	Circular, cast-in-place concrete	
Grit Collection Type	Vortex	
Quantity	1	
Diameter	12	*ft*
Single Basin Peak Flow Rating	12.0	*MGD*
Grit Extraction Type	Air lift	
Grit Extraction Air Requirements for Operation	75 @ 7	*cfm @ psi*
Air Supply Location	Basin Aeration Blowers	
Primary Channel Grit Handling Equipment		
Type	Classifier	
Quantity	1	
Classifier Surface Area	23	*sf*
Grit Slurry Capacity	250	*gpm*
Classifier Angle (from Horizontal)	20	*degrees*
Screw Diameter	12	*in*
Grit Conveying Capacity	70	*ft^3/hr*

cfm @ psi = cubic feet per at pounds per square inch

Operation

Plant influent is chlorinated and then flows through the Parshall flume. The automatic composite sampler draws samples of plant influent from the Parshall flume vault.

The primary screening channel includes an automated multi-rake bar screen. The backup channel includes a passive bar screen. Both the primary channel screen and backup channel screen meet the state biosolids rule, Chapter 173-308 Washington Administrative Code (WAC), with ⅜-inch aperture size. The backup channel is normally isolated by a slide gate that is overflowed near 14 million gallons per day (MGD) to avoid overwhelming the primary screen.

Differential water level is calculated from sensors upstream and downstream of the primary screen and used to initiate automatic cleaning of the screen. Screenings are automatically discharged into a washer/compactor system that automatically dewaters the screenings and deposits them into an integrated continuous bagger. The grit removal air lift system automatically extracts settled grit slurry from the chamber and discharges it to the grit classifier. The grit classifier automatically dewaters and washes the grit, before discharging into a dumpster housed in the building. Both the bagged screenings and the grit are periodically hauled out by garbage truck for landfill disposal.

Evaluation

The existing headworks is generally undersized for peak flow conditions. Flows above approximately 14 MGD bypass the automated screening system and grit removal by flowing through the backup channel, which includes a passive bypass screen requiring continual operator attention when in use. WWTP staff have observed estimated instantaneous flows of 20 to 21 MGD result in nearly overtopping both headworks channels. The bypass of automated screening and grit removal for flows above 14 MGD, as well as the near overtopping of channels at flows near 21 MGD, are considered major deficiencies. Further, WWTP staff desire 2-dimensional screening in the future to increase the screenings capture and decrease fouling of downstream equipment. However, 2-dimensional screening is too restrictive of the hydraulic capacity in the current channels.

The existing headworks was not configured for, nor has sufficient space for, redundancy in automated screening or grit removal. This is considered a major deficiency.

The Parshall flume is not actually used for flow measurement because of gross inaccuracy. The flume is not properly level and there are insufficient straight lengths of pipe upstream and downstream of the meter. Accurate flow measurement cannot be provided with open channel flow measurement at this area due to the significant space constraints that limit the necessary straight pipe runs. This is considered a major deficiency.

CONDITIONS ASSESSMENT

Plant Influent Conveyance

The plant influent conveyance through Bertola Road is constructed of concrete manholes and concrete pipe nearing 60 years of age. The exact condition of this infrastructure is unknown. As part of any WWTP major improvements or collection system improvements in the future, serious consideration should be given to fully replacing the manholes and pipes due to their age.

The remaining plant influent conveyance to the headworks is constructed of concrete manholes and structures and ductile iron pipe that are about 30 years of age and are expected to be in satisfactory condition.

Plant Influent Flow Measurement

The Parshall flume vault and flume visually appear to be in satisfactory condition as to allow for continued usage until the system can be replaced to alleviate the performance issues previously noted.

Plant Influent Sampling

The automatic composite sampler is currently in good condition. Based on a typical service life, the sampler will need to be replaced during the planning period.

Headworks Concrete Structure

The headworks cast-in-place concrete structure is about 35 years of age and is believed to be in satisfactory condition as to allow for continued usage until the system can be replaced to alleviate the performance and redundancy issues previously noted.

Primary Channel Screening Equipment

The primary channel screen and screenings handling system are currently in good condition. Based on a typical service life, all the equipment will need to be replaced during the planning period.

Primary Channel Grit Equipment

The grit paddle drive and associated equipment is over 30 years of age, which is well beyond a typical service life and necessitates near-term replacement.

The grit classifier is currently in good condition. Based on a typical service life, the classifier will need to be replaced during the planning period.

Backup Channel Screen

The backup channel screen is fabricated from 316 stainless steel and is currently in good condition. WWTP staff should visually inspect it periodically to monitor the condition.

SUMMARY OF MAJOR FINDINGS

Based on the assessments, a brief summary of the major findings and necessary improvements to the preliminary treatment system is as follows:

1. The influent pipe through Bertola Road is aging and should be evaluated for replacement where impacted by future improvements.
2. The location of the existing Parshall flume does not allow accurate influent flow measurement.
3. The existing headworks does not provide sufficient hydraulic capacity for projected peak flow conditions.
4. The existing headworks is undersized to provide sufficient space for mechanical equipment redundancy.
5. The mechanical equipment is aging and will require replacement during the planning period.

5.4.2 Primary Treatment

OVERVIEW

Screened and degritted wastewater from the headworks flows by gravity to the primary clarifiers. The primary clarifiers provide settling of a portion of the solids and skimming of floating material (scum, including grease) from the water surface.

There are four primary clarifiers: three rectangular and one circular. The outer concrete structure of the circular clarifier was constructed as part of the original WWTP in 1962 and then retrofitted with a circular steel clarifier in 1989. The circular clarifier is enclosed within Building No. 2, which houses multiple WWTP processes. The rectangular clarifiers were constructed in 1984 and are enclosed in Building No. 1 with the headworks. The removable covers for the rectangular clarifiers were replaced in 2015.

The single channel from the headworks splits into two channels with manual slide gates: one to the rectangular clarifiers and the other to a below-grade pipe to the circular primary clarifier.

Each rectangular clarifier has a chain and flight sludge collector mechanism, a cross screw sludge collector mechanism, a manual scum metal trough, and multiple metal weir troughs. Primary effluent from the weir troughs flows into a common concrete outlet channel. The scum troughs are connected between each rectangular clarifier and a common discharge pipeline that is routed below grade to the scum collection basin. Settled solids (primary sludge) are removed by pumping from the upstream-end sump of each clarifier.

The circular primary clarifier has a clarifier mechanism to collect the primary sludge for removal through underflow piping. A primary sludge pit and pump are adjacent to the clarifier. The mechanism also skims scum from the water surface and deposits it in the scum box. A scum discharge pipeline is routed from the box to the scum collection basin. Primary effluent flows over the metal weir plate, into the effluent trough, and then into a discharge pipeline that is routed to the concrete outlet channel at the rectangular primary clarifiers.

Primary effluent from all four clarifiers flows to the MPPS. Refer to **5.4.3 Bypass Overflow Structure and Primary Effluent** for details on the bypassing, flow measurement, and sampling of primary effluent.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing primary clarifiers process components are provided in **Table 5-4**.

Table 5-4. Design Criteria for Existing Primary Clarifiers

Parameter	Value	Units
Rectangular Primary Clarifiers		
Quantity	3	
Configuration	Rectangular, cast-in-place concrete	
Length (each)	105	*ft*
Width (each)	16	*ft*
Side Water Depth	8.5	*ft*
Surface Area (each)	1,680	*sf*
Volume (each)	0.11	*MG*
Design Average Surface Overflow Rate (at 7.4 MGD at MM)	1,115	*gpd/sf*
Design Peak Surface Overflow Rate (at 13.6 MGD)	2,050	*gpd/sf*
Circular Primary Clarifier		
Quantity	1	
Configuration	Circular, steel	
Diameter	45	*ft*
Side Water Depth	12.5	*ft*
Surface Area	1,590	*sf*
Volume	0.15	*MG*
Design Average Surface Overflow Rate (at 7.4 MGD at MM)	1,115	*gpd/sf*
Design Peak Surface Overflow Rate (at 13.6 MGD)	2,050	*gpd/sf*

MG= million gallons

Operation

Both slide gates at the split from the headworks common outlet channel are normally open to allow wastewater flow to all four primary clarifiers. The gates are manually set to balance flow as much as possible between the clarifiers, but there is no flow monitoring equipment installed. In the summer when plant influent flows are lower, WWTP staff shut down one clarifier at a time to visually inspect the condition and perform cleaning and maintenance. This is done annually.

Evaluation

The primary clarifiers were designed for a peak surface overflow rate of 2,050 gallons per day per square foot (gpd/sf) based on a total peak flow rate of 13.6 MGD into the clarifiers. WWTP staff have anecdotally noted that the flow to the circular primary clarifier typically appears to be more than the flow to each of the rectangular clarifiers. Typical design range for primary clarifier surface overflow rate is 2,000 to 3,000 gpd/sf based on peak design flow per both *Wastewater Engineering: Treatment and Reuse* (4th Edition by Metcalf & Eddy, 2003; referred to in this chapter as Metcalf & Eddy) and the Washington State Department of Ecology's (Ecology) *Criteria for Sewage Works Design* (commonly known as the Orange Book). Based on the maximum recommended primary clarifier surface overflow rate of 3,000 gpd/sf, the existing primary clarifiers can provide a maximum nominal capacity of 20 MGD with 4 primary clarifiers in service. This value is reduced to approximately 15 MGD with one clarifier out of service. Maximum day flows currently exceed 15 MGD and are projected to exceed 20 MGD by 2050. As such, the four primary clarifiers are necessary and do not allow for redundancy at maximum day conditions without an expansion or other means of increasing primary clarifier capacity.

CONDITIONS ASSESSMENT

Rectangular Primary Clarifiers

Structural

The rectangular primary clarifiers cast-in-place concrete structure is about 35 years of age and is believed to be in satisfactory structural condition. The aluminum Hallsten covers are only about 5 years of age. Therefore, dedicated structural improvements are not warranted during the planning period to alleviate conditions-based needs.

Mechanical

WWTP staff keep the mechanical components well maintained by performing annual visual inspections and maintenance. Improvements to the rectangular primary clarifiers are currently being made (chain, flight, scum troughs, effluent weirs, and drive system) with Primary Clarifier No. 1 completed in 2021 and Primary Clarifiers No. 2 and No. 3 to be completed in 2022. Currently, the only mechanical components identified for replacement are the two cross screw sludge collector mechanism drives (one drive operates the mechanism in both Primary Clarifiers No. 1 and No. 2).

Circular Primary Clarifier

Structural

The outer cast-in-place concrete structure of the circular clarifier is nearly 60 years of age and is believed to be in satisfactory structural condition. It does not warrant dedicated concrete structure improvements during the planning period.

The circular steel structure of the clarifier and fiberglass removable covers are about 30 years of age. They are believed to be in satisfactory structural condition, and improvements during the planning period to alleviate conditions-based needs are not anticipated.

Mechanical

WWTP staff keep the mechanical components well maintained by performing annual visual inspections and maintenance. Staff is not aware of any issues with the clarifier mechanism; however, it is about 30 years of age. Based on a typical service life, the mechanism will need to be replaced during the planning period.

SUMMARY OF MAJOR FINDINGS

Based on the assessments, a brief summary of the major findings and necessary improvements to the primary clarifiers is as follows:

1. The primary clarifiers do not provide sufficient capacity to allow for redundancy during current or future peak flow conditions. If the WWTP remains as configured through the planning period, additional primary clarifier area or other improvements are necessary.
2. If the primary clarifier mechanisms are to remain in use through the planning period, budgeting for full replacement of the existing mechanisms is recommended.

5.4.3 Bypass Overflow Structure and Primary Effluent

OVERVIEW

Effluent from the primary clarifiers combines in the Bypass Overflow Structure to flow to the MPPS. Effluent from the secondary clarifiers flows through a channel parallel to the primary effluent channel in the Bypass Overflow Structure. Rectangular openings in the shared wall between the two channels allows a portion of high primary effluent flow to bypass secondary treatment processes by bypassing the MPPS, which lifts primary effluent to the aeration basins and secondary clarifiers. Flows above approximately 14 MGD bypass secondary treatment.

The primary effluent common outlet channel was constructed in 1984 as part of the rectangular clarifiers concrete structure. In 1989, the concrete secondary effluent channel was constructed and connected to the primary effluent common outlet channel. Construction included cutting two rectangular openings in the shared concrete wall of the two channels and installing weir plates at the bottom of each opening. In 1989, primary effluent also was re-routed to the then newly constructed MPPS and a flow meter was installed.

Primary effluent that does not overflow into the secondary effluent channel flows to the MPPS. The electromagnetic flow meter is installed within a vault and used to measure primary effluent flow. An automatic composite sampler is located at the bypass overflow structure and is used to sample primary effluent.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing primary effluent flow measurement are provided in **Table 5-5**.

Table 5-5. Design Criteria for Existing Primary Effluent Flow Measurement

Parameter	Value	Units
Type	In-line electromagnetic flow meter	
Quantity	1	
Size (body diameter)	20	*in*
Measurement Maximum (at velocity limit of 10 fps)	14	*MGD*

Operation

Normally, primary effluent flows are not high enough to overflow into the secondary effluent channel and are conveyed to the secondary treatment processes. WWTP staff have observed overflow occurring during events with estimated instantaneous flow of 14 MGD and greater.

Primary effluent flowing to the secondary treatment processes is metered and sampled by an automatic composite sampler.

To raise pH in the primary effluent, WWTP staff manually add lime to the effluent of the circular primary clarifier year-round as necessary.

Evaluation

The electromagnetic flow meter is unable to measure some low flows that occur at night and result in only a partially full pipeline. Improvements to the flow metering are necessary to provide full flow range measurement of the primary effluent.

CONDITIONS ASSESSMENT

Bypass Overflow Structure

This structure visually appears to be in good condition, and dedicated structural improvements are not expected during the planning period.

Primary Effluent Flow Measurement

The flow meter vault visually appears to be in good condition and does not warrant any condition improvements during the planning period.

The flow meter is currently in good condition. As previously identified, there are performance issues with the flow meter that necessitate improvements if it is to remain in use through the planning period.

Primary Effluent Sampling

The automatic composite sampler is currently in good condition. Based on a typical service life, the sampler will need to be replaced during the planning period.

SUMMARY OF MAJOR FINDINGS

Flows above 14 MGD bypass secondary treatment due to the capacity limitations of the secondary treatment process. While this functions satisfactorily with the current permit conditions, to meet future nutrient limits, the secondary treatment system will need to treat all flow as discussed in **Chapter 6**. The existing system is not expected to require improvements prior to the major secondary treatment system upgrade.

5.4.4 Main Plant Pump Station

OVERVIEW

Effluent from the primary clarifiers and return activated sludge (RAS) both flow by gravity to the MPPS. The MPPS lifts flow up to the secondary treatment system.

The MPPS was constructed in 1989, along with the building that is installed on top of the below-grade concrete structure of the MPPS. The concrete structure of the MPPS is mostly rectangular and split into a wet well and dry well. Four pumps are installed in the dry well. Dedicated suction piping to each pump is routed from the wet well. Dedicated discharge piping is routed from each pump to a common discharge pipeline that is routed below grade to the aeration basins.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing MPPS are provided in **Table 5-6**.

Table 5-6. Design Criteria for Existing MPPS

Parameter	Value	Units
Configuration	Wet well/dry well, cast-in-place concrete	
Wet Well		
Volume	0.20	*MG*
Dry Well Pumps		
Pump Type	Non-clog centrifugal	
Pump Quantity	4	
Pump Capacity (each)	4,600 @ 48	*gpm @ ft TDH*
Pump Motor Size (each)	100	*hp*
Station Pumping Capacity (with 3 pumps running)	19.9	*MGD*
Station Pumping Capacity (with 4 pumps running)	26.5	*MGD*

gpm @ ft TDH = gallons per minute at feet of total dynamic head
hp = horsepower

Operation

Primary effluent and RAS flow continuously to the MPPS. Liquid level in the wet well is continuously measured by an air bubbler system. The liquid level measurement is used to control the pumps on and off. Normally, the pumps are automatically controlled. Two of the pumps are speed controlled by variable frequency drives (VFDs), and the other two pumps operate at constant speed. The two VFD-controlled pumps are used as the leads and operated in parallel. The two constant speed pumps are used as the first lag and second lag. Floats are installed in the wet well as backup liquid level measurement and pump control in case the air bubbler system is out of service. Plug valves on each suction and discharge pipe allows for individual isolation of each pump. A check valve is installed at the discharge of each pump.

Evaluation

As previously noted, WWTP staff have observed overflow (of primary effluent to secondary effluent) occurring during peak flow events with estimated instantaneous flows of 14 MGD and greater. As identified later in **5.4.6 Secondary Clarifiers and RAS**, WWTP staff target an average daily RAS recycle rate of approximately 40 percent of the secondary effluent flow rate. Therefore, the estimated total peak day flow of the MPPS to secondary treatment is 19.6 MGD. Three pumps provide a capacity is 19.9 MGD, which is sufficient to meet the peak flow condition to secondary treatment with one redundant pump. In the future, all flow will require secondary treatment for nutrient removal. The MPPS has insufficient capacity to pass all flow to secondary treatment.

Additionally, the MPPS wet well cannot be taken out of service for maintenance because it is the only means available for receiving the combined primary effluent/RAS.

CONDITIONS ASSESSMENT

MPPS Concrete Structure

The MPPS cast-in-place concrete structure is about 30 years of age and is believed to be in satisfactory condition. Therefore, dedicated concrete structure improvements are not warranted during the planning period.

Pumping System

WWTP staff keep the pump and motor components well maintained. When necessary, components have been replaced, including rebuilds of the pumps and motors. The next rebuild of each pump and motor will be needed during the planning period.

The liquid level measuring air bubbler system is currently in good condition. Based on a typical service life and its importance for pumping system operation, the system will need to be replaced in the near future.

SUMMARY OF MAJOR FINDINGS

The MPPS is not sufficiently sized to provide capacity for primary effluent flow higher than 14 MGD. While the MPPS functions satisfactorily with the current permit conditions, to meet future nutrient limits, the MPPS will need to be abandoned or reconfigured to allow all flow to be conveyed to the secondary treatment system. In the interim, the MPPS is not expected to require improvements prior to the major secondary treatment system upgrade.

5.4.5 Aeration Basins and Blowers

OVERVIEW

Combined primary effluent/RAS is pumped from the MPPS to the aeration basins. The aeration basins provide biological treatment via an activated sludge process. There are three aeration basins with four partition cells each. The aeration basins were constructed in 1989 and have a common concrete structure. Combined primary effluent/RAS flows split to flow into Cell No. 1 of each aeration basin. Flow through subsequent cells occurs over the top of the concrete internal walls separating the cells. Mixed liquor outfalls to a single concrete outlet trough that flows to the secondary clarifiers.

There is an aeration diffuser system in each cell of the three aeration basins. New aeration diffuser systems were installed in 2017 consisting of fine bubble, polyurethane panel-style diffusers. Air is supplied to the system through an above-grade pipeline from the aeration blowers. The pipeline branches to each aeration basin cell, with electric-actuated butterfly valves controlling air flow to each cell.

Three aeration blowers provide low pressure air to the aeration basin diffuser systems, the grit extraction air lift system at the headworks, and diffusers in the effluent chlorine contact tank. Three centrifugal aeration blowers were installed in the Blower Building in 1989 (refer to **5.7 Buildings** for details on the Blower Building). In 2013, a turbo blower was installed to replace one of the centrifugal blowers. Each of the two centrifugal blowers has dedicated suction air piping, whereas the turbo blower draws air directly into its enclosure. The blowers discharge a common header pipeline that is routed below grade and splits, with one pipe to the aeration basins and one to the chlorine contact tank and headworks.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing aeration basins process components are provided in **Table 5-7**.

Table 5-7. Design Criteria for Existing Aeration Basins

Parameter	Value	Units
Quantity	3	
Configuration	Rectangular, cast-in-place concrete divided into cells with fine bubble strip membrane diffusers	
Number of Cells (per Basin)	4	
Dimensions (each Basin)	55 x 31 x 24	*ft (L x W x SWD)*
Volume (each Basin)	0.31	*MG*
Total Volume	0.92	*MG*
Design Average Solids Retention Time (at 7.4 MGD MMF)	3.7	*days*
Design Average Mixed Liquor Concentration	3,500	*mg/L*
Cell No. 1 (each Basin)		
Volume	0.02	*MG*
Diffuser System Design Peak Airflow	33	*scfm*
Diffuser System Minimum Airflow for Mixing	13	*scfm*
Cell No. 2 (each Basin)		
Volume	0.02	*MG*
Diffuser System Design Peak Airflow	33	*scfm*
Diffuser System Minimum Airflow for Mixing	13	*scfm*
Cell No. 3 (each Basin)		
Volume	0.21	*MG*
Diffuser System Design Peak Airflow	988	*scfm*
Diffuser System Minimum Airflow for Mixing	141	*scfm*
Target DO Concentration Range	1 - 5	*mg/L*
Cell No. 4 (each Basin)		
Volume	0.06	*MG*
Diffuser System Design Peak Airflow	222	*scfm*
Diffuser System Minimum Airflow for Mixing	37	*scfm*
Target DO Concentration Range	1 - 5	*mg/L*
Air Requirements		
Design Peak Airflow (with 3 Basins in operation)	3,828	*scfm*
Design Peak Airflow (with 2 Basins in operation)	2,552	*scfm*
Nominal Pressure	12	*psi*
Internal Recycle		
Configuration	None	
Wasting System		
Configuration	Secondary Clarifier underflow	

scfm = standard cubic feet per minute
psi = pounds per square inch

The design criteria for the existing aeration blowers are provided in **Table 5-8**.

Table 5-8. Design Criteria for Existing Aeration Blowers

Parameter	Value	Units
Systems Supplying Air To	Aeration basin diffusers, headworks grit removal, and chlorine contact tank diffusers	
Primary Blower		
Blower Type	Turbo	
Blower Quantity	1	
Blower Airflow Nominal Range	1,200 - 2,400	*scfm*
Blower Discharge Pressure Rating	12	*psi*
Blower Motor Size	150	*hp*
Backup Blowers		
Blower Type	Multistage centrifugal	
Blower Quantity	2	
Blower Capacity (each)	2,500 @ 12	*scfm @ psi*
Blower Motor Size (each)	200	*hp*

Operation

All three aeration basins are typically online to provide the necessary biological treatment capacity during the wet weather period. In the summer, when plant influent flows are lower, WWTP staff shut down one aeration basin at a time to visually inspect the condition and perform cleaning and maintenance. This is done annually.

Low pressure air is continually required for the WWTP processes. The turbo blower is the primary blower and solely used during normal operation. The turbo blower is speed controlled by an integrated VFD and runs continuously. The two centrifugal blowers are used as backup blowers and are typically only used during periods of "dirty" power to avoid excessive starts and stops on the turbo blower. The centrifugal blowers also can be used during maintenance of the turbo blower. If the air demand is greater than the turbo blower can supply, WWTP staff will temporarily take the blower offline and use the centrifugal blowers. When using the centrifugal blowers, WWTP staff will manually set, and adjust as necessary, the suction piping butterfly valves to control air flow.

Air is continuously supplied from the blowers to meet the air demand. Normally, all four aeration diffuser systems are online when the corresponding aeration basin is online. The electric-actuated butterfly valves are automatically modulated to vary air flow to each cell. Dissolved oxygen levels are continuously measured by probes. WWTP staff adjust the dissolved oxygen level setpoints periodically based on process objectives. The master control system utilizes a modified most-open-valve control loop to vary blower speed and each electric-actuated butterfly valve position to maintain header pressure, air flow, and dissolved oxygen (DO) setpoints.

Evaluation

The aeration basins were designed for an average solids retention time of 3.7 days based on a total maximum month flow rate of 7.4 MGD into the basins with 3 basins online at an average mixed liquor concentration of 3,500 mg/L. This design has generally produced secondary effluent that meets the current permit requirements for $CBOD_5$ and TSS. As discussed in **Chapter 6**, the current design cannot support reliable nitrification and denitrification due to the insufficient design solids retention time and corresponding secondary treatment tankage size.

Based on historical trends, the single turbo blower is periodically unable to meet the total air demands of the aeration diffuser systems during the peak diurnal portion of the day. This is evidenced by the aeration system not being able to meet the required DO setpoints in some cells. For extended periods of increased aeration demand, one or more centrifugal blowers is necessary. This requires manually throttling the inlet valve and lacks automatic control. This is undesirable, as the operators must set the airflow rate high enough to meet peak diurnal demands, and as a result, over-aerate for a large portion of each day. This is considered a significant deficiency for the existing secondary treatment process. An ongoing project seeks to replace the existing centrifugal blowers with an additional turbo blower and two smaller screw blowers. All of the blowers would be automatically controlled and staged, and operated on VFDs to provide a robust aeration system for the existing basins with sufficient turndown to achieve energy savings. These improvements are described further in **Chapter 8**.

Additionally, removal of the grit extraction air lift system and chlorine contact tank air demands from the aeration basin system is desirable.

CONDITIONS ASSESSMENT

Aeration Basins Structure

The aeration basins cast-in-place concrete structure is about 30 years of age and is believed to be in satisfactory condition. Therefore, dedicated concrete structure improvements are not warranted during the planning period. The metal removable covers at the aeration basins are currently in good condition.

Aeration Diffuser Systems

The aeration membranes typically are replaced on 5- to 10-year intervals and will necessitate multiple replacements during the planning period. If the basins were to remain as configured during the planning period, the existing diffuser piping systems should be satisfactory. However, it is likely that a future secondary treatment project would substantially reconfigure the aeration system.

Aeration Blowers System

The centrifugal blowers will be replaced in the near-term as further described in **Chapter 8**. The turbo blower is currently in good condition but may reach the end of its service life during the planning period and should be budgeted for replacement.

WWTP staff have discovered numerous leaks in the blower discharge air piping and aeration basins air piping. Many have been fixed. WWTP staff should continue to monitor all above-grade air piping for leaks and have inspections performed for below-grade air piping. Should the aeration basins and air piping be maintained in their current configuration during the planning period, budgeting for some refurbishment or replacement of air piping is prudent.

SUMMARY OF MAJOR FINDINGS

The future requirements for nitrogen reduction will require significant changes to the aeration basins and associated systems as discussed in **Chapter 6** and **Chapter 8**. It is assumed that any deficiencies noted in this section based on current conditions and existing capacity will be alleviated by future improvements to achieve nitrogen reduction. If improvements to achieve nitrogen reduction are significantly delayed (i.e. greater than 10 years), incremental improvements to the basins and associated systems may be necessary to rectify deficiencies noted in this chapter.

In the near term, the remaining centrifugal blowers will be replaced with a combination of automatically controlled screw and turbo blowers in the existing Blower Room. This work is expected to be complete in 2023.

5.4.6 Secondary Clarifiers and RAS

OVERVIEW

Mixed liquor from the aeration basins flows by gravity to the secondary clarifiers. The clarifiers provide gravity settling of activated sludge and remove floating scum from the water surface. There are four rectangular secondary clarifiers. The clarifiers were constructed in 1989 and have a common concrete structure.

Each secondary clarifier has a dedicated above-grade inlet with a manual slide gate for isolation. There are four openings in the inlet trough at each clarifier. The clarifiers include chain and flights sludge collector mechanisms and a cross screw sludge collector mechanism. Secondary effluent flows by gravity to the disinfection system. Scum is collected and discharged to the headworks. Settled activated sludge is removed as RAS and WAS from the upstream-end sump of each clarifier. RAS and WAS both flow by gravity out of the secondary clarifiers. RAS continues by gravity to the MPPS, while WAS is pumped. The RAS piping for each clarifier is routed to a common pipe with an in-line pneumatic-actuated knife gate valve upstream of the MPPS.

Secondary effluent flows to the bypass overflow structure. The channel includes a chlorine solution injection for disinfection. From the bypass overflow structure, secondary effluent flows to the chlorine contact tank. An electromagnetic flow meter is installed within a vault and used to measure secondary effluent flow (this flow measurement is used as the plant effluent flow).

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing secondary clarifiers and effluent process components are provided in **Table 5-9** and **Table 5-10**.

Table 5-9. Design Criteria for Existing Secondary Clarifiers

Parameter	Value	Units
Quantity	4	
Configuration	Rectangular, cast-in-place concrete	
Length (each)	120	*ft*
Width (each)	24	*ft*
Side Water Depth	14	*ft*
Surface Area (each)	2,880	*sf*
Volume (each)	0.30	*MG*
Design Average Surface Overflow Rate (at 7.4 MGD MMF)	640	*gpd/sf*
Design Peak Surface Overflow Rate (at 10 MGD)	870	*gpd/sf*
RAS		
Configuration	Gravity flow to MPPS	

Table 5-10. Design Criteria for Existing Secondary Effluent/Plant Effluent Flow Measurement

Parameter	Value	Units
Type	In-line electromagnetic flow meter	
Quantity	1	
Size (body diameter)	30	*in*
Measurement Maximum (at velocity limit of 10 fps)	32	*MGD*

Operation

The slide gates at the inlet pipes to the clarifiers are normally open to allow mixed liquor to flow to all four secondary clarifiers. The gates are manually adjusted to balance the sludge blanket level between the clarifiers. In the summer when plant influent flows are lower, WWTP staff shut down one clarifier at a time to visually inspect the condition and perform cleaning and maintenance. This is done annually.

Manual plug valves at each secondary clarifier's combined RAS/WAS pipe are normally open to allow activated sludge to flow out. WWTP staff can use the valves to assist with flow control. Primary flow control of RAS flow from each clarifier is performed by setting the manual V-port ball valve, which is installed at each RAS piping branch. Upstream of the valve is an in-line flow meter to measure individual RAS flow. The four RAS flow measurements are summed to provide total RAS flow to the MPPS. WWTP staff target an average daily RAS recycle rate of approximately 40 percent of the secondary effluent flow rate.

The knife gate valve is normally open to allow RAS to flow to the MPPS. It is an emergency valve that closes only in the event of power failure and reopens after the standby generators start.

Scum in the secondary clarifiers is skimmed daily by WWTP staff through manual operation of the scum troughs.

Evaluation

The four secondary clarifiers provide a total nominal surface area of 11,520 square feet (sf). The clarifiers were designed for a peak surface overflow rate of 870 gpd/sf based on a total peak secondary effluent flow rate of 10 MGD with 4 clarifiers online. Typical design peak secondary clarifier surface overflow rate is 1,000 to 1,600 gpd/sf based on Metcalf & Eddy and 1,200 gpd/sf per the Orange Book for conventional activated sludge systems. At 1,200 gpd/sf, 4 online clarifiers could approximately treat over 13.82 MGD, which is in line with the original design intent to have flows above 14 MGD bypass the secondary treatment system.

At both existing and future conditions, the solids loading rate (SLR) to the secondary clarifiers will limit the capacity of the secondary treatment system. SLR represents the solids flux across the clarifiers due to the inlet mixed liquor flow. The solids loading to the clarifiers is limited by the settleability of the mixed liquor, which is a function of the biological treatment process configuration. With conventional activated sludge systems, the typical average and peak secondary clarifier SLR design values are 25 and 40 pounds per day per sf of clarifier area, respectively. Assuming 4 clarifiers in service and the original design value of 3,500 mg/L for mixed liquor concentration and 40-percent RAS rate (as a portion of influent), the allowable peak influent flow to the secondary treatment system would be approximately 11.3 MGD. If the mixed liquor concentration or RAS rate is reduced, this number could be nominally increased. However, the settleability of the mixed liquor in the conventional activated sludge system limits the ultimate capacity of the secondary treatment system. The City has generally maintained compliance with the existing National Pollutant Discharge Elimination System (NPDES) Permit while bypassing the secondary treatment system with flows above 14 MGD. However, this will not be allowable if future permit conditions include stringent effluent nitrogen limits.

CONDITIONS ASSESSMENT

Secondary Clarifiers

Structural

The secondary clarifiers cast-in-place concrete structure is about 30 years of age and appears to be in satisfactory condition. Therefore, dedicated concrete structure improvements are not warranted during the planning period.

The older metal removable covers at the secondary clarifiers are currently in good condition. Based on a typical service life, the covers will need to be replaced during the planning period. However, the newer aluminum Hallsten covers at the downstream end of the clarifiers will not need to be replaced during the planning period.

Mechanical

WWTP staff keep the mechanical components well maintained by performing annual visual inspections and maintenance. When necessary, components have been replaced. The chain and flights were replaced in 2020, at which time the drive units were either rebuilt or replaced. Currently, the only mechanical components identified for replacement the four cross screw sludge collector mechanisms. All four scum troughs were replaced in 2018 and are in good condition.

RAS System

The air compressor that supplies air to the pneumatic-actuated knife gate valve is currently in good condition. Based on a typical service life, the air compressor will need to be replaced during the planning period. As previously identified, there are performance issues with the lack of automation of RAS flow control. This will be rectified as part of a future secondary treatment project for nutrient removal.

Secondary Effluent/Plant Effluent Flow Measurement

The flow meter and vault visually appear to be in good condition and do not warrant any near-term improvements. It is likely this flow meter will be replaced and relocated as part of a future secondary treatment and disinfection system project.

SUMMARY OF MAJOR FINDINGS

Incremental improvements may be made to the existing secondary clarifiers as part of a future secondary treatment project to meet nitrogen reduction. However, the clarifiers are likely to be maintained in their current general configuration and as such, the following major conditions-based improvements are likely required during the planning period:

1. Replace the older removable covers with aluminum Hallsten covers (to be handled as part of the WWTP operations and maintenance (O&M) program and budget and recommended to be performed by 2030).
2. Replace components for all four cross screw sludge collector mechanisms (to be handled as part of the WWTP O&M program and budget and recommended to be performed by 2026).

5.4.7 Secondary Effluent Disinfection System

OVERVIEW

Secondary effluent is chlorinated at the secondary effluent channel of the bypass overflow structure and then flows by gravity to the chlorine contact tank. The tank provides contact time for sufficient disinfection to occur. Effluent is dechlorinated at the downstream end of the tank prior to the outfall to Puget Sound.

The chlorine disinfection contact tank concrete structure was constructed in 1984. In 1989, modifications to the tank structure were constructed, along with installation of the air diffuser systems. The Laboratory and Office Building also was constructed in 1989 on top of a majority of the tank structure (refer to **5.7 Buildings** for details).

The tank is rectangular and separated into two serpentine-baffled chambers, each with a dedicated inlet. The inlet pipeline splits to each chamber and can be isolated with a manual butterfly valve. An automatic composite sampler is located at the tank and used to sample dechlorinated secondary effluent (final effluent). Final effluent flows into the outfall piping.

An air diffuser system is installed in each chamber of the chlorine contact tank to provide mixing. Air is supplied from the aeration basin blowers.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing secondary effluent chlorine contact tank are provided in **Table 5-11**.

Table 5-11. Design Criteria for Existing Secondary Effluent Chlorine Disinfection and Dechlorination

Parameter	Value	Units
Chlorine Disinfection Contact Tank		
Quantity	1	
Configuration	Serpentine-baffled chambers, cast-in-place concrete with air diffuser systems	
Number of Chambers	2	
Chamber Serpentine Dimensions (each)	220 x 4.5	*ft (L x W)*
Height to Outlet Fixed Weir (each Chamber)	18.21	*ft (H)*
Design Total Contact Time at 7.4 MGD MMF	53	*minutes*
Design Total Contact Time at 13.6 MGD Peak Flow	29	*minutes*
Design Chlorine Dose	4.4	*mg/L*
Design Chlorine Gas Feed Rate (at Peak Flow)	500	*lb/d*
Contact Tank Air Diffuser Systems		
Diffusers Type	Coarse bubble, rubber disk	
Diffuser Systems Quantity (per channel)	1	
Diffuser Systems Quantity (total)	2	
Diffuser Systems Design Air Requirements (total)	100 @ 10	*cfm @ psi*
Air Supply Location	Basin Aeration Blowers	

Operation

Normally only the chamber on the east side of the chlorine disinfection contact tank is used as the outlet weir opening of the chamber on the west side of the tank is closer to the outfall and does not provide as much time for mixing of the sodium bisulfate. WWTP staff open the west chamber when secondary effluent flow reaches approximately 12 MGD. WWTP staff have observed an estimated instantaneous flow of 20 to 21 MGD results in nearly reaching an emergency overflow blockout in the effluent trough.

The aeration diffusers are continually aerated for the online chamber, and operators set a manual butterfly valve partially open to throttle air flow to the diffusers.

The automatic composite sampler draws samples of plant effluent from the downstream end of the common outlet trough.

Evaluation

The chlorine contact tank was designed for a total contact time (i.e. both chambers in use) of 53 minutes at a maximum month flow rate of 7.4 MGD into the tank. Typical design ranges for disinfection contact time based on average design flow is 30 to 120 minutes and 60 to 120 minutes per Metcalf & Eddy and the Orange Book, respectively. The contact tank design value is well within the Metcalf & Eddy range but less than the lower end of the Orange Book range. However, the contact tank design value is based on the maximum month flow rate, which is higher than average (annual) flow rate; therefore, it results in a shorter contact time. The tank also was designed for a total contact time of 29 minutes at a peak flow rate of 13.6 MGD into the tank. Typical design ranges for disinfection contact time based on peak design flow is 15 to 90 minutes and 20 minutes or greater per Metcalf & Eddy and the Orange Book, respectively. The contact tank design value is well within the typical design ranges. At the current peak hour flow of approximately 20 MGD, 2 chambers will provide approximately 20 minutes of contact time, which is near the minimum recommended duration. As evidenced by the historical fecal coliform levels, the system provides satisfactory disinfection at current flows.

At the minimum recommended contact time of 15 minutes, the existing chlorine contact tank provides a nominal capacity of 22.7 MGD. Peak hour flows are projected to exceed this level by 2030. Additionally, the chlorine contact chamber effluent trough is likely to overflow near 22 MGD per operator observations. As such, the maximum capacity of the chlorine contact chamber as currently configured is likely limited to 22 to 23 MGD, which is insufficient for future peak hour flows.

Additionally, as discussed in **5.4.8 Chlorination and Dechlorination Systems**, the use of the chemical chlorination system is undesirable for multiple reasons and operators prefer an alternate approach to disinfection.

CONDITIONS ASSESSMENT

Chlorine Contact Tank Structural

Most of the chlorine disinfection contact tank cast-in-place concrete structure is about 35 years of age. The structure is believed to be in satisfactory condition. Therefore, significant concrete structure improvements are not considered necessary during the planning period.

Four access ladders within the tank, two in each chamber, have significant corrosion. It is likely that the ladders and other internal components will need to be replaced in the near term as part of normal O&M.

Air Diffuser Systems

WWTP staff should periodically inspect each air diffuser system when the corresponding chamber is offline and perform any necessary maintenance and component replacements.

Final Effluent Sampling

The automatic composite sampler is currently in good condition. Based on a typical service life, the sampler will need to be replaced during the planning period.

SUMMARY OF MAJOR FINDINGS

Based on the assessments, a brief summary of the major findings and necessary improvements to the chlorine contact tank is as follows:

1. The hydraulic and treatment capacity of the chlorine contact tank will be exceeded during the planning period, necessitating expansion or replacement of the existing effluent disinfection system.
2. Replacement of the automatic composite sampler will be necessary during the planning period and will be completed as part of the normal WWTP O&M program and budget.

5.4.8 Chlorination and Dechlorination Systems

OVERVIEW

Chlorine solution is necessary for multiple processes within the WWTP, including various odor control systems, plant influent odor control (pre-chlorination), occasional chlorination of RAS flow to the MPPS, and major usage for secondary effluent disinfection (post-chlorination).

The chlorine chemical system was installed in 1984 in two adjacent rooms in Building No. 2. Prior to 2016, the pre-chlorination and post-chlorination chlorine gas injectors were replaced. In 2016, the chlorine chemical system was replaced except for the two new chlorine gas injectors and the Scrubber No. 4 chlorinator and chlorine gas injector.

Chlorine gas is used with an all-vacuum (pressure) system is to ultimately draw the gas by vacuum into non-potable water streams. The resulting chlorine solution feeds are then conveyed by the non-potable water stream pressure through pipelines to injection points for the purposes identified previously. Chlorine gas storage consists of two banks of three 1-ton containers.

Additionally, liquid sodium bisulfate is injected into the effluent trough of the chlorine contact tank to provide dechlorination of the final effluent.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing chlorine chemical system components are provided in **Table 5-12**.

Table 5-12. Design Criteria for Existing Chlorination and Dechlorination Chemical Systems

Parameter	Value	Units
Wastewater/Systems Supplying Chlorine Solution To	Secondary effluent, plant influent, and Odor Control Scrubber No. 4	
Chlorine Type	Chlorine Gas	
Chlorine Gas Storage and Withdrawal		
Storage Type	1-ton containers	
Storage Bank Quantity	1 Duty, 1 Standby	
Containers (per Bank)	3	
Vacuum Regulators (per Container)	1	
Vacuum Regulator Withdrawal Capacity (per Container)	500	*lb/d*
Withdrawal Limit (per Container, in 60 - 70 °F Ambient Room)	400	*lb/d*
Withdrawal Limit per Bank	1,200	*lb/d*
Secondary Effluent Chlorine Gas Feed		
Chlorinator Quantity	1	
Chlorinator Capacity	500	*lb/d*
Injector Quantity	1	
Injector Capacity	500	*lb/d*
Plant Influent Chlorine Gas Feed		
Chlorinator Quantity	1	
Chlorinator Capacity	100	*lb/d*
Injector Quantity	1	
Injector Capacity	500	*lb/d*
Scrubber No. 4 Chlorine Gas Feed		
Chlorinator Quantity	1	
Dechlorination Chemical System		
Chemical Type	Liquid Sodium Bisulfite	
Storage Type	Vertical tank	
Storage Quantity	1	
Metering Pump Type	Peristaltic	
Metering Pump Quantity	1	
Metering Pump Capacity	4.8	*gph*
Chlorinator Capacity	100	*lb/d*

gph = gallons per hour

Operation

Chlorine solution is continually required for influent odor control, secondary effluent disinfection, and odor control. Occasionally, chlorine solution is used for chlorinating RAS flow to the MPPS.

Non-potable water flowing through the injectors creates vacuum pressure all the way back to the 1-ton containers, resulting in chlorine gas to be withdrawn from the containers. A vacuum regulator with drip leg heater is installed at the withdrawal point of each container. The automatic vacuum switchover valve allows chlorine gas to be withdrawn from one bank of containers (the online bank) while preventing it from entering the other bank (the standby bank). When the online bank of containers near empty, the valve automatically allows chlorine gas to be withdrawn from the standby bank. WWTP staff manually switch containers delivered from a chemical supplier.

Secondary effluent chlorination automatically controlled to flow pace the chlorine gas feed rate based on an operator-adjustable chlorine dose setpoint and the flow rate measured at the secondary effluent flow meter.

Influent chlorination is automatically controlled to provide a fixed chlorine gas feed rate using an operator-adjustable feed rate setpoint.

The Scrubber No. 4 chlorinator and chlorine gas injector are used exclusively for the chlorine solution feed to the scrubber. The chlorinator has a dial for manually setting the chlorine gas feed rate.

If the non-potable water system is out of service, WWTP staff can connect to potable water backup supply piping to maintain the chlorine solution feeds. If the automatic vacuum switchover valve is out of service, it can be bypassed for either bank or both banks using manual ball valves at the chlorine gas piping.

Dechlorination of the disinfected secondary effluent is continually required. There is an oxidation reduction potential probe installed in the common outlet trough. The dechlorination metering pump is automatically speed controlled to increase or decrease the liquid sodium bisulfite feed based on the oxidation reduction potential measurement and the flow rate measured at the secondary effluent flow meter.

Evaluation

The chlorination and dechlorination systems function satisfactorily and provide sufficient dosing capacity. However, the systems are aging, and if they are to be maintained for usage through the planning period, they should likely be upgraded to ensure reliability and improve safety. The chlorine handling areas include sensors and alarming but do not include air scrubbing equipment in the event of a leakage.

Handling of chlorine gas is labor-intensive and hazardous. The WWTP relies on external deliveries of chlorine gas cylinders, which is undesirable due to the risks associated with transporting this hazardous material. The management of recurring deliveries of chlorine gas is challenged by the constrained nature of the WWTP. Further, use of chlorine gas requires reliance on external manufacturing and transport systems over which the City has no control. This presents a potential risk of failure due to supply chain issues.

The WWTP staff has expressed interest in other effluent disinfection systems to reduce the handling of chlorine at the WWTP. These options are reviewed further in **Chapter 6**.

CONDITIONS ASSESSMENT

Chlorine Gas Equipment and Piping

The chlorine gas equipment and piping are currently in satisfactory condition. If this system is maintained for usage during the planning period, it should be replaced to ensure reliability and improve safety.

Dechlorination Chemical System

The dechlorination chemical storage tank and metering pump is currently in good condition. If this system is maintained for usage during the planning period, it should be replaced based on its typical service life.

SUMMARY OF MAJOR FINDINGS

For multiple reasons, alternate methods of effluent disinfection should be considered for implementation at the WWTP.

5.4.9 Plant Effluent Outfall

The original outfall pipe consisted of a corrugated metal pipe, which was replaced in approximately 1998 with a high-density polyethylene (HDPE) pipeline. In approximately 2011, the existing diffuser was replaced with an HDPE diffuser. The outfall pipe extends approximately 750 linear feet offshore and terminates with the 240-foot diffuser section with 80 ports.

The design criteria for the existing plant effluent outfall components are provided in **Table 5-13**.

Table 5-13. Design Criteria for Existing Plant Effluent Outfall

Parameter	Value	Units
Type	Outfall pipe with multiple-port diffuser	
Outfall Pipe Material	HDPE	
Outfall Pipe Inside Diameter	31.5	*in*
Outfall Pipe Length	750	*linear ft*
Diffuser Pipe Material	HDPE	
Diffuser Pipe Inside Diameter	31.5	*in*
Diffuser Pipe Length	240	*linear ft*
Diffuser Ports Quantity	80	
Diffuser Ports Diameter	3 - 4	*in*

As a condition of the NPDES Permit, the submerged outfall pipe must be inspected each permit cycle. The existing outfall pipe and diffuser were inspected with a remotely operated vehicle on August 16, 2021, and minor necessary repairs were noted in an outfall evaluation report. The recommended repairs were completed on August 31, 2021 by a diver. No major concerns are noted with the outfall at this time, and the outfall is expected to continue to function as currently configured through the planning period with normal operation and maintenance. A detailed analysis of the hydraulic capacity of the outfall has not been recently performed; anecdotally, the outfall has hydraulically passed 20 to 21 MGD events without issue. Future peak hour flows are projected to be higher during the planning period. As previously noted, replacement of the existing disinfection system will be necessary. As part of a future disinfection system design, the outfall should be analyzed in detail to evaluate increasing the hydraulic capacity of the system by enclosing the upstream piping and disinfection system to allow for head pressure and the corresponding hydraulic capacity of the outfall to increase. In the near term, the outfall functions satisfactorily and no major deficiencies are required to be rectified.

5.4.10 Hydraulic Profile

The existing hydraulic profile is shown in **Appendix B**. The hydraulic profile shows that plant influent flows by gravity through the headworks to the primary clarifiers. Primary clarifier effluent flows to the MPPS, where it is lifted approximately 40 feet to the secondary treatment system. The WWTP is configured in this manner since the existing headworks and primary treatment system were constructed first, with the secondary treatment system being added later. As discussed, flows above approximately 14 MGD bypass the MPPS and secondary treatment system, which will not allow for meeting the future Total Inorganic Nitrogen (TIN) limits discussed in **Chapter 6.** In addition to the inability to meet future TIN limits, the hydraulic profile as currently configured is undesirable for multiple reasons. For one, the current configuration is less energy efficient than allowing for gravity flow from primary to secondary treatment. Additionally, the reliance on pumping of primary effluent prompts additional reliability and redundancy considerations that do not exist if flow proceeds by gravity from primary to secondary treatment. If major improvements to the WWTP are needed for other objectives, it is desirable to also reconfigure the hydraulic profile to allow gravity flow from influent through the preliminary, primary, secondary, and disinfection stages.

5.5 SOLIDS HANDLING SYSTEM ANALYSES

5.5.1 Primary Sludge Conveyance

OVERVIEW

Primary sludge collected from the primary clarifiers is blended with thickened WAS from the secondary treatment system prior to dewatering.

The air-operated diaphragm primary sludge pumps were installed with the primary clarifiers in 1984. The primary sludge pumps for the three rectangular primary clarifiers are housed in a dry pit that is integrated into the rectangular clarifiers concrete structure. The primary sludge pump for the circular primary clarifier is located adjacent to the circular clarifier in Building No. 2. The primary sludge pumps currently convey primary sludge to a mixing manhole that houses two submersible pumps and was constructed in 1984. These pumps lift all primary sludge to the concrete sludge blending tank that was constructed in 1989. In 2014, the primary sludge pump air compressors were replaced. Previously, primary sludge was attempted to be further thickened by a gravity thickener prior to blending with WAS. In 2015, the primary sludge gravity thickener and associated equipment were removed.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing primary sludge conveyance process components are provided in **Table 5-14**.

Table 5-14. Design Criteria for Existing Primary Sludge Conveyance

Parameter	Value	Units
Primary Sludge Pumps		
Pump Type	Air-operated diaphragm	
Pump Quantity (per Primary Clarifier)	1	
Pump Quantity (total)	4	
Pump Capacity (each)	50 @ 45	*gpm @ ft TDH*
Air Requirements for Operation (per pump)	35 @ 40	*cfm @ psi*
Air Supply Equipment Type	Compressors	
Compressor Quantity	2	
Compressor Motor Size (each)	20	*hp*
Mixing Manhole		
Configuration	Wet well, pre-cast concrete manhole	
Manhole Volume	1,000	*gallons*
Pump Type	Submersible	
Pump Quantity	2	
Pump Capacity (each)	206 @ 30	*gpm @ ft TDH*
Pump Motor Size (each)	5	*hp*
(Primary) Sludge Blending Tank		
Configuration	Rectangular, cast-in-place concrete	
Length	10	*ft*
Width	10	*ft*
Side Water Depth	14.5	*ft*
Volume	10,800	*gallons*
Mixer Type	Vertical shaft with dual impellers	
Mixer Quantity	1	
Mixer Motor Size	2	*hp*

Operation

The four primary clarifiers and associated sludge pumps are generally in operation except during periods of maintenance, when each clarifier can be taken offline sequentially. As previously mentioned, flow splitting the clarifiers is manually adjusted without the usage of flow monitoring equipment. The pumping rate for the air-operated diaphragm pumps are also manually set by adjusting the pulse cycle for each pump.

Evaluation

WWTP operations staff generally check the total solids concentration of the primary clarifier sludge from each clarifier at least once per week. Over the last 5 years, concentrations have ranged widely from below 2 percent to over 6 percent. The 5-year average is near 4 percent. Further, the concentrations can vary significantly between the clarifiers on any one day. As such, it is likely that the manual flow splitting between the clarifiers cannot adequately allow reliable primary sludge concentration. If the primary clarifiers are to be maintained for future use, a more accurate method of flow splitting would be recommended to ensure reliable thickening of the primary sludge.

Each primary sludge pump has a flow rate capacity of 50 gallons per minute (gpm). Each mixing manhole pump has a flow rate capacity of 206 gpm, allowing for full redundancy in the mixing manhole pumps with four clarifiers online. The primary sludge pumping equipment has sufficient capacity for the planning period.

CONDITIONS ASSESSMENT

Primary Sludge Pumping System and Mixing Manhole

The primary sludge pumps and dedicated control panels, as well as the mixing manhole pumps and dedicated control panel, are about 35 years of age, which is well beyond a typical service life. Should this equipment be continued for use during the planning period, it is recommended to be replaced to ensure continued reliable operation.

The primary sludge pump air compressors are currently in good condition. Based on a typical service life, the air compressors will need to be replaced during the planning period.

The concrete manhole is about 35 years of age and is believed to be in satisfactory condition. Therefore, dedicated manhole improvements are not warranted during the planning period.

Sludge Blending Tank

Structural

The sludge blending tank cast-in-place concrete structure is about 30 years of age and is believed to be in satisfactory condition. Therefore, dedicated concrete structure improvements are not warranted during the planning period. Normal maintenance for this structure and the metal covers may be needed during the planning period, but no major improvements are likely required.

Mechanical

WWTP staff keep the mixer well maintained by performing annual visual inspection and maintenance. Staff is not aware of any issues with the mixer; however, it is about 30 years of age. Based on a typical service life, the mixer will need to be replaced during the planning period.

SUMMARY OF MAJOR FINDINGS

The primary sludge system is expected to be decommissioned or largely reconfigured as part of the future secondary treatment system improvements described in **Chapter 6** and **Chapter 8**.

Minor improvements in the near term may be necessary, although these are expected to be completed as normal O&M, including:

1. Replace all four primary sludge pumps and the two dedicated control panels;
2. Replace both primary sludge pump air compressors;
3. Replace both mixing manhole pumps and the dedicated control panel;

4. Replace the removable covers at the sludge blending tank; and
5. Replace the sludge blending tank mixer.

5.5.2 WAS Thickening

OVERVIEW

Settled activated sludge in the secondary clarifiers is removed as RAS and WAS. The WAS is pumped to a pre-concentration tank, which provides gravity thickening. The thickened WAS (TWAS) is pumped to combine with primary sludge prior to dewatering.

The pre-concentration tank was constructed in 1989, and its concrete structure is integrated with the sludge blending tank structure. In 1997, a TWAS pump was installed and miscellaneous improvements were made to the pre-concentration tank. A WAS pump was first added in 1997 to control the rate of WAS flow. Prior to this, WAS flow from the RAS system was controlled by a valve, but the flow control was inadequate. In 2016, the WAS pump was replaced. As previously identified, the primary sludge gravity thickener and associated equipment were removed in 2015, which resulted not only in changes to the primary sludge process but also resulted in the current WAS thickening process. As previously identified in **5.2.1 History**, there is an active project for construction of improvements to the pre-concentration tank.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing WAS thickening process components are provided in **Table 5-15**.

Table 5-15. Design Criteria for Existing WAS Thickening

Parameter	Value	Units
WAS Pump		
Pump Type	Rotary lobe	
Pump Quantity	1	
Pump Solids Concentration Capacity	5	*%*
Pump Capacity	200 @ 35	*gpm @ ft TDH*
Pump Motor Size	7.5	*hp*
Pre-Concentration (TWAS) Tank		
Configuration	Rectangular, cast-in-place concrete with circular sludge thickener	
Length	20	*ft*
Width	20	*ft*
Side Water Depth	15	*ft*
Surface Area	400	*sf*
Volume	45,000	*gallons*
Sludge Thickener Diameter	20	*ft*
Design Surface Overflow Rate (Maximum Month)	864	*gpd/sf*
Design Solids Loading Rate (Maximum Month)	26	*lb/d/sf*
Design Underflow Solids Concentration	1.5	*%*
Thickened WAS (TWAS) Pump		
Pump Type	Progressive cavity	
Pump Quantity	1	
Pump Capacity	40 @ 15	*gpm @ psi*
Pump Motor Size	3	*hp*

Operation

Wasting of sludge via the WAS pump from the RAS system generally occurs continuously. WAS concentration is assumed to be the same as the RAS concentration and is blended from the online secondary clarifiers. Operations staff verify the total solids concentration for the RAS daily, which annually varies between 0.35 and 1 percent but is relatively steady from day to day. The WAS rate is set by the operation staff based on the target solids retention time to be achieved for the secondary treatment process.

Evaluation

The pre-concentration tank was designed for a surface overflow rate of 864 gpd/sf and a solids loading rate of 26 pounds per day per square foot (lb/d/sf). Over the past 5 years, the thickened WAS concentration has generally ranged from 1.5 to 3.5 percent, with the average being above 2 percent. The pre-concentration tank is intended to maintain a TWAS concentration above

1.5 percent, which it has generally achieved, although a downward trend in the thickened WAS concentration over the past 5 years is apparent. However, the pre-concentration tank can likely continue to achieve its design objective for the current secondary treatment system. Any significant changes to the secondary treatment system will likely prompt a new WAS thickening system.

CONDITIONS ASSESSMENT

WAS Pumping System

The WAS flow meter is about 25 years of age, which is beyond a typical service life. Although it is operable, replacement of the meter may be necessary in the near future.

The WAS pump and dedicated control panel (which includes the VFD) are in good condition. Based on a typical service life, the pump and panel will need to be replaced during the planning period.

Pre-Concentration Tank

Structural

Refer to **5.5.1 Primary Sludge Conveyance** for the condition of that part of the structure. The pre-concentration tank cast-in-place concrete part of the structure is about 30 years of age and is believed to be in satisfactory condition. Therefore, dedicated concrete structure improvements are not warranted during the planning period. Normal maintenance for this structure and the metal covers may be needed during the planning period, but no major improvements are likely required.

Mechanical

The thickener mechanism was replaced and the internals of the tank were refurbished in 2021. No additional improvements should be necessary during the planning period.

Thickened WAS Pumping System

The TWAS pump is about 25 years of age, which is beyond a typical service life. Although it is operable, replacement of the pump is necessary in the near future. As previously identified, increasing the flow rate capacity of the pump should be considered.

SUMMARY OF MAJOR FINDINGS

The WAS thickening system is expected to be decommissioned or largely reconfigured as part of the future secondary treatment system improvements described in **Chapter 6** and **Chapter 8**.

Minor improvements in the near term may be necessary, although these are expected to be completed as normal O&M, including:

1. Replace the WAS flow meter;
2. Replace the WAS pump and dedicated control panel;
3. Replace the TWAS pump; and
4. Replace the TWAS pump VFD.

5.5.3 Dewatering

OVERVIEW

Primary sludge and TWAS are combined (referred to as thickened sludge in this chapter) and pumped to the dewatering system prior to incineration.

The thickened sludge feed system was installed in 1989. In 2015, the dewatering system was entirely replaced, changing to a screw press from the previous centrifuges. The dewatering system is housed in the Solids Handling Building, which is adjacent to Building No. 2. The thickened sludge feed system is housed between the circular primary clarifier area of Building No. 2 and the Solids Handling Building.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing dewatering process components are provided in **Table 5-16**.

Table 5-16. Design Criteria for Existing Dewatering

Parameter	Value	Units
(Combined) Thickened Sludge Feed		
Sludge Grinder Type	Inline macerator	
Sludge Grinder Quantity	1	
Sludge Grinder Motor Size	3	*hp*
Pump Type	Progressive cavity	
Pump Quantity	2	
Pump Capacity (each)	65 @ 23	*gpm @ ft TDH*
Pump Motor Size (each)	5	*hp*
Dewatering System		
System Type	Screw press with upstream polymer addition/flocculation	
Flocculation Tank Quantity	1	
Flocculation Tank Volume	285	*gallons*
Flocculation Mixer Type	Vertical shaft with dual impellers	
Flocculation Mixer Quantity	1	
Flocculation Mixer Motor Size	1.5	*hp*
Screw Press Quantity	1	
Screw Press Dry Solids Loading Capacity	625	*lb/hr*
Screw Press Solids Loading Concentration Capacity	2.0 - 2.5	*%*
Polymer System Configuration	Polymer activation/feed skid with neat polymer storage	
Neat Polymer Storage Type	Totes	
Neat Polymer Storage Quantity	2	
Neat Polymer Storage Capacity (each)	2,300	*lb*
Polymer Activation/Feed Skid Quantity	1	
Polymer Activation/Feed Skid Neat Polymer Capacity	1,000	*lb/d*
Dewatered Sludge (Cake) Conveyance Equipment		
Type	Shaftless reversing screw conveyor	
Quantity	1	
Screw Diameter	9	*in*

Operation

The screw press is generally operated 7 days per week to continuously feed the incinerator. As discussed in **5.5.5 Incineration System**, it is likely that the City will suspend further use of the incinerator and transition to hauling dewatered sludge offsite. In this configuration, it is likely that the screw press will maintain continuous operation, but it may be paused periodically depending on the availability of hauling vehicles.

The WWTP staff target a ratio of two-thirds TWAS and one-third primary sludge for the thickened sludge to the centrifuge. Based on a TWAS solids concentration of 1.5 percent, a primary sludge concentration range of 3 to 4 percent, and the flow rate ratio, the resulting thickened sludge solids concentration range is 2 to 2.4 percent. This operating range falls within the rated inlet concentration range of the screw press, which is 2 to 2.5 percent.

Evaluation

The screw press is rated for a dry solids feed of 625 pounds per hour (lb/hr). At an inlet solids concentration range of 2.0 to 2.5 percent, the feed flow rate range is 50 to 63 gpm. Each thickened sludge pump has a flow rate capacity of 65 gpm such that full redundancy in thickened sludge pumping equipment is available. The screw press has produced dewatered sludge with a solids concentration range of approximately 16 to 28 percent, with the average generally being near 21 percent over the last 5 years. Further, the average dewatered sludge concentration appears to have been dropping in recent years.

The neat polymer storage weight scales are not measuring accurately. Improvements to replace and potentially upgrade both scales are necessary in the near future.

CONDITIONS ASSESSMENT

Thickened Sludge Feed System

The thickened sludge grinder, two pumps and corresponding VFDs, and flow meter are about 30 years of age, which is well beyond a typical service life. Although the equipment is operable, improvements to replace these components are necessary in the near future.

Dewatering System

The dewatering system equipment is currently in good condition. Based on a typical service life, all the equipment will need to be replaced during the planning period.

Dewatered Sludge Conveyor

The dewatered sludge shaftless reversing screw conveyor is currently in good condition. Based on a typical service life, the conveyor will need to be replaced during the planning period.

SUMMARY OF MAJOR FINDINGS

Based on the assessments, a brief summary of the major findings and necessary improvements to the dewatering system is as follows:

1. Replace the thickened sludge feed grinder, pumps (both), VFDs (both), and flow meter (recommended to be performed by 2026).
2. Replace the dewatering system equipment and dewatered sludge conveyor (recommended to be performed between 2031 and 2040).
3. Analyze options and design improvements to replace the weight scales to provide accurate weight measurement of stored neat polymer (recommended to be performed by 2026).

5.5.4 Scum Concentrating

OVERVIEW

Floating material (scum, including grease) is skimmed from the water surfaces of the primary clarifiers and flows by gravity to the scum collection basin. From the basin, scum is pumped to the scum concentrator and then flows by gravity into the concentrated scum hopper. The concentrated scum is pumped for combining with dewatered sludge and subsequent incineration (refer to **5.5.5 Incineration System** for details).

The scum collection basin was constructed in 1989, and its concrete structure is adjacent to the circular primary clarifier concrete structure in Building No. 2 (refer to **5.7 Buildings** for details on this building). A scum chopper pump was installed along with the collection basin. In 1997, the scum concentrator, concentrated scum hopper, and a concentrated scum pump were installed.

ASSESSMENT OF RATED CAPACITY OF MAJOR PROCESS UNITS

Existing System Design Criteria

The design criteria for the existing scum concentrating process components are provided in **Table 5-17**.

Table 5-17. Design Criteria for Existing Scum Concentrating

Parameter	Value	Units
Scum Collection Basin		
Configuration	Rectangular, cast-in-place concrete	
Volume	1,100	*gallons*
Scum Chopper Pump		
Pump Type	Centrifugal chopper	
Pump Quantity	1	
Pump Capacity	60 @ 30	*gpm @ ft TDH*
Pump Motor Size	5	*hp*
Scum Concentrator		
Configuration	Rectangular, steel tank with chain-driven scum collector flights	
Decant Tank Hydraulic Capacity	60	*gpm*
Decant Tank Volume Capacity	1,700	*gallons*
Concentrated Scum Hopper		
Configuration	Inverted conical steel tank with heater	
Volume	500	*gallons*
Mixer Type	Vertical shaft	
Mixer Quantity	1	
Mixer Motor Size	3	*hp*
Concentrated Scum Pump		
Pump Type	Progressive cavity	
Pump Quantity	1	
Pump Capacity	3 @ 60	*gpm @ psi*
Pump Motor Size	1.5	*hp*

Evaluation

WWTP staff have determined through operation of the process that the scum collection basin, scum chopper pump, and scum concentrator do not have sufficient capacity. Improvements to this equipment are necessary to provide sufficient capacity and should include replacement of the scum hopper and concentrated scum pump.

With grease in the concentrated scum it can impact incinerator operating parameters; WWTP staff must continue to be careful with the timing and duration of concentrated scum pumping.

CONDITIONS ASSESSMENT

Scum Collection Basin

The scum collection basin cast-in-place concrete structure is about 30 years of age and is believed to be in good condition. Therefore, dedicated concrete structure improvements are not warranted during the planning period. As previously identified, there is a capacity issue with the scum collection basin that necessitates improvements.

Scum Chopper Pumping System

The scum chopper pump was replaced in 2017 and is in good condition. As previously identified, increasing the flow rate capacity of the pump is necessary.

Scum Concentrator

As previously identified, there is a capacity issue with the concentrator that necessitates improvements.

Structural

The steel structure of the concentrator is about 25 years of age and visually appears to be in good condition. It is not anticipated that the structure warrants improvements during the planning period; however, WWTP staff should monitor the condition by visual observation.

Mechanical

The chain and flight scum collector mechanism is about 25 years of age, which is beyond a typical service life. Although it is operable, replacement of the mechanism is necessary in the near future.

Concentrated Scum Hopper

Structural

The steel structure of the concentrated scum hopper is about 25 years of age and, visually, it appears to be in good condition. It is not anticipated that the structure warrants improvements during the planning period; however, WWTP staff should monitor the condition by visual observation.

Mechanical

The mixer is about 25 years of age, which is beyond a typical service life. Although it is operable, replacement of the mixer is necessary in the near future.

Concentrated Scum Pumping System

The concentrated scum pump is about 25 years of age, which is beyond a typical service life. Although it is operable, replacement of the pump is necessary in the near future.

SUMMARY OF MAJOR FINDINGS

Based on the assessments, a brief summary of the major findings and necessary improvements to scum concentrating is as follows:

1. Analyze options and design improvements to provide more volume capacity for scum collection (recommended to be performed by 2026).
2. Design improvements to replace the scum concentrator with a larger capacity unit (recommended to be performed by 2026).
3. Replace the scum chopper pump with a larger flow rate capacity pump (recommended to occur by 2026).
4. Replace the concentrated scum hopper (recommended to occur by 2026).
5. Replace the concentrated scum pump (recommended to occur by 2026).

5.5.5 Incineration System

OVERVIEW

The City utilizes incineration to handle waste sludge generated from the WWTP. Chavond-Barry Engineering Corp. (CBE) performed an evaluation of the existing incinerator. A copy of CBE's report is included in **Appendix E**. CBE estimated a maximum theoretical capacity of approximately 620 lb/hr dry solids feed; however, the realistically achievable capacity for the incinerator as currently configured is estimated at approximately 527 lb/hr dry solids based on a dewatered sludge (cake) solids concentration of 21 percent.

During the drafting of this WWTP Facility Plan (Plan), the City commissioned Murraysmith to perform an analysis of the costs associated with continuing incineration compared to hauling dewatered sludge offsite for disposal via landfill. Due to the historically high O&M costs associated with the incinerator and routine issues with meeting air quality standards, this analysis concluded that it is more cost effective for the City to suspend incineration and proceed with hauling of dewatered sludge until a new solids handling system can be constructed. The Murraysmith report is included in **Appendix F**. Further, the analysis in **Chapter 7** also ruled out incineration as a future option for solids handling at the WWTP. Given this information, a detailed review of the capacity and conditions of the existing incineration system is not necessary in this Plan. The incinerator should be able to maintain operation into 2023, at which time the transition to hauling is expected to occur. **Chapter 7** evaluates the applicable options for new solids handling processes capable of producing biosolids in accordance with Chapter 173-308 WAC.

The basic design criteria for the existing incineration system is provided for informational purposes in **Table 5-18**.

Table 5-18. Basic Design Criteria for Existing Incineration System

Parameter	Value	Units
Dewatered Sludge (Cake) Feed (with Concentrated Scum)		
Pump Type	Progressive cavity with suction hopper	
Pump Quantity	2	
Pump Capacity (each)	5.1 @ 186	*gpm @ psi*
Pump Motor Size (each)	7.5	*hp*
Incinerator		
Type	Fluidized bed with hot windbox	
Quantity	1	
Diameter	9.5	*ft*
Dry Solids Capacity (Estimated)	527	*lb/hr*
Fluidizing Air Blower Type	Centrifugal	
Fluidizing Air Blower Quantity	1	
Fluidizing Air Blower Rating	1,900 @ 5.5	*scfm @ psi*
Fluidizing Air Blower Motor Size	100	*hp*

5.6 ANCILLARY SYSTEM ANALYSES

5.6.1 Plant Drain Lift Station

The Plant Drain Lift Station is located near Building No. 2 and serves to collect and pump building and process drainage from the lower site to the MPPS. The design criteria for the existing Plant Drain Lift Station are provided in **Table 5-19**.

Table 5-19. Design Criteria for Existing Plant Drain Lift Station

Parameter	Value	Units
Configuration	Wet well, pre-cast concrete manhole	
Manhole Volume	2,300	*gallons*
Pump Type	Submersible	
Pump Quantity	2	
Pump Capacity (each)	630 @ 70	*gpm @ ft TDH*
Pump Motor Size (each)	25	*hp*

It is likely that the Plant Drain Lift Station would be replaced or repurposed as part of any significant change to the solids handling system. There are currently no known critical conditions- or capacity-driven needs that must be addressed for the Plant Drain Lift Station in the near term.

5.6.2 Non-Potable Water

The existing non-potable water system is assumed to be reconfigured or replaced as part of future significant WWTP upgrades and, for this reason, a detailed analysis of the existing system is not provided in this Plan. In the interim, any repairs or upgrades are assumed to be incidental to normal WWTP O&M.

5.6.3 Odor Control

The existing odor control system is assumed to be reconfigured or replaced as part of future significant WWTP upgrades and, for this reason, a detailed analysis of the existing system is not provided in this Plan. In the interim, any repairs or upgrades are assumed to be incidental to normal WWTP O&M.

5.7 BUILDINGS

Refer to **Exhibit C-4 Existing Lower Site Plan** in **Appendix C** for building locations.

5.7.1 Buildings No. 1 and No. 2

Building No. 1 consists of a pre-engineered steel building enclosing the headworks and rectangular primary clarifiers. It was recently refurbished in 2021. Building No. 2 consists of a pre-engineered steel building enclosing the incinerator and associated equipment, circular primary clarifier, gravity thickener, chlorine gas system, non-potable water system, and other items. It was recently refurbished in 2020. As noted in **5.4 Liquid Stream Analyses** and **5.5 Solids Handling System Analyses**, the objective of future nitrogen reduction and the need for a new solids handling system will require either a significant reconfiguration or removal of these buildings, as analyzed further in **Chapter 6** and **Chapter 8**. As such, no detailed structural analysis is provided for these buildings as they are currently in satisfactory condition and can remain as-is for the near term.

5.7.2 Solids Handling Building (No. 3)

The Solids Handling Building was constructed in 1988 to house centrifuge equipment. The building is constructed of cast-in-place concrete walls. The roof consists of poured concrete over corrugated steel deck pan and steel joists. As noted in **5.5 Solids Handling System Analyses**, and as will be further described in **Chapter 6** and **Chapter 8**, a significant change to the solids handling system will be necessary during the planning period. It is likely that this building will be reconfigured or demolished as part of that work. As such, no major improvements are necessary to the building and it is in satisfactory condition for the near term.

5.7.3 Control Building (No. 4)

The Control Building was built above the existing chlorine contact tank in 1988. The building is constructed of exterior concrete masonry unit walls and interior steel stud walls. The roof is supported by steel joists and steel deck with rigid insulation and roofing above. The Control Building is believed to be in satisfactory condition and is expected to only require normal maintenance during the planning period.

5.7.4 MPPS Building (No. 5)

As noted in **5.4 Liquid Stream Analyses**, the objective of future nitrogen reduction will require either a significant reconfiguration or change to the primary and secondary treatment systems. This includes the MPPS, which lifts primary effluent to the secondary treatment system. No detailed structural analysis of the MPPS Building is performed as part of this Plan, as the building is expected to be removed or substantially changed during future improvements. This building is currently in satisfactory condition and can remain as-is for the near term.

5.7.5 Blower Building (No. 6)

The Blower Building was constructed in 1988 as part of the addition for secondary treatment to the WWTP. The building is constructed of cast-in-place concrete walls and roof. It is in satisfactory condition and no major improvements to this structure are expected during the planning period.

5.7.6 Generator Building (No. 7)

The Generator Building was constructed in approximately 2010 and is in satisfactory condition. No major improvements to this structure are expected during the planning period.

5.8 ELECTRICAL AND CONTROL SYSTEM ANALYSES

The existing WWTP has two electrical utility services: the electrical service located in Building No. 2, and the electrical service entrance located outside the Blower Building.

The electrical service equipment in Building No. 2 was installed circa 1984 and generally serves the preliminary and primary treatment systems, solids handling, effluent disinfection, and ancillary processes. The electrical service equipment includes a pad-mount transformer provided by Snohomish County PUD (SNOPUD), an outdoor current transformer enclosure, and a 1,600 Amp (A) main distribution switchboard located inside Building No. 2. Incorporated into the switchboard is an automatic transfer switch (ATS) which is connected to a 800 Kilowatt (kW) standby generator. The standby generator was installed in 1999 and is located inside Building No. 2. An underground fuel tank supplies diesel fuel to both the generator and the incinerator. This electrical service and distribution equipment along with the ATS are original and has exceeded its intended life. The City has experienced numerous problems with the ATS. According to the City, this generator has limited hours of usage and is in good working condition. However, this generator is over twenty years old and is nearing the end of its intended life. Future improvements will dictate the size of future standby generators at the WWTP, so replacement of this generator is likely as the WWTP is improved.

The electrical service equipment located outside the Blower Building was installed circa 2010 and generally serves the secondary treatment system and MPPS. The electrical service equipment includes a pad-mount transformer provided by SNOPUD, an outdoor current transformer enclosure, an outdoor 2,500A switchboard including digital metering and surge protection, two (2) 1,200A ATS' operating in parallel fed by 1,200A feeder circuit breakers in the switchboard, and two (2) outdoor switchboards (SWBD-1 and SWBD-2). This equipment is in the beginning to middle stages of its intended life. Replacement is not recommended unless it is required to serve future improvements. An 800 kW standby generator is installed in the Generator Building, near the electrical equipment outside the Blower Building and is sized to provide standby power for the MPPS, Blower building and secondary clarifiers. This generator has a dedicated above ground diesel fuel tank located east of the generator building.

A detailed analysis of the electrical system downstream of the electrical service and standby power equipment is not provided in this Plan, as the significant WWTP improvements necessary to rectify other needs identified in the Plan are likely to completely reconfigure or replace the WWTP electrical systems. These improvements shall be designed to replace or refurbish the aging motor control and other electrical equipment at the two service locations as further discussed in **Chapter 8.**

The WWTP control system consists of several control panels located throughout the WWTP that communicate via a fiber optic control network. A Supervisory Control and Data Acquisition (SCADA) computer system allows for overall monitoring and control of the WWTP processes. Large monitors are located in the WWTP control room which provide operators the ability to monitor and control the operation of the WWTP.

The overall WWTP control system was upgraded in 2011/2012. The upgrades to the control panel hardware throughout the plant were limited as only programmable logic controllers (PLC's) and fiber optic network hardware was replaced. The previous control panel enclosures, power supply equipment, terminal blocks, relays, wiring, and overcurrent protection devices from the original installation remain. This has limited the ability to add new inputs and outputs (I/O) to the existing control panels and has reduced the reliability of the control panels since several of the older components are obsolete. The PLC's are now approximately ten (10) years old but are older generation PLC's that utilize obsolete software. As the significant WWTP improvements are completed, replacement of these control panels is recommended with the exception of the Aeration Control Panel. The Aeration Control Panel is located on the second floor of the blower building and was upgraded with a new modern PLC and control panel components in 2018.

The SCADA computer system was completely installed as new at the time of the upgrade. The SCADA computer system is using software that is still relevant and the overall computer system and network has been well maintained by both the City and SCADA consultants. Continued maintenance and updates are recommended for this system.

5.9 WWTP SITE CONSIDERATIONS

5.9.1 Constraints and Considerations

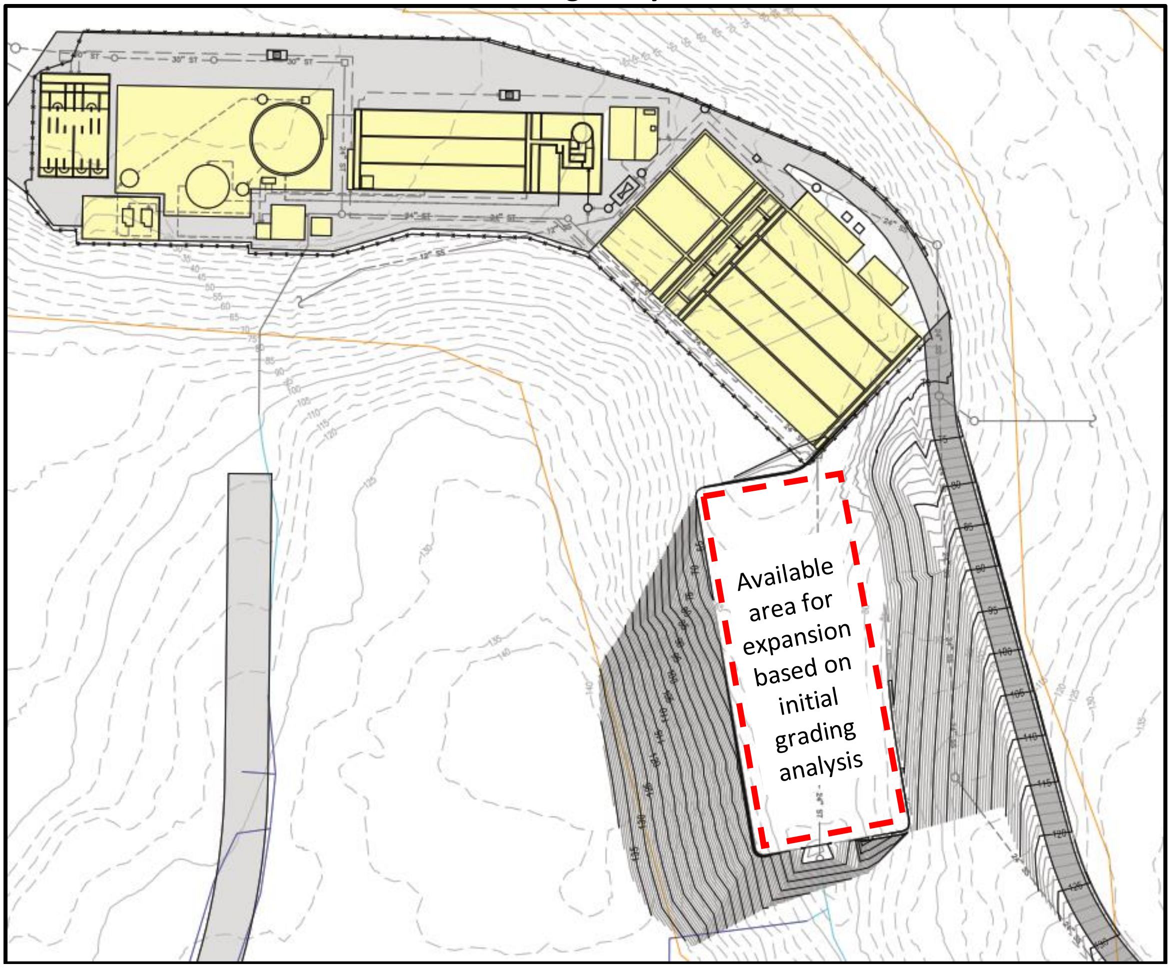
An expansion of the WWTP will be necessary to meet the needs identified in this chapter and previous chapters. However, the existing site exhibits many factors that will impact or constrain such an expansion.

The two most restrictive constraints on future expansion are:

- The necessity to maintain existing WWTP operation during construction of new improvements; and
- The physical constraints of the site that limit the developable area for new processes.

Figure 5-1 shows the approximate footprint of the only significant undeveloped area on the City property that could be used for expansion of WWTP processes while maintaining operation of the existing WWTP.

Figure 5-1 – Approximate Footprint Available for Expansion Based on Preliminary Site Grading Analysis



Note: Available footprint likely requires relocation of the existing access road and influent sewer pipe. Footprint must provide space for new headworks, additional basins, pipe routing, and access.

Additionally, the site prompts the following considerations for any expansion:

- The City owns a limited amount of property around the existing WWTP that can be used for expansion.
- Outfall Creek transects the WWTP and will need to be relocated for any significant WWTP improvements to occur and must consider potential fish passage issues.
- The topography and geological characteristics of the site will impact excavations, grading, and slope stabilization measures.
- The site access corridor must be maintained throughout any construction project and configured in a manner that allows larger trucks continual access to existing and future solids handling facilities.

- Environmental impacts due to vegetation removal for future WWTP improvements, sediment and erosion control, and other considerations.
- The proximity to neighbors, which prompts considerations of visual, noise, and other impacts.

The constrained nature of the site is visually apparent in **Exhibit C-1 WWTP Aerial**. The City property ownership and geohazards are mapped on **Exhibit C-2 Existing Site Overview**. Both figures are in **Appendix C**.

5.9.2 Potential Reconfiguration

To meet the potential future regulatory requirements for TIN reduction noted in **Chapter 3**, and the future flow and loading projections in **Chapter 4**, it is apparent that the secondary treatment system will need to be substantially expanded, as is further discussed in **Chapters 6** and **8**. The analyses in this chapter also noted deficiencies for which improvements could have substantial footprint impacts. Based on these chapters, the four areas of improvements that will significantly impact the footprint and layout of the WWTP are as follows, listed in order of relative magnitude of necessary footprint:

1. Secondary treatment system for nitrogen reduction.
2. New solids handling facility to replace the aging incineration system.
3. Additional primary clarifier capacity *if the primary treatment is to be maintained*.
4. New headworks to increase capacity and add redundancy.

Installing a new headworks in the undeveloped area shown in **Figure 5-1** is likely the only viable location in which a new headworks can be installed on the site while allowing the existing headworks to remain in service during construction.

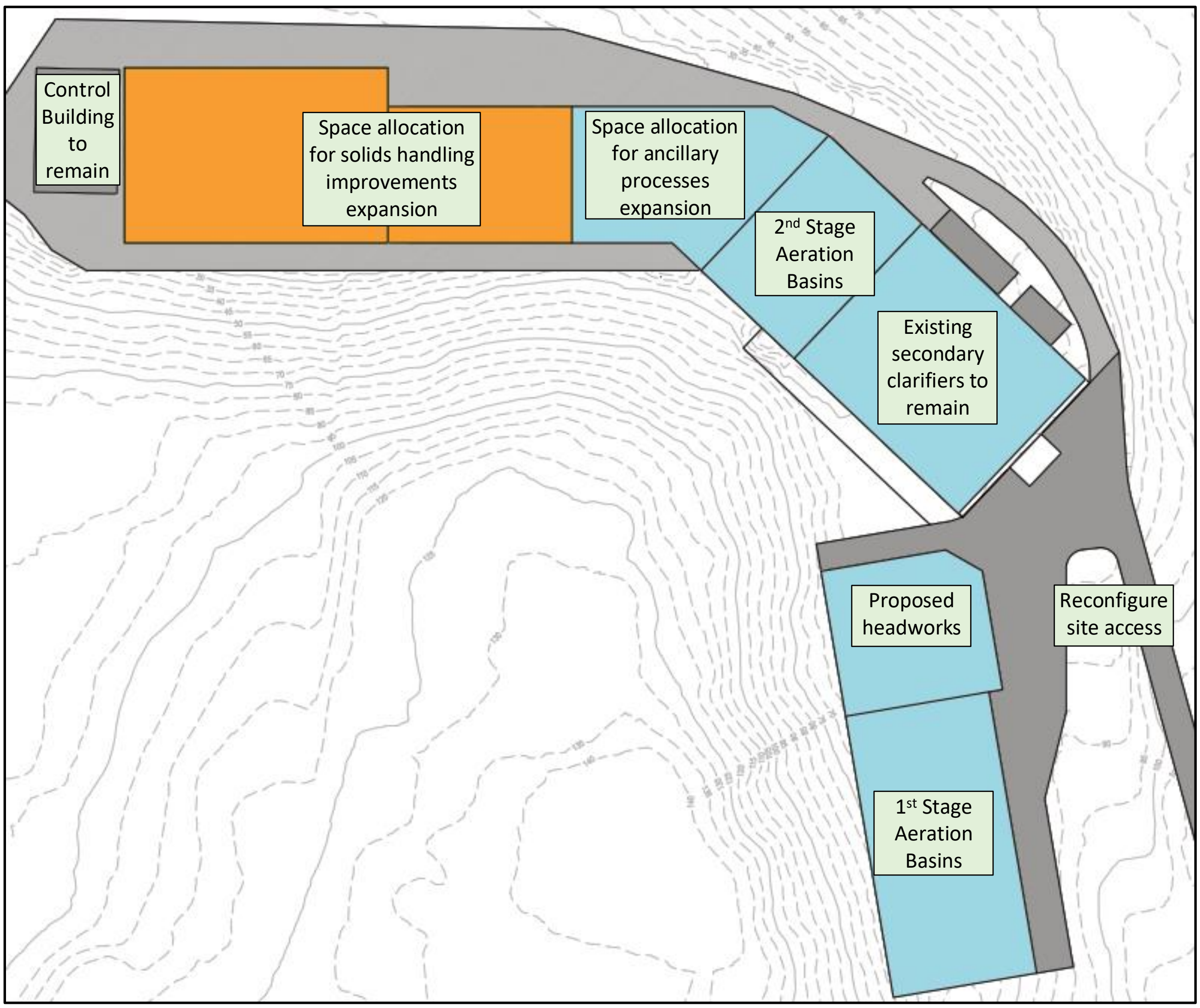
A new headworks would only use a portion of the undeveloped area. The remaining area is the only location on the site that additional secondary tankage can feasibly be constructed. It would generally be infeasible to add secondary tankage downhill from the existing secondary tankage due to the 35 feet of elevation difference between the primary and secondary tankage.

Locating the new headworks and additional secondary tankage in the undeveloped area is an important consideration for phasing of facility improvements as it will require a new solids handling facility to be constructed within at least a portion of the existing primary clarifier footprint. The primary clarifiers are the only area that provides sufficient space for construction of a new solids handling facility while allowing for operation of the existing solids handling system to be maintained.

This approach to reconfiguring the WWTP entirely removes primary treatment. All influent would receive preliminary treatment and flow directly to the secondary treatment system. This is considered desirable as the major treatment objective will be the reduction in TIN. Primary clarifiers provide 10 percent or less reduction in influent nitrogen at a high footprint cost. Additionally, primary clarifiers reduce influent carbon, which is undesirable as this carbon is critical to driving any nitrogen removal process in the secondary treatment system.

The proposed reconfiguration as described is considered the only viable option for reconfiguring the WWTP to meet future needs within the constraints of the existing site. This approach also will facilitate reconfiguration of the existing hydraulic profile to allow flow by gravity through the preliminary, secondary, and disinfection treatment processes, and to utilize the space available for improvements while allowing for construction of these improvements to occur while the existing headworks, MPPS, and primary clarifiers remain in operation. Once the existing headworks, primary clarifiers, and MPPS are removed, this area can be utilized for the new solids handling system, as well as potentially some ancillary secondary treatment system improvements. **Figure 5-2** provides a schematical footprint layout of the proposed reconfiguration, is used for the basis of analyses of treatment alternatives in **Chapter 6**, and is further developed with the recommended improvements in **Chapter 8**.

Figure 5-2 – Possible Reconfiguration of WWTP Based on Site Constraints



Note: Liquid stream improvements are hatched in blue and solids handling improvements are hatched in orange.

This reconfiguration of the WWTP alleviates the hydraulic profile issues discussed in **5.4.10 Hydraulic Profile**. Locating the new headworks uphill from the existing liquid stream treatment system would allow for gravity flow of influent from preliminary treatment to the subsequent liquid stream treatment processes.

With any reconfiguration of the WWTP, it is difficult to envision a method to add additional secondary clarifier area. Space uphill of the existing secondary clarifiers is needed for the new headworks and aeration basins and, as previously noted, constructing additional secondary tankage downhill from the existing aeration basins is infeasible. As such, the existing secondary clarifier area is a limiting factor on the capacity of the WWTP as analyzed in detail in **Chapter 6**.

5.10 SUMMARY OF MAJOR FINDINGS

Due to the age of the current WWTP infrastructure and the projected growth, there are many needed improvements to provide reliable treatment through the planning period. The major findings are summarized as follows based on the conditions- and capacity-based assessment of the existing WWTP in this chapter.

- **Preliminary treatment (complete replacement required)**
  - This system has significant deficiencies in terms of capacity, condition, reliability, and redundancy and requires complete replacement.
- **Primary treatment (complete abandonment necessary)**
  - Complete abandonment of this system is recommended. Removal of the primary clarification is necessary to support the reconfiguration of the site to support nutrient removal and other improvements.
- **Secondary treatment (significant expansion required)**
  - Significant expansion of the secondary treatment system is necessary to support the projected growth and meet future nutrient removal requirements.
- **Solids handling (complete replacement required)**
  - Suspension of incinerator usage is necessary due to operating costs and air permit violations. In the interim, continual hauling of dewatered sludge will occur. A new solids handling facility will be needed to produce biosolids meeting Class B requirements.
- **Effluent disinfection (complete replacement required)**
  - The treatment capacity will be exceeded during the planning period and an alternative to chlorine gas usage should be pursued for future effluent disinfection.

Chapter 6 will evaluate options for improvements to the liquid stream processes and **Chapter 7** will do the same for the solids handling system.

6 | EVALUATION OF WWTP LIQUID STREAM ALTERNATIVES

6.1 INTRODUCTION

The City of Lynnwood's (City) Wastewater Treatment Plant (WWTP) will require significant improvements to remedy current deficiencies and meet future treatment objectives for the planning period. **Chapter 3** outlines the future regulatory requirements that will drive improvements to the WWTP, and **Chapter 4** projects flow and loading growth that will prompt improvements to increase plant capacity. **Chapter 5** identifies needs based on the age of the existing facilities, current capacity limitations, and difficulty maintaining compliance with the current National Pollutant Discharge Elimination System (NPDES) Permit. This chapter will analyze the necessary liquid stream treatment improvements; the solids handling improvements are analyzed in **Chapter 7**.

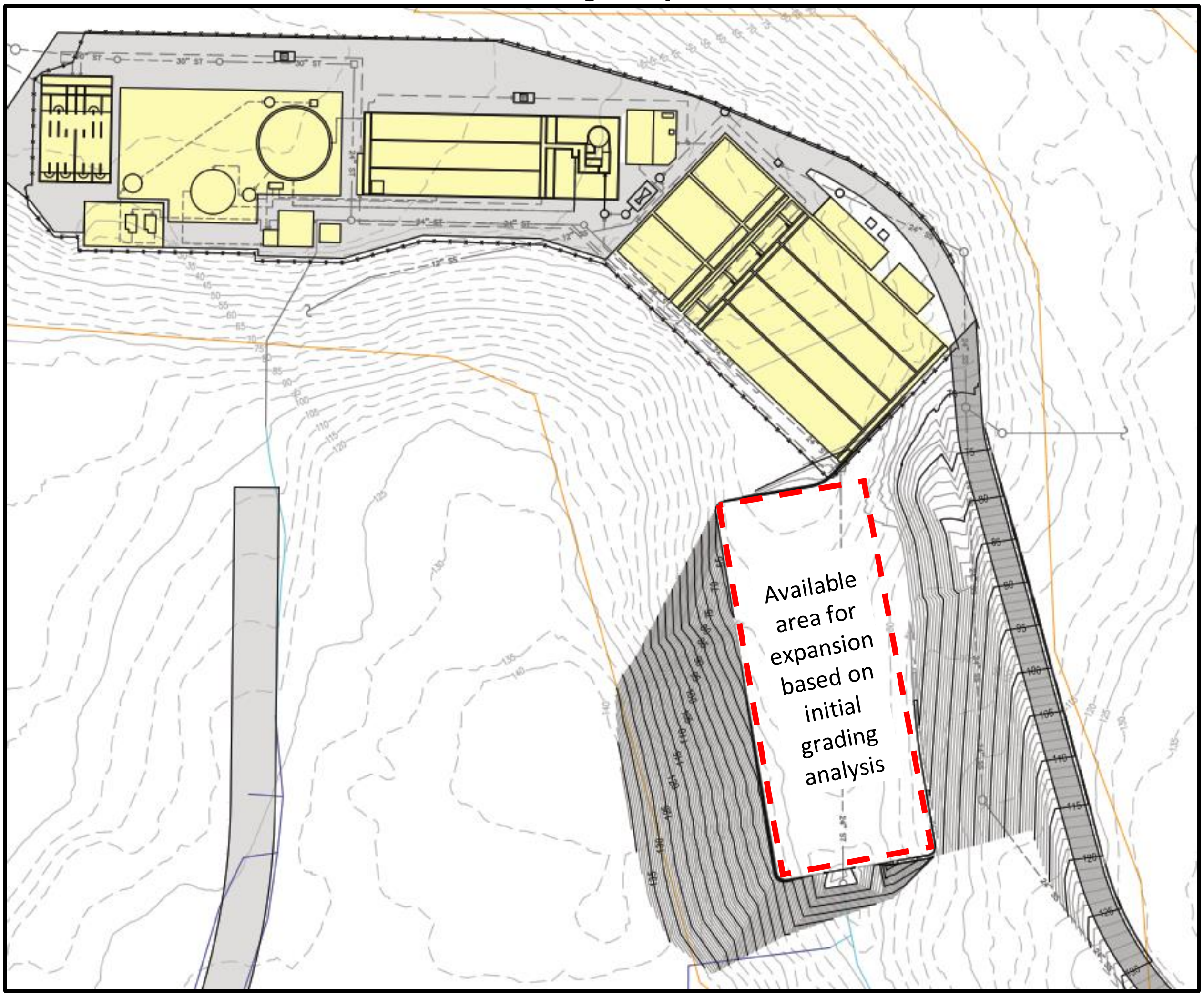
The improvements necessary to rectify the conditions- and capacity-based issues will substantially impact the overall layout of the site and will necessitate complex phased construction to maintain WWTP operation. Any proposed improvements must also plan to meet the future regulatory requirements for nitrogen reduction. This is currently assumed to be a target seasonal effluent Total Inorganic Nitrogen (TIN) limit of 3 milligrams per liter (mg/L) (April through October) based on the Puget Sound Nutrient General Permit (PSNGP) that was issued during the drafting of this WWTP Facility Plan (Plan), as noted in **Chapter 3**.

Therefore, it is prudent to formulate a cohesive strategy for the WWTP improvements. Secondary treatment improvements are expected to have the largest impact on WWTP layout and footprint, and as such, the review of treatment alternatives for major processes are analyzed in the following order:

1. Secondary treatment.
2. Preliminary treatment.
3. Effluent disinfection.
4. Solids handling (**Chapter 7**).

The configuration of the City's property and existing processes substantially constrain future improvements to the site. As outlined in **Chapter 5**, there is an undeveloped area uphill of the existing secondary clarifiers that can be used for a new headworks and new aeration basin tankage. Based on the area available and assuming a side water depth of 24 feet (equal to the existing basins), the undeveloped area outside of the proposed headworks footprint could potentially support up to approximately 2 million gallons (MG) of additional aeration basin tankage. The undeveloped area is shown in **Figure 6-1**.

Figure 6-1 – Approximate Footprint Available for Expansion Based on Preliminary Site Grading Analysis



Note: Available footprint likely requires relocation of the existing access road and influent sewer pipe. Footprint must provide space for new headworks, additional basins, pipe routing, and access.

The addition of aeration basin volume to the undeveloped area will allow for a rounded total of slightly less than 3 MG of aeration basin volume at the WWTP. This volume represents the maximum amount of additional secondary treatment tankage that can be added to this site and is used as the basis for the analyses in this chapter.

Chapter 5 noted that primary clarifiers will no longer be feasible at this site, nor will any substantial expansion of the existing secondary clarifiers, due to the constraints of the site and space needs for other process improvements. This chapter reviews the potential strategies for nitrogen reduction assuming:

- primary clarification will not be included;
- total aeration basin volume will be limited to less than 3 MG;
- secondary clarifier area will be limited to the four existing secondary clarifiers.

6.2 FLOW AND LOADING CRITERIA

The existing and projected flow and loading is defined in **Chapter 4** and summarized in **Table 6-1** for the purposes of evaluating treatment alternatives.

Table 6-1. Project Influent Flow and Loading

Parameter	*Units*	2019	2026	2030	2040	2050
Hydraulic Loading						
Annual Average Daily Flow	*MGD*	4.04	5.19	5.49	6.34	6.97
Maximum Month Daily Flow	*MGD*	5.01	6.64	7.03	8.12	8.92
Maximum Week Daily Flow	*MGD*	9.30	8.84	9.36	10.81	11.88
Maximum Day Flow	*MGD*	16.53	15.72	16.64	19.21	21.11
Peak Hour Flow	*MGD*	20.13	22.20	23.50	27.14	29.82
BOD Loading						
Annual Average Daily BOD	*lb/d*	9,177	10,500	11,400	13,700	15,700
Maximum Month Daily BOD	*lb/d*	9,702	11,400	12,400	14,800	17,000
TSS Loading						
Annual Average Daily TSS	*lb/d*	7,452	9,000	9,800	11,700	13,400
Maximum Month Daily TSS	*lb/d*	7,998	9,700	10,500	12,600	14,400
TKN Loading						
Annual Average Daily TKN	*lb/d*	1,480	1,740	1,890	2,270	2,610
Maximum Month Daily TKN	*lb/d*	1,570	1,890	2,060	2,460	2,830

TKN = Total Kjeldahl nitrogen

6.3 SECONDARY TREATMENT

6.3.1 Background

An analyses of secondary treatment technologies is provided in this section. These analyses start by reviewing an expansion of the existing conventional activated sludge system to highlight difficulties created by the space constraints at this site. These analyses will show the need for a more densified secondary treatment system, for which multiple options will be reviewed. Due to the combination of challenges, including the site constraints, high wet weather flow events, moderately cold climate, and stringent potential TIN limit posed for the City, it will be noted that most of the currently available treatment technologies capable of densifying the treatment process to meet this combination of challenges are not yet in widespread use and are generally considered emerging technologies for this specific application. The goal of this analysis is to identify the alternative that poses the most cost-effective method of maximizing the achievable capacity at the current WWTP site in conjunction with providing the highest likelihood of success in meeting the potential future TIN limit.

The current version of the PSNGP permit proposes a potential seasonal effluent TIN concentration of 3 mg/L. It is understood that continued modeling by the Washington State Department of

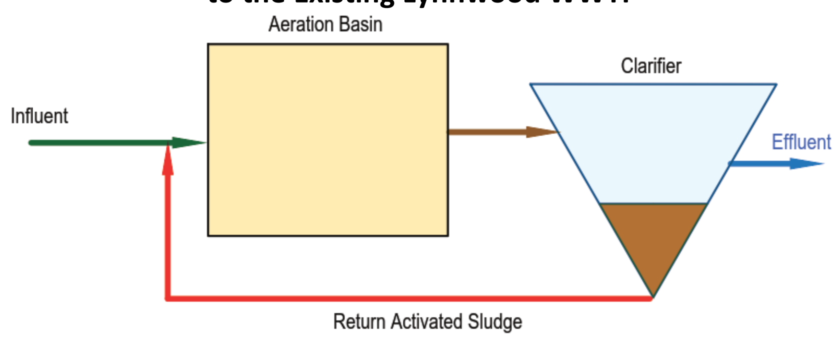
Ecology (Ecology) or other factors may change the structure of the final TIN limit. The analyses of this chapter compares secondary treatment strategies on the basis of an effluent TIN limit of 3 mg/L.

The PSNGP also requires all permittees to prepare and submit an approvable Nutrient Reduction Evaluation (NRE) to Ecology by December 31, 2025, which must include an analysis of all known and reasonable treatment (AKART) methods in accordance with Revised Code of Washington (RCW) 90.48.010. The PSNGP states that the AKART analysis "shall present an alternative representing the greatest TIN reduction that is reasonably feasible." The analyses provided in this chapter are not intended to serve as a standalone NRE, but instead provide technical analysis to identify the approach with the highest likelihood of meeting the PSNGP requirements through known and reasonable methods. It is assumed that this analysis will form the backbone of a future NRE document.

6.3.2 Conventional Activated Sludge

The existing secondary treatment process at the WWTP consists of aeration basins and clarifiers designed to reduce the conventional parameters of biochemical oxygen demand (BOD) and total suspended solids (TSS). The WWTP has a short solids retention time (SRT). The design criteria from the 1988 secondary treatment project notes a design mixed liquor suspended solids (MLSS) concentration of 3,500 mg/L with a 3.7-day SRT at the maximum month condition of 7.4 million gallons per day (MGD). Based on these design parameters, nitrification under current design loading conditions could not be reliably achieved. A basic schematic of the existing secondary treatment process is shown in **Figure 6-2**.

Figure 6-2 – Schematical Representation of a Conventional Secondary Treatment System, Similar to the Existing Lynnwood WWTP



Note: Figure not to scale

TIN consists of ammonia (NH_3), nitrate (NO_3^-), and nitrite (NO_2^-). A reduction in TIN requires a biological treatment process that supports both nitrification and denitrification. Nitrification is the oxidation of ammonium (NH_4^+) to nitrate, catalyzed by bacteria, and is a key part of global nitrogen cycling. In the first step of nitrification, chemolithoautotrophic ammonia oxidizing bacteria (AOB) transform ammonium to nitrite (**Equation 1**). Nitrite is subsequently oxidized to nitrate by the nitrite oxidizing bacteria (NOB), as shown in **Equation 2**.

$$2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 4H^+ + 2H_2O \quad \textbf{Equation 1}$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^- \quad \textbf{Equation 2}$$

Nitrate reduction in wastewater systems occurs through assimilation and denitrification. In assimilatory nitrate reduction, nitrate is reduced to ammonia and assimilated for cell synthesis. In denitrification, bacteria use nitrate as an electron acceptor in the absence of oxygen to oxidize an organic or inorganic electron donor. Nitrate is reduced to nitrite, nitric oxide, nitrous oxide, and nitrogen gas in a four-step process shown in **Equation 3**.

$$\mathbf{NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2} \qquad \textbf{Equation 3}$$

Equation 4, the overall reaction, shows glucose as the electron donor. Most denitrifying bacteria require a reduced carbon substrate such as glucose, acetate, or methanol. The carbon source as represented by the chemical oxygen demand of the wastewater is often a limiting factor in achieving biological nitrogen and phosphorous removal.

$$\mathbf{C_6H_{12}O_6 + 4.8NO_3^- + 4.8H^+ \rightarrow 6CO_2 + 2.4N_2 + 8.4H_2O} \qquad \textbf{Equation 4}$$

The rate of denitrification (RDN) is dependent on temperature and dissolved oxygen (DO) concentration, where K is the temperature correction coefficient, and is commonly assumed to be 1.09 (**Equation 5**).

$$\mathbf{R_{DN(T)} = R_{DN(20)} \times K^{(T-20)} \times (1 - DO)} \qquad \textbf{Equation 5}$$

Equation 5 shows that the rate of denitrification decreases linearly from 0 to 1 mg/L of DO. At DO levels of 1 mg/L and above, the rate of denitrification becomes negligible.

A secondary treatment process that provides nitrification can reliably reduce ammonia to less than 0.5 mg/L. However, without denitrification, the ammonia is converted to nitrate, and as such, the effluent TIN is not significantly reduced. To provide nitrification, the secondary process must support the growth of nitrifying bacteria, which grow much slower than the heterotrophic bacteria that reduce BOD. To facilitate a robust nitrifier population, the SRT must be significantly longer than that required for BOD reduction. Microbial growth decreases with decreasing water temperature, and as such, the cold weather condition drives the design of biological systems. As an example of the necessary SRT to support nitrification in the City, **Table 6-2** provides Biowin model results for the existing Lynnwood WWTP operating at the currently permitted maximum month condition of 7.4 MGD and 15,120 pounds per day (lb/d) BOD.

Table 6-2. Biowin Results for Existing Lynnwood WWTP at 7.4 MGD and 15,120 lb/d BOD

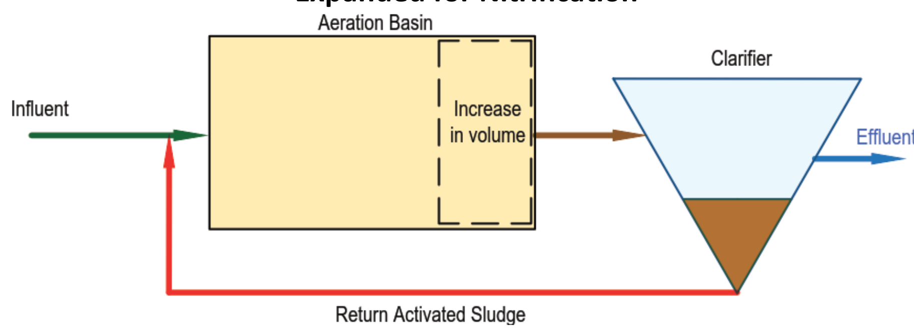
SRT	NH_3	MLSS	SLR
(days)	*(mg/L)*	*(mg/L)*	*(lb/sf/d)*
2.0	19.35	1950	13.6
3.0	19.58	2690	18.8
3.7	18.76	3250	22.8
4.0	16.48	3440	24.2
6.0	1.26	4670	32.9
8.0	0.38	5700	40.2
10.0	0.23	6630	46.8
12.0	0.18	7450	52.6

The design temperature for the WWTP is 12 degrees Celsius, and the design SRT is 3.7 days. As shown in the table, appreciable nitrification is not expected at the design condition. A minimum SRT of 8 days is likely necessary for substantial nitrification to occur as evidenced by the predicted effluent ammonia level of 0.38 mg/L. However, a longer design SRT would be necessary to allow for nitrification during the peak diurnal flow condition; it would likely be near 12 days minimum, which equates to an approximate increase of 300 percent over the current design condition. This demonstrates the significantly increased SRT necessary to support reliable nitrification.

Table 6-2 also demonstrates that as SRT increases, the MLSS concentration increases, as does the corresponding solids loading to the secondary clarifiers. For conventional activated sludge, the typical design criteria for average secondary clarifier solids loading rate (SLR) is 25 pounds per square foot per day (lb/sf/d). This limits the SRT at the City-permitted maximum month condition to 4 days. To maintain the necessary SLR with conventional activated sludge, proportionally expanding secondary treatment relative to SRT is likely required. This equates to adding approximately 300 percent additional aeration basin volume.

A basic secondary treatment schematic, configured to support nitrification, is shown in **Figure 6-3**.

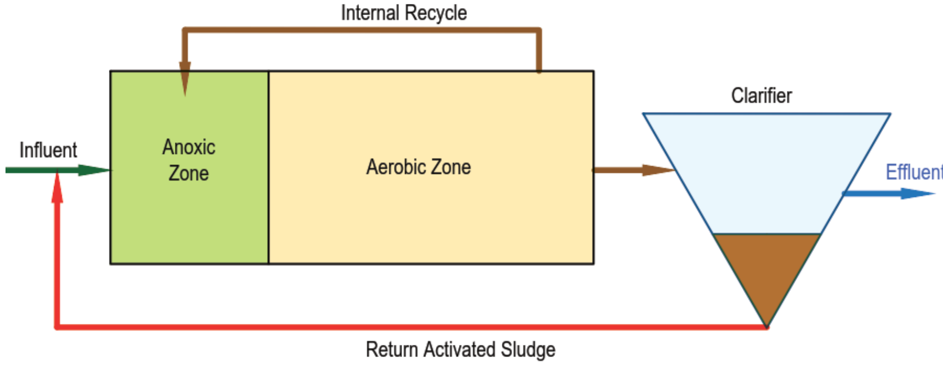
Figure 6-3 – Schematical Representation of a Conventional Secondary Treatment System Expanded for Nitrification



Note: Figure not to scale

To provide denitrification, the nitrate produced through nitrification must be returned to an anoxic zone (devoid of oxygen) to allow for bacteria to convert a significant fraction of the nitrate to nitrogen gas. The bacteria need carbon to perform this conversion, requiring the anoxic zone to be located upstream of the aerobic zone, where BOD reduction occurs. The nitrate must be returned with an internal recycle stream at a high rate of 300 percent to 500 percent of the influent flow rate. A basic secondary treatment schematic, configured to support nitrification and denitrification, is shown in **Figure 6-4**.

Figure 6-4 – Schematical Representation of a Secondary Treatment System Capable of Nitrification and Denitrification

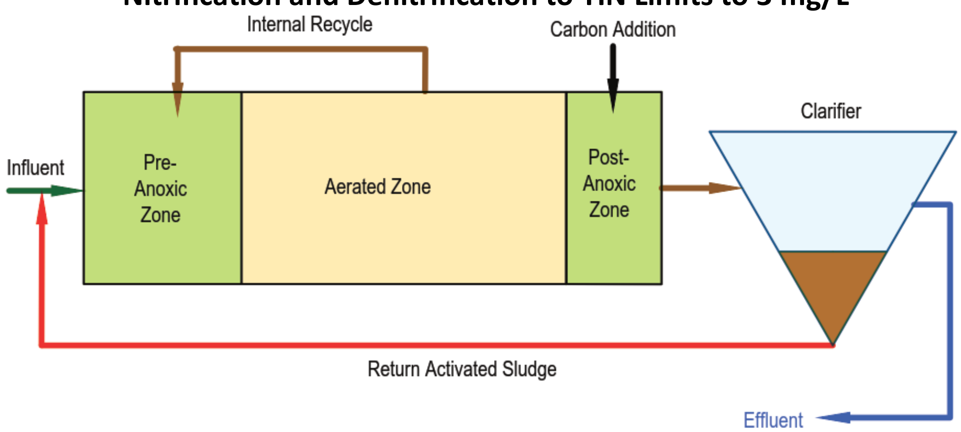


Note: Figure not to scale

The configuration shown represents the Modified Ludzack-Ettinger (MLE) process. This configuration is proven to reduce TIN, at lowest, to approximately 5 mg/L for normal domestic wastewater. The analysis shown in **Table 6-2** did not account for denitrification, which further increases the necessary tankage volume, likely in the range of a 400 percent increase over the existing aeration basin volume, to achieve nitrification and denitrification.

Domestic wastewater typically does not have enough carbon to support enough denitrification to achieve low TIN limits (less than 5 mg/L) using conventional nitrification/denitrification activated sludge design configurations. Such limits typically necessitate a post-anoxic zone with supplemental carbon feed. A basic secondary treatment schematic, configured to support nitrification and denitrification with TIN limits to 3 mg/L, of a known and available technology that has been utilized to achieve this level of treatment is shown in **Figure 6-5**.

Figure 6-5 – Schematical Representation of a Secondary Treatment System Capable of Nitrification and Denitrification to TIN Limits to 3 mg/L

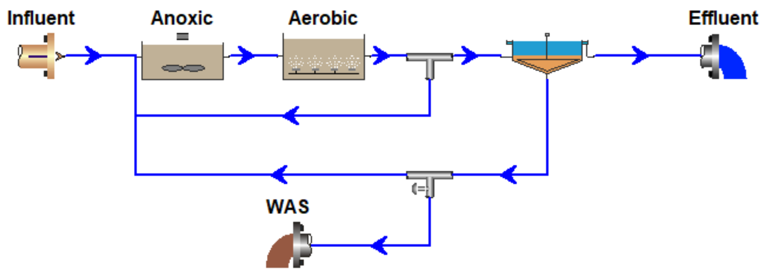


Note: Figure not to scale

6.3.3 Expansion of Conventional Activated Sludge in Lynnwood

As previous discussed, a total of up to 3 MG of aeration basin tankage may be feasible at the WWTP, assuming that there are no primary clarifiers and the existing secondary clarifiers remain as configured and are not expanded. To review expansion of the existing conventional activated sludge system to provide nitrogen reduction, an MLE process could be employed with approximately 3 MG of total basin volume as shown in **Figure 6-6**.

Figure 6-6 – Schematic of Conventional Secondary Treatment Expansion at Lynnwood (MLE Process)



Note: Approximately 3 MG total aeration basin volume (~1 MG anoxic, ~2 MG aerobic); four secondary clarifiers (11,520 sf total area)

The settleability of the mixed liquor in the system restrains the capacity of any secondary treatment system by restricting the allowable SLR to the secondary clarifiers. As noted, the typical average design criteria for secondary clarifier SLR is 25 lb/sf/d based on the settling characteristics of conventional activated sludge. As the MLSS concentration increases, the SLR increases proportionally. As SRT increases, so does the predicted MLSS concentration due to the extended time available for microbial growth. As such, SRT is limited indirectly by the settling of the mixed liquor solids in the clarifiers.

BioWin ties together biological, chemical, and physical models to simulate activated sludge systems. BioWin and similar software programs are based on a set of mathematical equations and process state variables that were developed originally by a task group of the International Water Association. The effect of the SLR limitation is demonstrated with BioWin modeling in **Table 6-3** for the system shown in **Figure 6-6**. The table estimates the MLSS concentration that can be supported at various maximum month flow conditions and the corresponding SRT and effluent TIN predicted by BioWin.

Table 6-3. Initial BioWin Model Results – MLE Configuration with SLR of 25 lb/sf/d

Year	Units	2019	2026	2030	2040	2050
Estimation of Maximum MLSS to Achieve Target SLR of 25 lb/sf/d						
Maximum Month Influent Flow Rate	*MGD*	5.01	6.64	7.03	8.12	8.92
RAS Flow Rate	*MGD*	3.8	5.0	5.3	6.1	6.7
Influent + RAS Flow Rate	*MGD*	8.8	11.6	12.3	14.2	15.6
Maximum Allowable MLSS	*mg/L*	3,940	2,980	2,810	2,440	2,220
BioWin Predicted Results						
SRT	*days*	10.5	5.0	4.3	3.0	2.3
Effluent Ammonia	*mg/L*	0.9	3.1	5.1	17.2	17.6
Effluent Nitrate	*mg/L*	3.4	0.5	0.2	0.0	0.0
Effluent Nitrite	*mg/L*	0.3	2.4	2.3	0.0	0.0
Effluent TIN	***mg/L***	**4.6**	**6.0**	**7.6**	**17.2**	**17.6**

SLR = 25 lb/sf/d; 12 deg C MLSS temperature | 300% internal recycle:influent | 75% RAS:influent

Table 6-3 demonstrates that an MLE process with 3 MG of aeration basin tank and 4 existing secondary clarifiers could provide some TIN reduction at near-term flows, but the SRT must be significantly reduced at future flows to maintain the maximum MLSS concentration at a level that provides an SLR at 25 lb/sf/d. At the projected 2030 condition and beyond, it is unlikely that the SRT is sufficient to support reliable nitrification. The table demonstrates that the available aeration basin tankage and the average SLR of 25 lb/sf/d are the primary limitations for the City to achieve the nitrogen reduction with conventional activated sludge. A conventional approach is to further expand aeration basin volume and/or secondary clarifier area to reduce the required MLSS concentration and SLR. However, such expansion is not feasible per **Chapter 5**.

Alternatively, the secondary treatment system can be densified to increase capacity; such processes must be analyzed for the City herein for the purpose of meeting nitrogen reduction objectives.

6.3.4 Summary of Technologies that Densify Secondary Treatment and Reduce Nitrogen

There are multiple approaches to secondary treatment densification that generally can be categorized as follows:

- Alternative physical separation processes in which the activated sludge is separated from the effluent by a means other than sedimentation in a secondary clarifier.
- Addition of a biofilm component to the secondary treatment system, which increases microbial population that is fixed in the aeration basins and does not proportionally increase clarifier SLR.
- Microbial selection processes that facilitate self-assembled dense microbial communities to significantly increase the settleability of the activated sludge such that an SLR of much greater than 25 lb/sf/d can be achieved.

The following sections review a broad range of processes that both densify secondary treatment and substantially reduce effluent TIN. The best-known of these processes are generally divided into three categories as follows.

1. Alternate physical separation processes
    a. Membrane bioreactor (MBR)
2. Biofilm processes – biomass is grown attached to movable or fixed carriers
    a. Standard biofilm processes
        i. Fixed bed biofilm reactors
        ii. Moving bed biofilm reactors
        iii. Biologically active filters (BAF)
        iv. Denitrification filters (post-secondary treatment)
    b. Integrated biofilm and activated sludge processes
        i. Integrated fixed film activated sludge (IFAS)
        ii. Membrane aerated biofilm reactor (MABR)

            iii. Mobile organic biofilm (MOB)

3. Microbial selection processes
    a. Sequencing batch reactor (SBR)
    b. Continuous flow reactor (CFR)

6.3.5 Discussion on Established and Emerging Technologies

During facility planning, it is typical to consider and evaluate well established, readily available, and cost-effective technologies for secondary treatment improvements. However, the challenging nature of the existing WWTP site, coupled with the high peak wet weather flows and stringent proposed TIN limit, makes it likely that the secondary treatment process which will be employed to meet these challenges will need to be an emerging or developmental technology with limited comparable full-scale installations. As such, the application of any secondary treatment technology to meet a TIN limit of 3 mg/L at this site should be considered new or developmental as described under Section G1-5.4.1 of Ecology's *Criteria for Sewage Works Design*. This section states: "Any new or developmental technology shall be thoroughly tested in a full-scale or representative pilot installation (or similar installation) before approval can be given. The results of this testing must be submitted to Ecology". Based on the results, the Ecology may review and approve plans for construction of the facility, followed by a provisional approval to operate the facility such as to demonstrate its efficacy in meeting the permit requirements. Once demonstrated, Ecology can give the final approval to operate.

The configuration of the Lynnwood WWTP, and the City's reliance on all basins and clarifiers to meet current loading conditions, makes a full-scale or representative-scale pilot demonstration of a developmental secondary treatment technology very difficult to implemental at this facility. Piloting a developmental technology at a reduced scale could be useful but small scale pilot testing is not recommended to be relied on solely for planning an upgrade of this magnitude.

Alternatively, a full-scale demonstration at another facility would be necessary to validate such a technology. An offsite demonstration would need to simulate the particular constraints present at Lynnwood. Identifying such a facility and scoping of a full-scale demonstration is outside the scope of this Plan, but City could consider reviewing the potential for such a demonstration prior to design. The combination of challenges the City faces to meet the proposed TIN limits will be present for many Puget Sound dischargers and a full-scale demonstrations could be of considerable value to other dischargers as well.

Since full-scale pilot testing or a demonstration project at another facility is outside of the scope of the current planning effort, this Plan seeks to analyze the best available information to determine the technology that poses the highest likelihood of success for the City in the absence of representative operational data.

6.3.6 Initial Screening Secondary Treatment Densification Technologies

This section provides an initial screening of densified secondary treatment processes that could be applicable to the City. The goal of this screening is to identify the major primary factor(s) that might eliminate a process from further consideration through this initial screening such that the top two to four processes can be identified for further analyses.

ALTERNATIVE PHYSICAL SEPARATION PROCESS – MBR

MBR is a proven technology, with large MBR installations operating near the City. MBR utilizes membranes in lieu of sedimentation to separate the biomass from the bulk liquid. Biological treatment is provided by the suspended activated sludge, and various configurations have been utilized to provide biological removal of nitrogen and phosphorus. MBRs may reduce WWTP footprint relative to conventional activated sludge by allowing higher MLSS concentrations as the secondary clarifier SLR is not applicable for MBRs. However, significant drawbacks to MBRs are:

- High capital cost related to the MBR and ancillary equipment;
- Instances in which the design flux rates across the membranes could not be achieved due to fouling or other factors, which in turn reduces overall system capacity;
- The membranes required replacement approximately every 10 years, or sooner, in the case of failure or premature fouling;
- High operational costs related to chemical cleaning, de-sludging, and other procedures unique to MBRs; and
- High energy usage for pumping of effluent through the membrane.

MBRs have historically utilized hollow fiber or flat sheet polymeric membranes. Recently, ceramic membranes have entered the MBR market and are being promoted as an improvement over some of the known deficiencies of polymeric membranes. Currently, there are few such installations with minimal operating time, and as such, ceramic membranes are not a widely used technology that can be accurately assessed for consideration as part of this Plan.

Regardless of membrane type or configuration, all flow needs to pass through the secondary treatment system at the WWTP to meet the future nitrogen limits. As such, an MBR system would need to be sized to pass the high wet weather flows without bypass to avoid violation of the proposed nitrogen limits. This would greatly expand the required membrane area, which would cause the capital costs and operating costs for this technology to rise. MBR is impractical for the City due to the high life-cycle cost associated with it.

BIOFILM PROCESS – FIXED AND MOVING BED BIOFILM REACTORS

In these processes, liquid is treated as it moves through a reactor filled with either fixed or moving carriers containing attached biofilm. There are many subcategories for this type of treatment, but when low TIN must be achieved, a component of suspended growth is typically needed to denitrify the nitrate formed by the oxidation of ammonia and nitrite in the reactor. In this case, the common approach is a process that incorporates both biofilm and suspended growth, such as the IFAS process. IFAS is reviewed later in this chapter as a potentially viable option, but standalone fixed or moving bed biofilm reactors (MBBR) are not considered applicable for the City.

BIOFILM PROCESS – BAF

The acronym “BAF” historically meant “biological aerated filters.” *Design of Water Resource Recovery Facilities Manual of Practice 8*, Water Environment Federation (WEF MOP 8) uses the term “biologically active filters” in place of the historical term to incorporate biological filters that are not continuously aerated, such as those operated anoxically for denitrification. The term BAF is used herein to mean biologically active filters to cover a broad range of biological filters. There are a variety of configurations of BAFs used for primary, secondary, and tertiary filtration, including upflow and downflow reactors, differing filter backwash methods, and various types of media.

In general, BAF systems include biofilm that grows attached to a carrier. Influent passes through the carriers, which can be configured in multiple stages with different carriers for each stage. Backwashing is intended to flush captured solids to the solids handling process. Non-backwashing configurations have been applied in which solids are carried through the normal flow path and removed in a solids separation system such as sedimentation; these configurations are similar to MBBR or IFAS.

As stated in **Chapter 5**, a primary objective of future improvements to the WWTP is to provide flow by gravity through a new headworks to the subsequent treatment processes. To implement BAF on the site, the BAF must be constructed in the area allocated for secondary treatment expansion uphill of the proposed headworks shown in **Chapter 5**. This would allow the BAF to be constructed while the existing secondary treatment system remains in service. BAF configurations are substantially different than the existing CFR configuration of the WWTP. This is likely to significantly add to the complexity of implementing this process at the City. It is unlikely that BAF can be implemented in a manner that is as cost effective as other systems that expand upon the existing CFR configuration; therefore, BAFs are not considered for further evaluation for the Lynnwood WWTP.

BIOFILM PROCESS – DENITRIFICATION FILTERS

Denitrification filters are a subset of biofilm processes that are not a standalone secondary treatment process but can be added to the secondary treatment process to aid in TIN reduction. In this process, nitrified effluent (in which most ammonia has been converted to nitrate) is passed through a filter bed containing heterotrophic organisms that metabolized nitrate into nitrogen gas in the anoxic conditions of the filter bed. This typically requires a carbon feed ahead of the filter as most of the influent carbon has been reduced through the preceding secondary process. To meet an effluent TIN limit of 3 mg/L, all flow would be required to pass through denitrification filters after the secondary clarifiers. For this technology to be applied at the City, the secondary treatment system preceding the filters would need to provide complete nitrification. As such, substantial improvements and expansion of the existing secondary treatment system would be needed in addition to the filtration system.

The high wet weather flows at the City present a major challenge to a filtration system. The system could not be bypassed as TIN reduction would be completely reliant on all flows passing through filtration for denitrification. Such a system would require a substantial amount of filtration capacity to pass peak flows. However, the high flow events present a significate risk to the filtration system, as such flows typically increase solids carryover from the clarifiers. If substantial solids are discharged to the filters, they could require very high backwash volumes to maintain the necessary throughput or they could be completely blind. Since the WWTP would be completely reliant on the filtration system to meet a TIN limit, the potential issues at high flows present too high of a risk for this technology to be prudently considered for the Lynnwood WWTP.

INTEGRATED PROCESS – IFAS

IFAS is a biological treatment that integrates both suspended growth activated sludge with fixed film growth. IFAS is typically configured as a CFR, which could be implemented in the City by reusing and expanding upon the existing CFR. IFAS adds inert carriers, typically plastic, to the activated sludge system to facilitate fixed film growth. A screen retains the carriers in the aeration basins while suspended growth is carried through the normal flow path to the secondary clarifiers and returned by the return activated sludge (RAS) or wasted. Multiple manufacturers provide IFAS systems, with many proven installations. The typically stated benefits of this system include:

- Biomass density can be increased through the addition of fixed film organisms without proportionally increasing secondary clarifier SLR;
- Simultaneous nitrification and denitrification can potentially occur within the biofilm; however, there is not enough information to verify that this can reliably be achieved at all operating conditions;
- Nitrification and denitrification can be achieved at SRTs lower than conventional flocculant sludge;
- The likelihood of microbial washout at high flows is decreased due to the retention of the fixed film organisms; and
- Reduced yield of waste sludge.

The degree to which these potential benefits can be reliably achieved is dependent upon the space available for the reactor. IFAS is evaluated in further detail for the WWTP later in this chapter.

INTEGRATED PROCESS – MABR

MABR is another biological treatment that integrates both suspended growth activated sludge with fixed film growth. MABR can be configured in a CFR, which could be implemented in the City by reusing and expanding upon the existing CFR secondary treatment system. In this system, cassettes of membranes are installed into one or more zones of an activated sludge system. The membrane cassettes are similar to those used in MBR systems, though with MABR, the membranes are used as both a fixed biofilm carrier and an aeration device. The membranes are stationary in the tank and biofilm attaches to the surface of the membranes. The membranes are used to transfer oxygen directly to the biofilm. Suspended growth activated sludge develops in the bulk liquid, is passed to subsequent zones, and is returned from the secondary clarifiers as normal with CFRs. The MABR process has been characterized in the *Criteria for Sewage Works Design* as a new and developmental technology as defined in Section G1-5.4.1.

Two manufacturers, Suez and Fluence, currently provide MABR systems in the U.S. Oxymem is another manufacturer of MABR systems, but they currently do not sell systems in the U.S. MABR is a relatively new technology and full-scale installations have been generally operating less than 5 years. The typically stated benefits of MABR include:

- Biomass density can be increased through the addition of fixed film organisms without proportionally increasing the clarifier SLR;
- The total system oxygen transfer efficiency is increased as a portion of the total oxygen is delivered through the membranes directly to the biomass in lieu of passing through the bulk liquid;
- Simultaneous nitrification and denitrification can potentially occur within the biofilm, but there is not enough information to verify that this can reliably be achieved at all operating conditions;
- Nitrification and denitrification can be achieved at SRTs lower than conventional flocculant sludge;
- The likelihood of microbial washout at high flows is decreased due to the retention of the fixed film organisms; and
- Reduced yield of waste sludge.

MABR is evaluated in further detail for the Lynnwood WWTP later in this chapter.

INTEGRATED PROCESS – MOBILE ORGANIC BIOFILM

MOB is a biological treatment process intended to enhance suspended growth activated sludge systems. Nuvoda is currently the only company known to sell such systems. The MOB process consists of adding small organic carriers to an activated sludge system to facilitate biofilm development. The porous organic carriers are manufactured from Kenaf plant stalks. The carriers vary in size but are generally near 1 millimeter (mm) in diameter. These organic carriers have a very high surface area relative to the particle size and facilitate faster settling compared to conventional floc. As such, the process intends to densify activated sludge systems by adding a biofilm component to increase biomass concentration while increasing settleability. The carriers are removed from the RAS stream via a rotary drum screen and returned to the basins.

The MOB process has been implemented at a few municipal facilities over approximately the last 5 years. However, it does not appear that Nuvoda has full-scale installations that face comparable challenges to that of the City. Notably, demonstration of the Nuvoda process was undertaken at the Edmonds WWTP in Washington and the Forest Grove WWTP in Oregon in the last 2 years. However, results from these demonstrations are not sufficient to allow this technology to be considered for the Lynnwood WWTP, except as new and developmental technology as previously described.

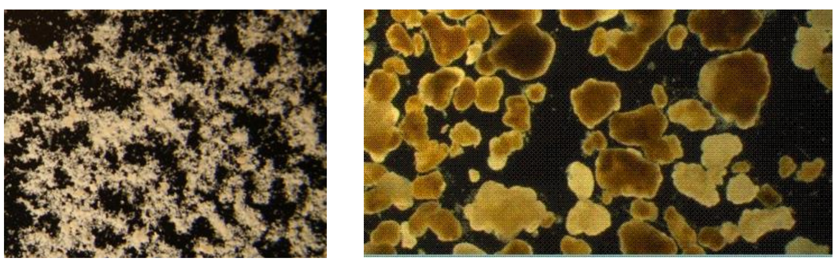
An initial proposal was provided by Nuvoda for upgrading the Lynnwood WWTP to a MOB process, which included a modeling report and budgetary equipment proposal. The modeling report included simulation results for a 5-stage Bardenpho configuration, which would require significant reconfiguration of the existing secondary treatment system. However, the simulations predicted effluent TSS above the NPDES average monthly permit limit of 30 mg/L at the projected 2026 maximum month average day condition with the use of the existing 4 secondary clarifiers. The simulations showed TSS levels further increasing in subsequent years. The potential loss of solids from the clarifiers at high flow rates would be a severe limitation for this technology in the City, which experiences peak wet weather events that greatly exceed the maximum month hydraulic conditions used in Nuvoda's simulations. The Nuvoda proposal recommended effluent filtration to meet the required effluent TSS limits. As previously discussed with denitrification filters, filtration is not considered a reliable method for meeting effluent limits at the City.

Until more is known through full-scale applications about the densification, TIN reduction, and TSS removal provided by Nuvoda, it will not be considered as an applicable technology for upgrading the Lynnwood WWTP. However, it is important to provide as much flexibility as feasible in the future secondary treatment system to allow the future addition of MOB or similar technologies, if needed, and should they become more widely proven and accepted for this application.

OVERVIEW OF MICROBIAL SELECTION PROCESSES

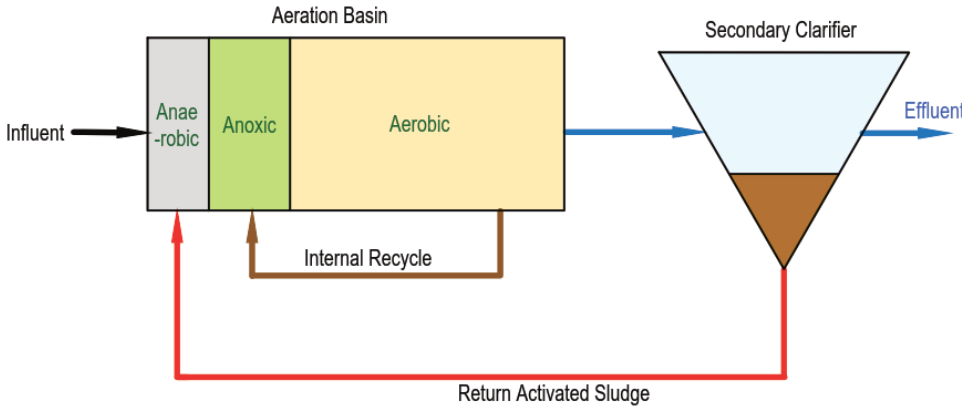
Microbial selection processes can be employed in various activated sludge process configurations to facilitate a biomass with exceptional settling characteristics in addition to providing nutrient removal. This generally includes the formation of self-assembled dense microbial communities in the activated sludge. This includes the formation of aerobic granules, which are microbial communities that grow and configure in a dense granular structure, as shown in comparison to flocculant activated sludge in **Figure 6-7**.

Figure 6-7 – Examples of Flocculant Activated Sludge (left) and Aerobic Granular Sludge (right)



Currently, the term aerobic granular sludge (AGS) has been used to describe the relatively large granules that can be produced in laboratory or full-scale batch reactors. However, in 2015, the University of Washington completed a field survey on many WWTPs and determined that multiple continuous flow WWTPs contained a fraction of aerobic granules within the activated sludge biomass; however, the surveyed facilities were not designed to specifically select for the formation of aerobic granules. However, the surveyed facilities all employed an enhanced biological phosphorus removal (EBPR) configuration. A typical EBPR flow diagram, which adds an anaerobic selector ahead of the typical continuous flow secondary treatment configuration, is shown **Figure 6-8**.

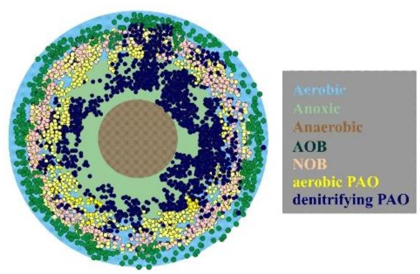
Figure 6-8 – Schematical Representation of a Secondary Treatment System Capable of EBPR



Note: Figure not to scale

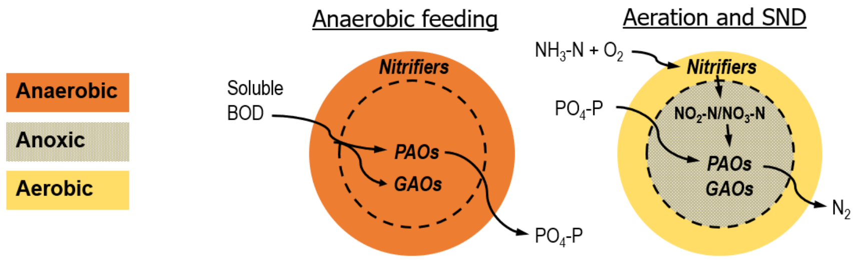
This configuration is proven to select for phosphorus accumulating organisms (PAOs), which are key to the development of microbial communities with exceptional settling properties and are integral to the interior structure of an aerobic granule. Aerobic granules can range in size from 0.2 mm to 3 mm or larger and exhibit settling velocities upwards of 10 times faster than those of flocculate sludge. An aerobic granule is shown graphically in **Figure 6-9**.

Figure 6-9 – Schematical Representation of Aerobic Granules



For the purposes of analyzing microbial selective processes that facilitate aerobic granule development within an activated sludge system, this Plan uses the term "densified activated sludge" (DAS) to broadly describe activated sludge facilities of various process configurations that can achieve a significant fraction of aerobic granules in the mixed liquor. Due to the dramatically increased mixed liquor settleability that aerobic granules provide relative to flocculant sludge, DAS can allow for an MLSS concentration of 6,000 to 10,000 mg/L, whereas flocculate sludge concentrations are typically kept below 3,000 mg/L. Further, AGS has been shown to perform simultaneous nitrification/denitrification (SND). As shown in **Figure 6-9**, the microbial communities that form granules generally assemble with AOB congregate near the exterior portion of the granule. NOB generally congregate further into the granule from the AOBs. PAOs generally congregate further into the granule relative to NOBs. The close proximity of AOBs, NOBs, and PAOs within the granule structure facilitates SND and EBPR as graphically shown in **Figure 6-10**.

Figure 6-10 – Schematical Representation of EBPR and SND with Aerobic Granules



PAOs = phosphorus-accumulating organisms
GAOs = glycogen-accumulating organisms

- Same carbon used for PAO/GAO growth and denitrification
- DO controlled to provide simultaneous nitrification/denitrification
- Denitrification provides alkalinity for pH control

For the purposes of initial screening, this chapter reviews the SBR and CFR activated sludge processes that could be configured to achieve a DAS.

SBR Configured to Achieve DAS

Multiple full-scale SBRs have been configured to select for microbial communities with good settling characteristics. Many SBRs globally have been configured using the Nereda technology, which specifically promotes the formation of a mixed liquor that has been shown to produce a large fraction of relatively large aerobic granules. Other SBRs, such as one in Peshastin, Washington, have been configured to produce DAS that contains a significant fraction of aerobic granules that vary in size. These facilities have been shown to provide exceptional mixed liquor settleability and nutrient removal.

At various WWTPs globally, CFRs have been replaced with SBRs capable of producing aerobic granular sludge. For this to occur, the CFR must be maintained while the SBRs are constructed. The primary challenge to implementing an SBR process at the City is the limited space available due to the existing site and process constraints. Similar to the challenges described for implementing BAF at the WWTP, an SBR process is a complete process change from the existing CFR. The existing aeration basins and clarifiers must generally remain in service during the construction of an SBR, which requires the necessary new headworks and SBR process to be constructed in the space available uphill from the existing secondary clarifiers. An SBR system would likely include significant volume of influent equalization to manage the peak wet weather flow events typical of the City, requiring an additional footprint. Once the new SBR system was commissioned and treating the full flow of the WWTP, the existing secondary treatment tanks could be demolished or repurposed for further expansion of the SBR system.

Converting the existing Lynnwood WWTP to a completely new process configuration, such as an SBR, is likely to be much more complicated and costly in comparison to implementing a system that improves the existing CFR. For this reason, the SBR process is not analyzed further for the City. However, the advantages of aerobic granules cannot be overlooked for the City as part of any future secondary treatment upgrade.

CFR Configured to Achieve DAS

The existing secondary treatment system consists of a CFR. To achieve DAS, the existing secondary treatment system would be expanded and changed to an EBPR process. Though phosphorus removal is not required at the Lynnwood WWTP, an EBPR configuration is necessary to formation of DAS as previously discussed. The limitations of total aeration basin volume and existing secondary clarifier area will be significant challenges to any process implemented in a CFR configuration. However, the potential benefits of dramatically increased mixed liquor settleability and exceptional nutrient removal warrant further investigation of this process at the City.

6.3.7 Evaluation of Technologies Applicable to Secondary Treatment Densification Technologies

After the initial screening, the remaining secondary treatment processes that could potentially be applicable to the Lynnwood WWTP are listed as follows.

1. Microbial selection processes
    a. CFR configured to achieve DAS (CFR-DAS)
2. Biofilm processes
    a. Integrated fixed film activated sludge (IFAS)
    b. Membrane aerated biofilm reactor (MABR)

For each of these processes, an overview of each system is given to provide an understanding of how each may be applied at the City. The year 2050 was chosen as the basis of comparison of these processes, and initial computational modeling results are provided for the 2050 loading conditions. A high-level review of the following key aspects is provided to qualitatively compare each process:

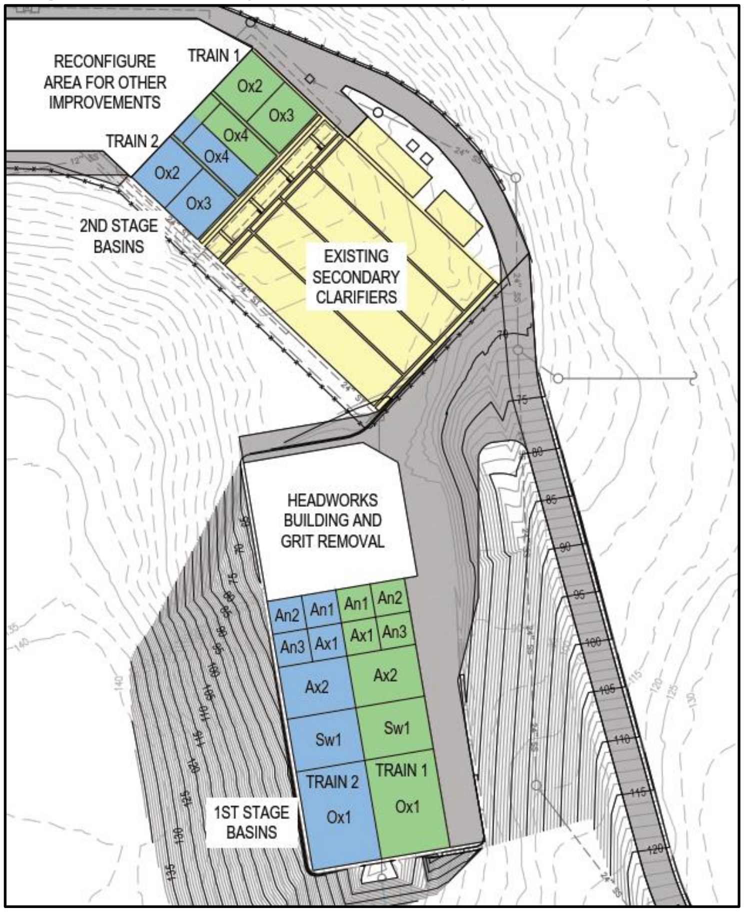
- Mixed liquor requirements.
- Secondary clarifier loading.
- Wet weather flow management.
- Influent screening.
- Energy usage.
- Installation history.

Following this review for each process, a basic quantitative comparison is provided to determine the process that has the highest potential for cost effectively and reliably meeting the challenging objectives presented by the necessary upgrades to the WWTP.

CFR-DAS

As previously noted, the existing WWTP site offers space for up to approximately 3 MG of total available aeration basin volume while maintaining the 4 existing secondary clarifiers. There are multiple methods to configure basins to achieve EBPR, but for the purposes of this Plan, two identical trains of basins are assumed. The available space on the upper site as well as the footprint of the existing basins must be used to achieve the maximal basin tankage. The basin locations will be separated by the existing secondary clarifiers as shown in **Figure 6-11,** creating 1st and 2nd stage basins.

Figure 6-11 – Proposed Secondary Treatment System



Note: Figure does not show proposed utilities interconnecting the 1st and 2nd stage basins

As shown in the figure, the 1st stage basins will consist of some combination of anaerobic, anoxic, and aerobic zones and the 2nd stage basins will be latter aerobic zones.

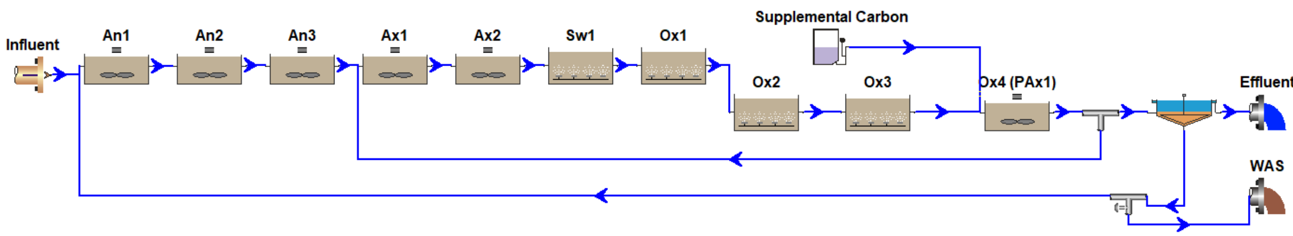
While the current version of BioWin was not developed specifically to model the densified activated sludge, it can be used to estimate the biomass necessary to achieve the process objectives for a CFR-DAS system. BioWin modeling was completing to analyze the following parameters:

1. Organism growth rates and corresponding mixed liquor concentrations at varied temperatures and influent loading rates.
2. The SRT necessary to provide reliable nitrification.
3. Anoxic and aerobic volumes, as well as internal and RAS recycle rates. It should be noted that any simultaneous nitrification and denitrification provided by aerobic granules in the CFR-DAS is not included in the model. Further, the potentially valuable effects of fermentation on nutrient removal, as discussed in **Chapter 8**, are also not considered by the model. For these reasons, the model results are likely more conservative than those that can actually be achieved with a CFR-DAS system.

4. Secondary clarifier hydraulic and solids loading rates at various MLSS concentrations.
5. Aeration demand.
6. Waste activated sludge generation.

The initial BioWin model, assuming the configuration shown in **Figure 6-11**, is shown in **Figure 6-12**.

Figure 6-12 – Schematic of Proposed Secondary Treatment System Layout in BioWin



AN – anaerobic; Ax – anoxic; Sw – Swing (anoxic or aerobic); Ox – aerobic; Pax – post anoxic

Initial steady-state modeling was completed for the 2050 maximum month influent loading conditions and the cold weather design mixed liquor temperature of 12 degrees Celsius, which is the most conservative condition to model for TIN reduction. **Table 6-4** displays the initial effluent TIN and mixed liquor concentrations predicted by the model at varied SRTs.

Table 6-4. Initial BioWin Model Results – CFR-DAS Configuration at 2050 Loading

Parameters	Effluent Results				Process Results	
SRT	NH_3	Nitrate	Nitrite	TIN	MLSS	SLR
(days)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(lb/sf/d)
5.0	2.49	0.00	2.15	4.64	4,550	44
6.0	1.17	0.60	1.91	3.68	5,200	50
7.0	0.71	1.78	0.76	3.25	5,850	56
8.0	0.49	2.22	0.25	2.96	6,480	62
9.0	0.38	2.36	0.10	2.84	7,060	68
10.0	0.32	2.43	0.06	2.81	7,600	73
11.0	0.28	2.47	0.04	2.79	8,140	79
12.0	0.26	2.49	0.04	2.79	8,640	83

2050 Loading Conditions: Flow - 8.92 MGD; BOD - 240 mg/L ; TSS - 200 mg/L; 175 mg/L volatile suspended solids (VSS); 35 mg/L TKN; 6 mg/L total phosphorus (TP)
2050 Operating Conditions: 12 deg C; 300% IR; 50% RAS; swing zone operated as aerobic with post anoxic zone; 300 gpd methanol
Carbonaceous BOD estimated at 90% of BOD

As shown in the table, the model predicts stable nitrification, as evidenced by effluent ammonia below 0.5 mg/L, occurring at an SRT of 8 days. The corresponding effluent TIN is predicted at approximately 3 mg/L. As the SRT is further increased, the effluent TIN is not predicted to appreciably decrease further without adding further supplemental carbon.

The BioWin model was operated in steady-state simulations. To account for peak diurnal loading conditions in this steady-state model, a simple method is to increase the SRT proportional to normal peak diurnal loading condition relative to the average loading condition. In **Chapter 4**, the peak diurnal to average flow condition was analyzed. A conservative peak diurnal to average day flow factor of 1.5 was established based on the analyses of **Chart 4-3** and **Chart 4-4**. To apply this factor to BioWin modeling, organic loading is assumed to increase proportionately with flow. Therefore, increasing the 8-day SRT shown in **Table 6-2** by a factor of 1.5 results in a 12-day SRT. This SRT is predicted to provide reliable nitrification and denitrification at the normal peak diurnal condition. At a 12-day SRT, the predicted mixed liquor concentration is 8,640 mg/L, and the clarifier solids rate is estimated at 83 lb/sf/d.

Major Considerations

Mixed Liquor Requirements

At the 2050 condition, the initial BioWin modeling predicts the mixed liquor conditions necessary to provide an effluent TIN of 3 mg/L with 3 MG of aeration basin tankage. An SRT of 12 days is necessary to support the maximum month peak diurnal condition. Supplemental carbon will be necessary to achieve this level of TIN reduction. As previously noted, BioWin does not account for any effects of SND or mixed liquor fermentation, which could further improve the treatment and potentially reduce the reliance on supplemental carbon for a CFR-DAS system, as discussed further in **Chapter 8**. To support this level of TIN reduction, the predicted mixed liquor concentration is estimated at 8,600 mg/L or higher, resulting in very high solids loading rates to the existing clarifiers.

Secondary Clarifier Solids Loading Rate

Based on initial modeling with the four existing clarifiers online, the predicted maximum month average day clarifier solids loading rate is approximately 83 lb/sf/d. This significantly exceeds the typical average design criteria of 25 lb/sf/d for conventional activated sludge. For this SLR to be achieved without significant loss of TSS from the clarifiers, CFR-DAS with exceptional settling characteristics will be necessary.

Conventional design aids, such as the Daigger-Roper Operating Chart, are based on empirical observations of conventional activated sludge. However, this chart can be used as a starting point to predict the general level of sludge volume index (SVI) necessary to support a specific SLR in a CFR-DAS system. The Daigger-Roper Operating Chart for secondary clarifiers in shown in **Figure 6-13**. This is adapted from Figure 12.89 in WEF MOP 8. The chart relates clarifier solids flux to SVI. If a point, as determined by a combination of SLR, RAS concentration, and/or underflow rate, lands to the left of or below the operating SVI, the clarifier is operating below the limiting solids flux. For points above or right of the operating SVI, the clarifier is operating above the limit flux and is at risk of solids washout.

Figure 6-13 – Daigger-Roper Operation Chart for Secondary Clarifiers

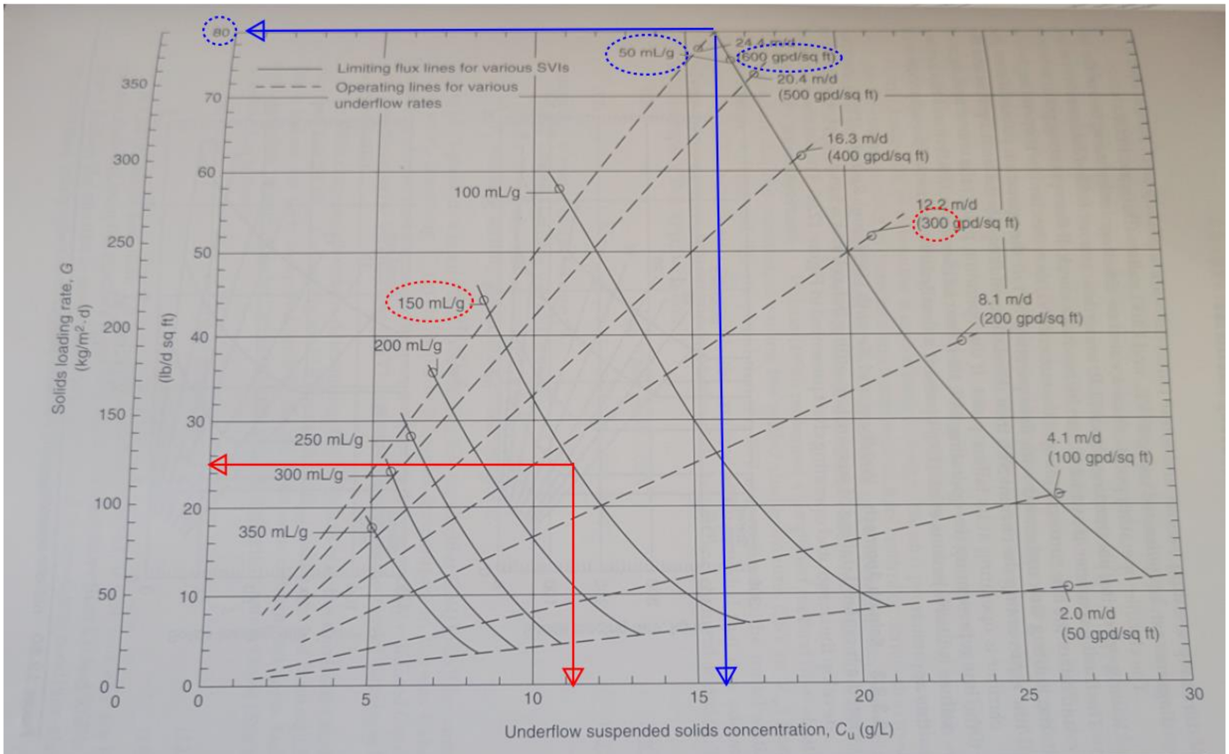


FIGURE 12.89 Daigger operating chart (Daigger, 1995).

As shown in **Figure 6-13**, the red lines denote the maximum combination of SLR and RAS concentration (25 lb/sf/d and 12,000 mg/l, respectively) that can be tolerated with an operating SVI of 150. This point corresponds to an underflow rate of approximately 260 gallons per day per square foot (gpd/sf). These are typical design values for conventional activated sludge.

The predicted 2050 maximum month average day SLR of 83 lb/sf/d with a CFR-DAS system is off the chart. At an SLR of 80 lb/sf/d, the chart predicts an SVI of approximately 50 as necessary to support this SLR at a RAS concentration of 16,000 mg/L and the underflow rate is 600 gpd/sf.

The findings from this chart cannot be exactly correlated to CFR-DAS. However, this chart denotes the importance of maintaining a low SVI with the future secondary treatment process in the City. To meet the 2050 maximum month average day condition, an average SVI of less than 50 will likely be necessary. Full scale AGS systems in SBRs have demonstrated that an SVI below 40 can be achieved. The Cashmere, Washington WWTP, as discussed further in **Chapter 8**, has achieved an SVI of less than 50 for extended periods with a continuous flow EBPR configuration. Achieving this level of settleability in a CFR-DAS system at the City is likely possible with the correct design elements, but is not yet widely proven at a full-scale plant under operating conditions similar to the City.

Wet Weather Flow Management

4.1.1 Historical Flow of **Chapter 4** analyzes the wet weather flow events for the City. Historically, wet weather events have produced peak hour flows to the WWTP of approximately 20 MGD and sustained peaks above 18 MGD for up to 6 hours. As noted in **Chapter 4**, wet weather events that produce daily flows 20 percent or higher than maximum month average daily flow occur approximately 10 to 20 days out of the year.

Wet weather flow events can significantly increase the secondary clarifier SLR and potentially cause solids washout. Clarifiers can typically withstand a peak SLR of approximately 1.5 times the average design SLR for a short duration. During the typical wet weather events for the City, it is likely that the peak SLR will be sustained for many hours and on rare occasions, up to 1 to 2 days in duration. This assumes the four existing clarifiers are in operation during this period. Having one clarifier out of service would worsen this condition.

It is likely that additional measures will be necessary to mitigate the peak SLR during wet weather events. These measures are discussed further in **Chapter 8** and could include:

- Bypassing some influent to the later zones of the basin to effectively reduce the MLSS concentration entering the clarifiers;
- Reducing or suspending RAS pumping during peak flow events; and
- Reducing or suspending aeration in the latter aerobic zones to store sludge and effectively reduce the MLSS concentration entering the clarifiers.

The potential mitigatory effects of these measures cannot be quantitatively predicted at this time due to the lack of similar, full-scale installations. Wet weather events and the corresponding mitigation for these events could have extended adverse impacts to the process. These risks are similar for any activated sludge system; however, CFR-DAS with exceptional settling characteristics provides the highest likelihood for wet weather flow management.

Influent Screening

A CFR-DAS system should not have any more stringent influent screening requirements than normal activated sludge. Screening with 6-mm spacing should be adequate for this system. This level of headworks screening should significantly reduce the screening system footprint compared to systems requiring 3 mm screening.

Energy Usage

Typical of any of the activated sludge systems reviewed in this Plan, a DAS system will primarily utilize energy to meet the aeration demand. Mixers and recycle pumps also will consume energy, though not to the level of aeration. One of the major potential benefits of a CFR-DAS system is simultaneous nitrification and denitrification with aerobic granules. Should this be achieved, aeration demand can be significantly reduced, as well as the internal recycle rate. Both would facilitate lower energy usage than typical activated sludge systems.

Installation History

As previously noted, multiple continuous flow EBPR facilities have been shown to contain aerobic granules as a fraction of the activated sludge biomass. Of note is the Cashmere, Washington WWTP, which is further discussed in **Chapter 8**. This facility operates a highly densified continuous flow EBPR process that exhibits an activated sludge in which a significant fraction is aerobic granules.

Further, AGS facilities that operate in an SBR configuration have been completed worldwide in the last decade. While these facilities operate in a different process configuration than the continuous flow configuration intended at the City, they demonstrate that biological treatment with AGS is being broadly employed.

While these facilities provide intriguing results in terms of process densification and nutrient removal, it is unlikely that any such facility operates under the combination of challenges posed for the Lynnwood WWTP. CFR-DAS, and the role in which AGS plays in this technology, should still be considered an emerging technology for applications such as the City.

IFAS

Vendor Proposal

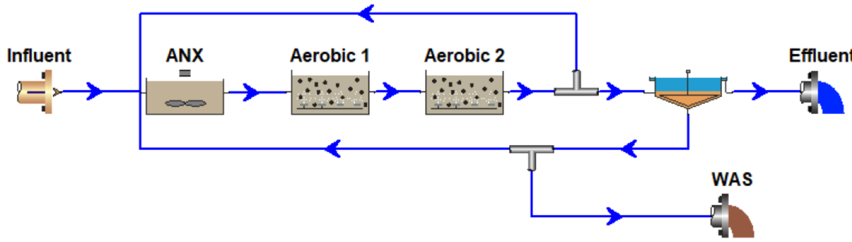
For this Plan, Suez was consulted regarding its Meteor IFAS system. The 2050 maximum month condition was used for this initial analysis. The influent design and effluent targets are included in **Table 6-5**.

Table 6-5. IFAS Parameters at 2050 Maximum Month Condition

Influent Loading and Effluent Discharge Requirements		
Influent Parameters		
Flow	8.92	*MGD*
BOD	239	*mg/L*
	17,800	*lb/d*
TSS	198	*mg/L*
	14,700	*lb/d*
TKN	36.3	*mg/L*
	2,700	*lb/d*
Phosphorus	6.1	*mg/L*
	450	*lb/d*
Alkalinity	250	*mg/L as* $CaCO_3$
Winter Low Average Daily	12	*deg C*
Effluent Requirements		
BOD	< 30	*mg/L*
TSS	< 30	*mg/L*
NH_3-N	< 1	*mg/L*
NO_3-N	< 2	*mg/L*
TIN	< 3	*mg/L*

Due to the previously identified constraints that will suspend further usage of primary clarifiers at the WWTP, the Suez proposal provided sizing and configuration requirements without the usage of primary clarifiers. It also assumes reuse of the existing secondary clarifiers with no additional clarifier area to. A basic BioWin model schematic provided in the Suez proposal is included in **Figure 6-14**.

Figure 6-14 – BioWin Schematic of Secondary Treatment System Layout per IFAS Proposal



Note: Suez assumed methanol addition and a post anoxic zone in the final proposal. These are not shown in the basic schematic provided in the proposal.

The IFAS proposal included an anoxic zone followed by two aerobic zones that contain the IFAS carriers, as well as a post anoxic zone with a supplemental carbon feed to achieve the low TIN limit of 3 mg/L. The carriers are retained in the first aerobic zones with screens in the basins. The configuration includes both internal and RAS recycle streams. The basic model results for the proposed configuration are provided in **Table 6-6**.

Table 6-6. IFAS Proposal Process Results for 2050 Maximum Month Condition

IFAS Model Results		
Pre-Anoxic Tank Working Volume	1.00	*MGD*
Aerobic Tank Working Volume	0.90	*MGD*
Post-Anoxic Tank Working Volume	0.26	*MGD*
Post-Aerobic Tank Working Volume	0.17	*MGD*
Total Reactor Volume	2.33	*MG*
Media Fill Fraction (Aerobic Tank Only)	56	*%*
Aerobic Design SRT	2.4	*days*
Total Design SRT	6.1	*days*
Internal Recycle Rate	250	*% of influent*
Return Recycle Rate	100	*% of influent*
Total Design Aeration Demand	11,700	*SCFM*
Design MLSS Concentration	3,500	*mg/L*
Design Clarifier SLR	35	*$lb/ft^2/d$*

Table from Suez proposal dated July 7, 2021.

Major Considerations

Mixed Liquor Requirement

The IFAS proposal estimates that a TIN of 3 mg/L can be met at the 2050 maximum month condition with a total aeration basin volume of 2.33 MG, which is below the approximate volume of 3 MG used to analyze CFR-DAS and MABR. The IFAS proposal predicts a MLSS concentration of 3,500 mg/L and a total SRT of approximately 6 days.

While the IFAS proposal appears to require less tankage than the other options analyzed in this section, it is prudent to maximize the construction of new secondary treatment tankage from the outset as it will be difficult to add to the site later. This also can facilitate more process flexibility.

For these reasons, the tankage required for IFAS is assumed equal to that of the other processes for the purposes of comparing processes.

Secondary Clarifier Solids Loading Rate

At an MLSS concentration of 3,500 mg/L, the proposal estimates a clarifier SLR of 35 lb/sf/d for the 2050 maximum month average day flow. The IFAS system shown in the proposal is likely to produce suspended growth activated sludge that has similar settling properties to that of conventional activated sludge, for which the typical design value for average SLR is 25 lb/sf/d.

It should be noted that the IFAS proposal does not include anaerobic zones. To design for a clarifier SLR higher than the typical design SLR of 25 lb/sf/d (as discussed in the following section), measures should be employed to increase the settleability of the mixed liquor. At a minimum, this would likely include the addition of anaerobic zones to facilitate the formation of PAOs. For IFAS to be applicable at the City, some method of increasing mixed liquor settleability is likely necessary.

Wet Weather Flow Management

Wet weather flow events will cause extended periods of high clarifier SLRs at the City with any activated sludge system. As discussed previously with the CFR-DAS system, there are potentially methods to reduce the peak SLR, but of primary importance is the settleability of the mixed liquor. Though the proposed IFAS system predicts a lower suspended growth mixed liquor concentration than the CFR-DAS option due to the biofilm carriers, the suspended growth mixed liquor that passes to the clarifiers in IFAS is unlikely to have settling characteristics that are significantly better than conventional activated sludge. This poses a significant risk of solids washout for an IFAS system during periods of extended peak clarifier loading due to wet weather events.

Further, the proposed rectangular aeration basins, in which the flow path is generally parallel to the long direction of the basin, pose the concern that the IFAS carriers will migrate to one end of the basin during high flow events. An uneven distribution of the carriers could severely impact the treatment efficacy of the system. This is of particular concern at the City, where wet weather events produce extended periods of high influent (and corresponding recycle) flows through the basins.

Influent Screening

Without primary clarifiers preceding the IFAS system, 2 to 3 mm perforated plate screening of the influent is recommended to protect the IFAS carriers from fouling. This is a significantly more restrictive screening requirement than is necessary for CFR-DAS and will increase the size of the new headworks and associated equipment to accommodate the reduced hydraulics afforded by this level of screening.

Energy Usage

The IFAS proposal estimates an aeration rate of 11,700 standard cubic feet per minute (SCFM) at the 2050 maximum month average day condition. Coarse bubble aeration is used in the IFAS system to maintain the carriers in suspension and scour excess biofilm from the carriers. However, coarse bubble aeration transfers oxygen to the biomass less efficiently than the fine bubble aeration used in the CFR-DAS and MABR systems, and as such, IFAS has approximately double aeration demand as these systems. This significantly increases the energy demand for this system relative to the others.

Installation History

IFAS has been implemented in many full-scale installations globally. There are multiple manufacturers that provide IFAS systems, and of the three processes analyzed in this section, IFAS would provide the most historical data from operating installations. It is generally a proven and reliable process for increasing biomass through the addition of a fixed film component to the activated sludge system. However, it is unlikely that sufficient operating data exists from IFAS facilities that face the combination of challenges posed by the City. The settleability of the suspended growth activated sludge in this system, and the potential loss of solids from the clarifiers at high flows, is a significant risk to the City that cannot be quantified at this time. As a result, the application of IFAS in the City should be considered emerging and not entirely proven.

MABR

Vendor Proposal

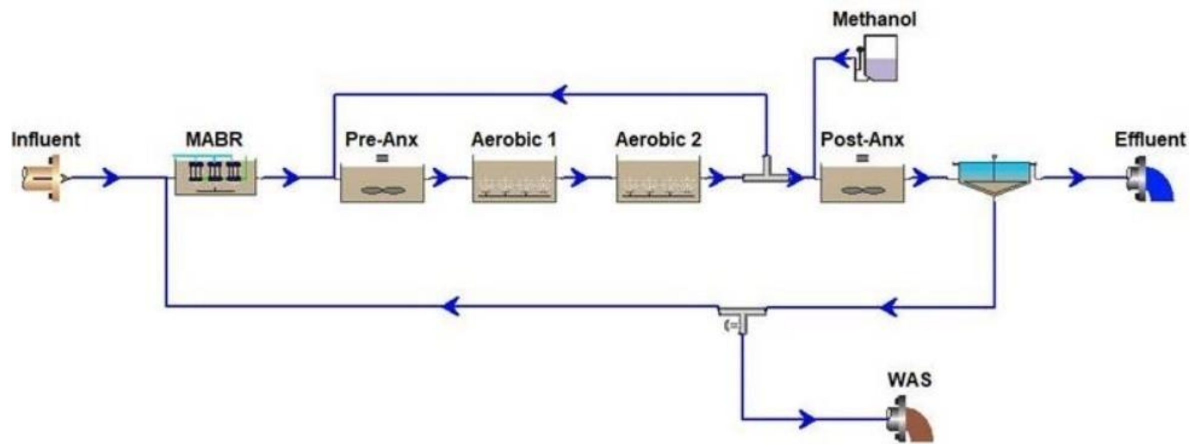
Suez was consulted regarding its ZeeLung MABR system. The 2050 maximum month condition was used for this initial analysis. The influent design and effluent targets are included in **Table 6-7**.

Table 6-7. MABR Parameters at 2050 Maximum Month Condition

Influent Loading and Effluent Discharge Requirements		
Influent Parameters		
Flow	8.92	*MGD*
BOD	239	*mg/L*
	17,800	*lb/d*
TSS	198	*mg/L*
	14,700	*lb/d*
TKN	36.3	*mg/L*
	2,700	*lb/d*
Phosphorus	6.1	*mg/L*
	450	*lb/d*
Alkalinity	250	*mg/L as $CaCO_3$*
Winter Low Average Daily	12	*deg C*
Effluent Requirements		
BOD	< 30	*mg/L*
TSS	< 30	*mg/L*
NH_3-N	< 1	*mg/L*
NO_3-N	< 2	*mg/L*
TIN	< 3	*mg/L*

Due to the previously identified constraints that will suspend further usage of primary clarifiers at the WWTP, the proposal provided sizing and configuration requirements without the usage of primary clarifiers. The proposal also assumes that there is no expansion of the existing secondary clarifiers. A basic schematic of the BioWin model from the proposal is included in **Figure 6-15**.

Figure 6-15 – BioWin Schematic of Secondary Treatment System Layout per MABR Proposal



The schematic shows an initial tank containing the MABR membrane cassettes followed by an anoxic zone and two aerobic zones. A post anoxic zone with a supplemental carbon feed also is shown to achieve the target TIN limit of 3 mg/L. This configuration includes both internal and RAS recycle streams. The basic criteria for the proposed configuration are provided in **Table 6-8**.

Table 6-8. MABR Proposal Process Results for 2050 Maximum Month Condition

MABR Model Results		
Pre-Anoxic Tank Working Volume	0.50	*MGD*
Aerobic Tank Working Volume	2.30	*MGD*
Post-Anoxic Tank Working Volume	0.20	*MGD*
Total Reactor Volume	3.00	*MG*
Aerobic Design SRT	5.5	*days*
Total Design SRT	7.5	*days*
Internal Recycle Rate	250	*% of influent*
Return Recycle Rate	70	*% of influent*
Total Design Aeration Demand	4,750	*SCFM*
Design MLSS Concentration	4,000	*mg/L*
Design Clarifier SLR	43	*$lb/ft^2/d$*

Table from Suez proposal dated July 7, 2021.

Major Considerations

Mixed Liquor Requirement

The MABR proposal estimates that a TIN of 3 mg/L can be met at the 2050 maximum month condition with a total aeration basin volume of approximately 3 MG. The MABR proposal predicts a MLSS concentration of 4,000 mg/L and a total SRT of approximately 7.5 days.

Secondary Clarifier Solids Loading Rate

At an MLSS concentration of 4,000 mg/L, the proposal estimates a clarifier SLR of 43 lb/sf/d for the 2050 maximum month average day flow. Similar to IFAS, MABR is likely to produce suspended growth activated sludge that has similar settling properties to that of conventional activated sludge, for which the typical design value for average SLR is 25 lb/sf/d.

Similar to IFAS, to justify a higher SLR than the typical design parameter, the MABR system should prudently include some additional process elements to increase mixed liquor settleability.

Wet Weather Flow Management

MABR systems are likely to be similar in mixed liquor settling characteristics to the IFAS system. Both systems are predicted to have lower mixed liquor concentrations compared to CFR-DAS due to the biofilm component that is retained in the basins. However, without enhanced mixed liquor settleability, these systems pose a significant risk of solids washout during periods of extended peak clarifier loading due to wet weather events.

Influent Screening

MABR will require similar requirements to IFAS to protect the MABR membrane cassettes from fouling. As previously discussed, this will significantly increase the size of the proposed headworks facility.

Energy Usage

The MABR proposal predicts an aeration demand of 4,750 SCFM, which is the lowest of the three processes reviewed. This is primarily due to the efficiency of the oxygen transfer directly to the fixed film biomass on the MABR cassettes. Similar to CFR-DAS, one of the major potential benefits of MABR is simultaneous nitrification and denitrification within the fixed film biomass. Both of these attributes facilitate lower aeration demand and resultant energy usage compared to other activated sludge systems.

Installation History

As previously discussed, few full-scale MABR systems are operating globally and those that are have operating times of 5 years or less. It is unlikely that any MABR facility operates under the combination of challenges posed for the Lynnwood WWTP. MABR should be considered an emerging or developmental technology for applications such as the City.

6.3.8 Secondary Treatment Alternatives Analysis

Based on the analysis of the CFR-DAS, IFAS, and MABR, each of these options are considered emerging and not entirely proven in applications similar to those posed for the City. This may change as additional systems are installed and the understanding of each technology is more fully developed for challenging applications. However, none of these options currently have full-scale installations with significant operating data that are comparable to the City in terms of the stringent future effluent TIN requirements, the high wet weather flow events, and the constrained

WWTP footprint. As such, this section seeks to synthesize and compare the options for the following categories.

- Category 1 – Mitigation of secondary clarifier solids loading
- Category 2 – Capital costs
- Category 3 – Ongoing costs
- Category 4 – Full scale installations
- Category 5 – Carbon footprint
- Category 6 – Allowance for process flexibility

This section compares the major differing aspects of each technology to assign a ranking to each (3 points – best option; 1 point – worst option) for the purposes of identifying the option that offers the highest current likelihood of success in meeting the City's process objectives.

CATEGORY 1 – MITIGATION OF SECONDARY CLARIFIER LOADING

Each of the three secondary treatment technologies seek to provide TIN reduction in significantly less footprint than a conventional activated sludge system. These systems are limited in size to the footprint available for approximately 3 MG of total aeration basin tankage at the WWTP. The most significant constraint on the capacity of these systems is the fixed size of the existing secondary clarifiers. **Table 6-9** qualitatively reviews the method by which each technology mitigates the solids loading to the secondary clarifiers and weighs the likelihood of each technology necessitating additional future mitigation.

Table 6-9. Relative Scoring: Mitigation of Secondary Clarifier Loading

Alt.	Discussion	Rank
CFR-DAS	As noted in the CFR-DAS discussion, PAOs have been found to be critical to forming microbial communities with good settling characteristics. The CFR-DAS process is developed on an EBPR process configuration containing multiple anaerobic zones and process controls to facilitate a mixed liquor containing dense, self-assembled microbial communities with exceptional settling characteristics. This will facilitate achieving an SLR significantly above the typical conventional activated sludge design SLR of 25 lb/sf/d. Additional process elements, such as surface wasting and mixed liquor fermentation, will be employed to further promote mixed liquor densification. These process elements would not otherwise be necessary for a process strictly designed to reduce nitrogen, and they are not included in the vendor proposals.	3
IFAS	This process supplements an activated sludge system by using inert mobile carriers in the aeration basins, allowing biofilm growth to supplement the activated sludge system and increase biological treatment capacity. This system inherently mitigates some increase in the secondary clarifier SLR by retaining the fixed film portion of the biomass in the aeration basins. This allows the biological treatment capacity of the system to be increased disproportionately to the SLR. However, the system must provide a sufficiently long SRT to allow for TIN reduction and this also allows for suspended growth activated sludge population to increase, such that the MLSS and corresponding SLR increase. However, this vendor proposal provided no process elements (such as anaerobic zones) specifically targeted at enhancing the settleability of the suspended growth fraction of the biomass. As such, this system should be designed to the typical average SLR design criteria of 25 lb/sf/d. As shown in the initial proposal, the estimated SLR at 2050 maximum month condition is 35 lb/sf/d for this system. Some means of mitigating this level of clarifier solids loading is considered necessary for this system from the outset to be considered equal to CFR-DAS. However, this proposal uses the maximal amount of available footprint for tankage and does not leave space for mitigatory measures, such as the addition of anaerobic zones.	2
MABR	Similar to IFAS, this process supplements conventional activated sludge with biofilm attached to fixed carrier/aerators in the aeration basin to increase biological treatment capacity without proportionally increasing the secondary clarifier SLR. Also similar to IFAS, MABR does not inherently change the settling characteristics of the suspended growth activated sludge and is limited to the average SLR design criteria of 25 lb/sf/d. As shown in the initial proposal, the estimated SLR at 2050 maximum month condition is 43 lb/sf/d for this system. The MABR proposal shows a lower SLR and would score better in this category.	1

CATEGORY 2 – CAPITAL COSTS

The three secondary treatment technologies all consist of activated sludge systems with varying configurations. Due to the space constraints of the WWTP, each system will generally utilize the maximum footprint and tankage available. The structural and civil costs are likely to be generally equivalent between the options. Further, each system will consist of a similar CFR with multiple zones, aeration, mixing, and pumping equipment. As such, the mechanical, electrical, and control costs are likely to be equivalent across the options. The major differences in capital costs for these options will be related to the influent screening requirements and associated headworks facility, the inclusion of anaerobic selectors, and the purchase of proprietary secondary treatment equipment.

Influent Screening

IFAS and MABR have more stringent screening requirements, which will necessitate 3 mm or less perforated plate screening. The CFR-DAS process can be preceded by 6 mm screening. The capital costs of screening will be higher for IFAS and MABR, as the screening required will restrict flow and necessitate significantly larger headworks channels and screens than the CFR-DAS option.

Anaerobic Zones and Associate Equipment

To facilitate the formation of dense microbial communities within the suspended growth activated sludge, CFR-DAS includes an EBPR process with anaerobic selector zones to allow for PAOs development. The anaerobic selectors are relatively small and equate to approximately 10 percent of the total aeration basin volume. Each selector requires mixing equipment. Anaerobic selectors in the CFR-DAS system increase the capital cost relative to IFAS and MABR as proposed.

As noted in Category 1, the CFR-DAS configuration intends to promote greatly enhanced mixed liquor settleability to mitigate clarifier SLR; utilizing an anaerobic selector is one aspect of meeting this objective. The IFAS and MABR proposals do not include anaerobic selectors, but may necessitate this addition or other modifications to mitigate the clarifier SLR. However, this consideration is not included in the capital cost scoring as it is accounted for in Category 1.

Proprietary Equipment

The CFR-DAS configuration can be configured with equipment such as blowers, pumps, and mixers typical of any secondary treatment system and will not have the proprietary vendor systems posed by IFAS and MABR. IFAS, which requires the plastic media carriers and retention screen, has propriety equipment costs higher than MABR. However, MABR also has a substantial vendor cost related to the membrane aeration units. **Table 6-10** compares the differing aspects of each technology that relate to any major capital cost differences between the technologies and provides a ranking.

Table 6-10. Relative Scoring: Differential in Capital Costs

Alternative	Influent Screening	Anaerobic Zones	Proprietary Equipment	Total Differential	Rank
CFR-DAS	$---	$1,100,000	$---	$1,100,000	3
IFAS	$750,000	$---	$5,300,000	$6,050,000	1
MABR	$750,000	$---	$4,600,000	$5,350,000	2

CATEGORY 3 – ONGOING COSTS

Each of the secondary treatment systems are expected to have similar operation and maintenance (O&M) costs for the pumps, blowers, and other equipment typical of activated sludge systems. For this analysis, ongoing costs are compared for the following major cost categories that are likely to differ between the systems.

Aeration Energy

IFAS has a substantial additional cost related the aeration energy necessary to maintain the carriers in suspension, causing the IFAS system to require approximately double the aeration energy of the other two options. For the purposes of comparing energy usage, MABR may have slightly less air demand than CFR-DAS.

Equipment Labor

IFAS and MABR include proprietary equipment that necessitate higher labor requirements. Otherwise, the labor requirements for each system are expected to be generally equal.

Proprietary Equipment Replacement Capital Cost

An IFAS system may have some O&M cost related to the plastic carriers, but this is not expected to be significant over the lifespan of the system. The lifespan of the MABR membrane cassettes are currently estimated at 20 years by the manufacturer, but it has yet to be proven in full-scale installations. Typical membrane aeration equipment necessitates replacement of the membrane diffusers on an interval of 7 to 10 years. Without having field data demonstrating the lifespan of MABR membranes, a conservative replacement interval of 10 years is assumed for this analysis.

Additional Labor

The three systems will have comparable labor for O&M of the equipment typical of an activated sludge system, and as such, the labor required for the CFR-DAS system is assumed to be the base level of labor. IFAS may require some additional labor related to the proprietary mobile carriers and screens, but this is expected to be relatively small and is not a significant factor in this analysis.

The normal O&M of the propriety MABR membrane cassettes is not fully understood due to the limited length of operating time for MABR installations. However, it is likely to have increased ongoing O&M for membrane cleaning and other procedures. The MABR system is expected to necessitate one additional full-time employee relative to CFR-DAS.

Table 6-11 compares the differing aspects of each technology that relate to any major ongoing cost differences between the technologies and provides a ranking.

Table 6-11. Relative Scoring: Differential in Ongoing Costs

Alternative	Aeration Energy	Proprietary Equipment Replacement	Proprietary Equipment Labor	Total Differential	Rank
CFR-DAS	$20,000	$---	$---	$20,000	3
IFAS	$200,000	$---	$---	$238,000	2
MABR	$---	$200,000	$75,000	$275,000	1

1. All costs are representing present worth cost differentials.
2. Aeration energy calculated based on an estimated utility rate of $0.10 per kilowatt-hour and is shown as the cost in addition to the base alternative cost (MABR).
3. MABR membrane replacement is estimated on 10-year intervals.
4. An annual labor cost of $75,000 per full-time employee is assumed for this analysis.

CATEGORY 4 – FULL-SCALE INSTALLATIONS

Table 6-12 qualitatively reviews the full-scale installations provided by each technology and ranks each accordingly.

Table 6-12. Relative Scoring: Full-Scale Installations

Alt.	Discussion	Rank
CFR-DAS	There are few, if any, full-scale CFR-DAS facilities that would be comparable to the City. However, the underlying principles, including an EBPR configuration with surface wasting, fermentation, and other process elements, have been applied in many full-scale AGS facilities.	1
IFAS	IFAS possesses the most full-scale installations and the longest running installations of the three options. The challenges posed by the City would necessitate implementing IFAS in a manner that is considered emerging and not widely proven.	3
MABR	MABR has few full-scale US installations with limited operating time. MABR has additional installations globally, though they are likely at operating times of 5 years or less.	2

CATEGORY 5 – CARBON FOOTPRINT

The carbon footprint of a WWTP is measured based on the on- and off-site greenhouse gas (GHG) emitted from the facility. GHG can be emitted from a variety of sources; some of the major sources include:

- Facility construction;
- Manufacturing and transport of treatment equipment;
- Manufacturing, transport, and usage of chemicals for treatment processes;

- Ongoing energy usage. Aeration demand contributes to the largest energy usage for these options and is considered the basis of comparing energy demand between technologies; and
- Ongoing biological process emissions, including carbon dioxide, methane, and nitrous oxide.

For the purposes of this high-level analyses of treatment options, it is assumed that the GHG emissions related to construction and biological process emissions are expected to generally be equal between the three options. **Table 6-13** qualitatively compares the differing aspects of each technology as they relate to carbon footprint and ranks each accordingly.

Table 6-13. Relative Scoring: Carbon Footprint

Alt.	Proprietary Equipment	Energy Usage	Supplemental Carbon Reduction Potential	Rank
CFR-DAS	CFR-DAS does not include equipment beyond the normal scope of mixers, pumps and aeration equipment necessary for any activated sludge system.	CFR-DAS may represent slightly higher aeration energy consumption than MABR.	Mixed liquor fermentation may facilitate reduced external carbon demand to support denitrification, as further discussed in **Chapter 8**.	3
IFAS	IFAS has additional GHG emissions associated with the manufacturing and transport of proprietary plastic carriers for both the initial installation and end-of-life replacement.	IFAS represents the highest aeration demand due to the aeration needed to suspend the mobile carriers.	IFAS is unlikely to offer any significant reduction in supplemental carbon for denitrification.	1
MABR	MABR has additional GHG emissions associated with the manufacturing and transport of proprietary membranes and associated equipment for both the initial installation and end-of-life replacement.	MABR likely represents the lowest potential aeration energy demand.	MABR is unlikely to offer any significant reduction in supplemental carbon for denitrification.	2

1. Comparison of aeration energy used and associated GHG emissions is based on the aeration comparison provided in Category 3 of these analyses.

CATEGORY 6 – ALLOWANCE FOR PROCESS FLEXIBILITY

Table 6-14 qualitatively reviews the flexibility provided by each technology to incorporate elements of other applicable technologies and ranks each accordingly.

Table 6-14. Relative Scoring: Allowance for Process Flexibility

Alt.	Discussion	Rank
CFR-DAS	The CFR-DAS system includes anoxic and aerobic zones similar to IFAS and MABR and could likely be reconfigured to incorporate elements of either IFAS of MABR into this system without significant difficulty.	3
IFAS	As previously noted, the IFAS system as proposed does not include anaerobic zones, which limits the flexibility of this system in achieving densification of the suspended growth sludge if necessary to mitigate clarifier SLR. Further, the IFAS system includes coarse bubble aeration to maintain suspension and scoring of the mobile carriers. This system likely offers the least flexibility, as CFR-DAS and MABR require fine bubble aeration.	1
MABR	As previously noted, the MABR system as proposed does not include anaerobic zones, which limits the flexibility of this system in achieving densification of the suspended growth sludge if necessary to mitigate clarifier SLR.	2

SUMMARY OF ALTERNATIVES ANALYSIS

Table 6-15 summarizes the relative scoring of the three treatment options for each category.

Table 6-15 – Scoring Summary for Densified Secondary Treatment Processes

Category	CFR-DAS	IFAS	MABR
Category 1 – Mitigation of Secondary Clarifier Solids Loading	3	2	1
Category 2 – Capital Costs	3	1	2
Category 3 – Ongoing Costs	3	2	1
Category 4 – Full-Scale Installations	1	3	2
Category 5 – Carbon Footprint	3	1	2
Category 6 – Allowance for Process Flexibility	3	1	2
Total (Highest Score Preferred)	**16**	**10**	**10**

CFR-DAS receives the highest total score, demonstrating that it is the preferred treatment technology based on the range of categories in this analysis. IFAS and MABR have similar scores and either could be considered a runner-up to CFR-DAS.

6.3.9 Recommended Secondary Treatment Improvements

The site constraints of the Lynnwood WWTP will not allow widely used conventional technology to be conservatively implemented at the WWTP for the purposes of achieving nitrogen reduction to 3 mg/L TIN. As shown in the previous analysis, CFR-DAS seeks to achieve maximal usage of the WWTP footprint available to afford the highest level of treatment capacity and system flexibility. Future process adjustments to this system could be made that would allow incorporation of elements from either MABR or IFAS if such improvements are deemed beneficial. Based on this analysis, the CFR-DAS approach appears to offer both the lowest cost and the highest likelihood of success in achieving the future capacity needs and nutrient limits. It is the recommended approach for mainstream secondary treatment at the WWTP and is further developed for implementation in **Chapter 8**.

6.4 PRELIMINARY TREATMENT

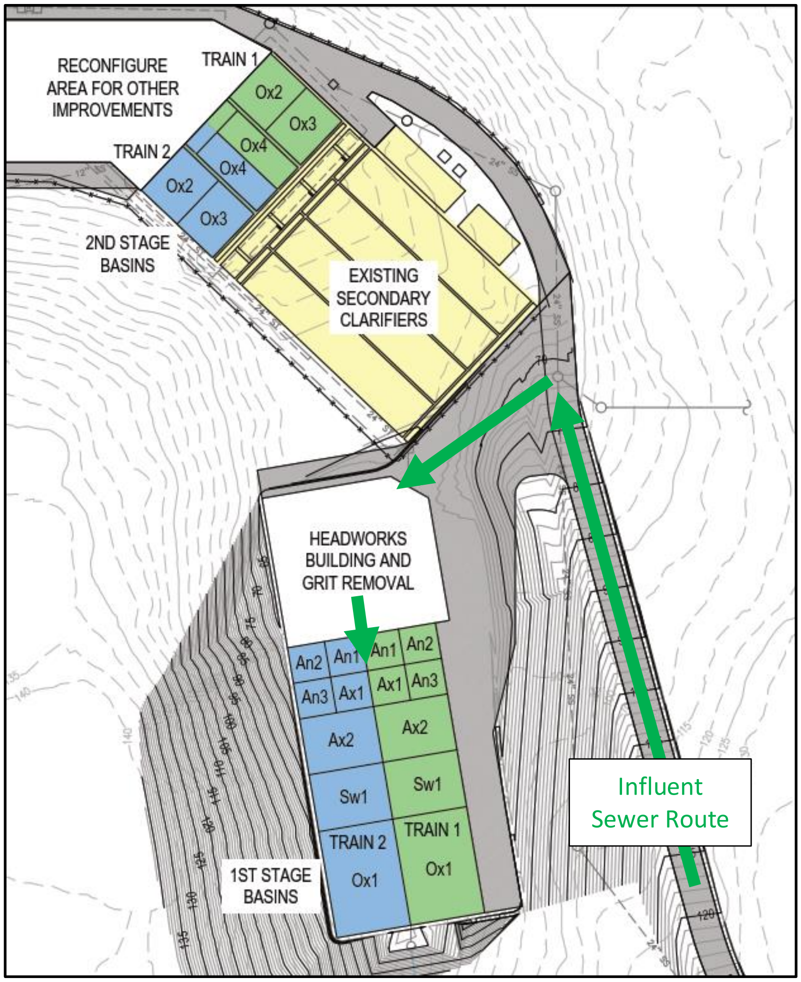
6.4.1 Background

As discussed in **5.4.1 Preliminary Treatment** of **Chapter 5**, the existing headworks is limited in hydraulic capacity to pass future peak hour flow events. The headworks also lacks redundancy in the mechanical screening and grit removal systems, and the age of these systems necessitates replacement during the planning period. There is insufficient space to make these improvements in the existing headworks.

6.4.2 Headworks Relocation

5.9 WWTP Site Considerations of **Chapter 5** outlines constraints of the existing WWTP site. One of the significant constraints is the location of the headworks below the secondary treatment system. This significantly complicates any expansion of treatment at the site. **5.9 WWTP Site Considerations** of **Chapter 5** recommended construction of a new headworks, uphill of the existing secondary clarifiers. The influent sewer pipe would be rerouted such that flow would be entirely by gravity through the new headworks to the subsequent existing and future treatment processes. This would eliminate the need for the Main Plant Pump Station. This general configuration is shown in **Figure 6-16**.

Figure 6-16 – General Location of New Headworks at Lynnwood WWTP



Note: Figure does not show proposed utilities interconnecting 1st and 2nd stage basins

6.4.3 Influent Flow Metering

Influent metering will be necessary upstream of the proposed headworks location. With the realignment of the access road to the new headworks location, it is likely that influent sewer pipe can be routed in a manner that dissipates energy from the influent and aligns the flow to allow for use of an open channel meter upstream of the screening channels, outside of the proposed Headworks Building. As such, an alternatives analysis of other metering options or configurations is not warranted, and the recommended meter configuration is further developed in **Chapter 8**.

6.4.4 Screening System

The future screening system must be sized to pass the projected 2050 peak hour flow of approximately 30 MGD. The existing screening system consists of a single multi-rake screen with ¼-inch bar spacing with a capacity limitation of approximately 14 MGD. The City has noted that some screenings bypass the existing screening system, and the City desires a higher level of screening with the future system in addition to the increased capacity. Two-dimensional perforated plate screening would provide significantly increased screenings removal compared to the current one-dimensional bar screen. Perforated plate screening provides a high level of protection of downstream processes; for these reasons, it is expected to be implemented in the future. As previously noted, the CFR-DAS system recommended in this chapter would be adequately protected by perforated plate screenings with 6 to 9 mm openings. The City also desires redundancy in screening equipment, and as such, a least two mechanical screens will be installed in separate channels. No alternatives analyses is necessary as redundant, in-channel, perforated plate fine screens will be necessary to meet these objectives. The recommended configuration for this system is fully developed in **Chapter 8**.

6.4.5 Grit Removal System

The grit removal system also must provide capacity for the projected 2050 peak hour flow of approximately 30 MGD. The existing grit removal system consists of a single 12-foot-diameter grit chamber, grit pump, and classifier. Similar to the screening system, the future grit removal system must provide significantly increased capacity, as well as redundancy in equipment. For the peak flows experienced at the City, vortex-style grit removal in concrete channels is a standard and proven approach to grit removal and is recommended. Based on initial analyses, partial redundancy could be provided with two 16-foot-diameter grit chambers, each rated for approximately 20 MGD. Full redundancy likely could be provided with two 18-foot-diameter grit chambers rated for 30 MGD each. Each system would include a grit pump and classifier dedicated to each grit chamber. The equipment costs for either system would be similar, with the primary capital cost difference originating from the nominal increase in concrete necessary for the larger chambers. For conservative budgetary and space planning, the dual 18-foot-diameter grit chambers are recommended to provide 100-percent redundancy at the projected peak hour flow. The recommended configuration of this system is fully developed in **Chapter 8**.

6.5 EFFLUENT DISINFECTION

6.5.1 Background

The existing effluent disinfection system consists of chlorination, using a chlorine gas system and a liquid sodium bisulfate dechlorination system. The chlorine gas system is housed in Building No. 2 and the sodium bisulfate dechlorination system is located in a small building at the north end of the chlorine contact chambers. The chlorine contact chamber is located below the Control Building. The maximum capacity of the chlorine contact chamber as currently configured is likely limited to 22 to 23 MGD, which is insufficient for future peak hour flows as shown in **Chapter 5**. Further, the existing chlorination system is aging, and the City desires to change to alternate disinfection system to avoid future use of chlorine gas, which bears high costs and risks associated with the transport, storage, and handling of a hazardous material.

Disinfection alternatives generally include those that utilize an oxidizing agent, such as chlorine, ozone, or peracetic acid. Alternatively, ultraviolet light (UV) is commonly used for the disinfection of secondary effluent. These options are considered for the City in this section.

6.5.2 Initial Screening of Alternatives

CHLORINATION WITH HYPOCHLORITE

In lieu of using chlorine gas, the City could utilize hypochlorite as an alternate method of chlorination. This can be accomplished with bulk sodium hypochlorite delivered to the WWTP or on-site generation of hypochlorite from salt and water; however, for the City, on-site generation would likely be the common approach to chlorination. Chlorination poses the following advantages and disadvantages.

Advantages:

- Relatively simple operation and maintenance.

Disadvantages:

- Large footprint requirement:
  - The existing contact chambers will need to be expanded to provide sufficient contact time for the projected peak hour flow; and
  - The chlorination and dechlorination systems create additional footprint requirement adjacent to the contact chambers
- Truck traffic impact to the WWTP for salt delivery.
- Reliance on outside chemical delivery (either bulk sodium hypochlorite or salt for on-site generation).
- Corrosive material handling requirements.
- Requires dechlorination to remove residual toxicity.
- Disinfection byproduct formation.

For the City, the footprint impact is a significant drawback for chlorination relative to other disinfection options. The existing chlorine contact chambers will require expansion to provide capacity for future flow, and new chlorination and dechlorination systems will require space to be allocated near the chambers. These footprint requirements will impact the expansion of the future solids handling system and other improvements. Additionally, the City prefers to avoid the need for truck delivery of chemicals for chlorination due to the impacts to operations within the constrained site. Removing this delivery from local residential roads also is desirable. Other disinfection options, such as UV systems, have significantly reduced footprint requirements and do not rely on outside chemical deliveries. For this reason, chlorination is not considered further in these analyses.

OZONE DISINFECTION

Ozone disinfection was fairly widely employed for municipal wastewater effluent disinfection in the 1970s and 1980s. However, the ongoing costs associated with these systems prompted many too be abandoned and chlorination became the prominent disinfection method. In recent years, ozone disinfection has resurged as the generation equipment has improved and users have looked for alternatives to chlorination that provide disinfection for a broader range of compounds. Ozone gas is generated onsite from atmospheric air using a high voltage generator. Ozone gas cannot be transported due to its instability, which prompts it to decompose in a short duration. The ozone gas produced is injected into the wastewater with various diffusers in differing contact tank configurations. Ozone systems are typically cost prohibitive when compared to other systems where disinfection of secondary effluent is the primary objective. When there are process objectives in addition to secondary effluent disinfection, such as the removal of emerging contaminants, ozone systems become more competitive. WEF MOP 8 notes that, "…as of 2016, ozone disinfection systems are in use or in construction at approximately 20 U.S. [Water Resource Recovery Facilities] WRRFs, many of which cite color removal or the destruction of trace organics as deliberate supplementary goals." However, secondary effluent disinfection is the sole process objective for the disinfection system at the City, and in the absence of any additional process objective, ozone is not likely to be cost competitive for this application and is not considered further in this Plan.

PERACETIC ACID DISINFECTION

Peracetic acid is another potential chemical disinfection method that has been gaining interest in recent years as an alternative to chlorination. However, there are few full-scale installations for peracetic acid disinfection for municipal wastewater currently. Peracetic acid is a strong oxidant that is generated from acetic acid and hydrogen peroxide. It shows potential advantages compared to chlorination, including a reduction in the required contact time, no required dechlorination, no harmful byproducts and broad effectiveness. The major disadvantages of this system include the lack of full-scale installations and potential for shortages or high costs in the chemical supply as acetic acid and hydrogen peroxide are not currently utilized widely in the Puget Sound area for this purpose.

The fact that peracetic acid disinfection is not yet widely employed for disinfection in the Puget Sound region, combined with the City's desire to avoid reliance on outside chemical delivery and chemical handling, justifies removing peracetic acid disinfection from further consideration.

UV DISINFECTION

UV disinfection is widely employed for municipal wastewater effluent disinfection and is available in a variety of configurations for both open-channel and enclosed vessel systems. UV radiation inactivates pathogens by destroying their genetic material. UV systems offer the following major advantages and disadvantages.

Advantages:

- Compact footprint.
- Lack of disinfection byproducts.
- Automated system with relatively low operations labor.

Disadvantages:

- High equipment cost.
- High energy usage.
- Skilled maintenance that can require varying levels of reliance on vendor support.

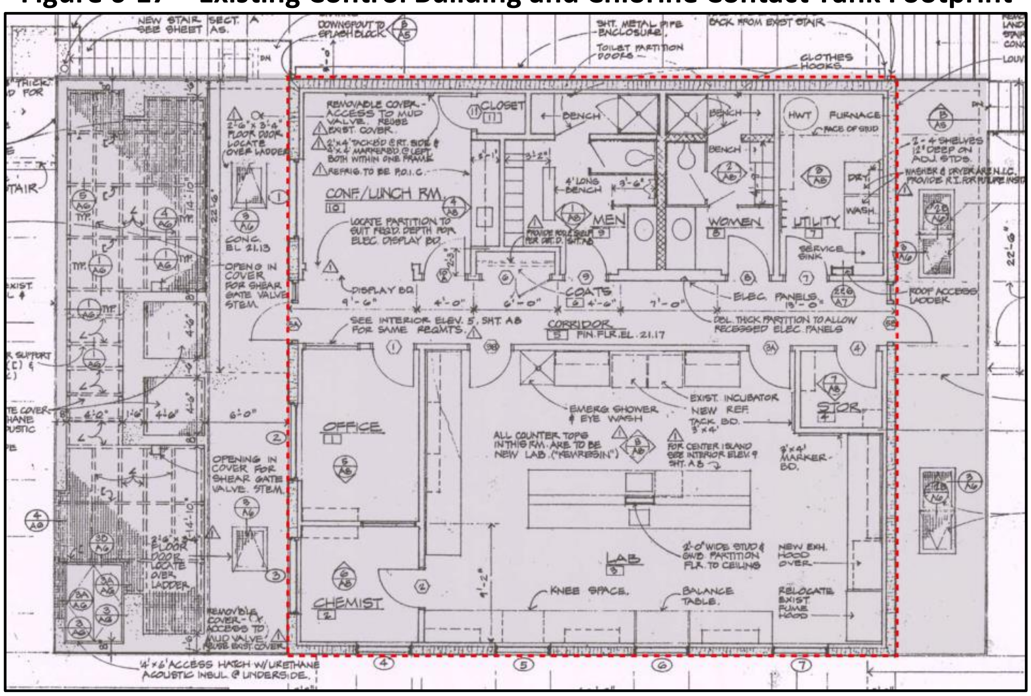
Two UV system configurations are applicable to the City: open channel and enclosed vessel. An open channel system could potentially be configured within a portion of the existing chlorine contact basins or in a new channel elsewhere on the site. An enclosed vessel system could likely be configured in multiple locations at the WWTP. The available head from the existing secondary clarifiers to Puget Sound would allow significant flexibility in configuring either type of UV system at the existing WWTP. Both potential disinfection options are analyzed further in the following section.

6.5.3 Effluent Disinfection Alternatives Analysis

OPEN CHANNEL UV SYSTEM

Open channel UV systems generally consist of multiple banks of UV lamps either in series or in parallel channels. In many cases, in-channel UV systems have been retrofitted into existing chlorine contact chambers. This requires the addition of partitions to create channel(s) within to the tolerances necessary to house banks of UV lamps. UV systems provide a high level of treatment within a compact footprint. Generally, in-channel UV systems can be installed within a portion of existing contact chambers. However, the existing Control Building is housed over a significant portion of the existing chlorine contact chamber as shown in **Figure 6-17**, which complicates placement of UV equipment in the existing chlorine contact tank at the City.

Figure 6-17 – Existing Control Building and Chlorine Contact Tank Footprint



Note: The extents of the chlorine contact chamber is shaded in gray and the Control Building above is outlined in red.

Open channel UV lamps require periodic visual inspection and maintenance, so it is not practical to install in-channel equipment below the extents of the Control Building. A portion of the existing contact tank is outside the extents of the Control Building on the northern portion of the structure. However, this area is fairly limited in size. Further, half of the tank must remain in service while any UV system is constructed to maintain chlorine disinfection. Based on vendor proposals for in-channel UV systems, it appears that there is insufficient space in the existing chamber, outside of the Control Building footprint, to prudently plan for an in-channel UV system to be installed in the existing chlorine contact tank.

Alternatively, a new channel could be constructed elsewhere on the site, allowing the existing chlorine contact chamber to be decommissioned. The technology cost for a new open channel UV system is estimated in **Table 6-16** for comparison to an enclosed UV system.

Table 6-16. Technology Comparison Cost of New Open Channel UV System

Item Description	Total Cost
Equipment	$800,000
Concrete Channels and Installation	$1,000,000
Shelter	$500,000
SUBTOTAL	**$2,300,000**

1. Estimate excludes similar items such as mobilization, OH&P, tax, contingency, or indirect costs.
2. Shelter assumed to consist of roof structure to protect above channel equipment from rain and sunlight. Complete enclosure of the equipment is not assumed.
3. Electrical and control system costs are excluded from analysis as they are likely to be similar for either type of UV system.

The open channel system as estimated in **Table 6-16** assumes two concrete channels with multiple banks of inclined lamps installed in series in each channel. This configuration would provide for treatment of the approximate 2050 maximum hour flow of 30 MGD with one redundant UV bank. The lamps for each bank are retrievable from above the channel for maintenance, allowing a single bank of lamps to be taken offline without taking the channel out of service.

ENCLOSED VESSEL UV SYSTEM

Enclosed vessel UV systems consist of multiple UV modules connected to a pipe manifold. These systems are typically enclosed in a building for protection from the elements. The technology cost for a new enclosed UV system is estimated in **Table 6-17** for comparison to an open channel UV system.

Table 6-17. Technology Comparison Cost of New Enclosed Vessel UV System

Item Description	Total Cost
Vendor Equipment	$1,500,000
Mechanical and Ancillary Systems and Installation	$1,500,000
SUBTOTAL	**$3,000,000**

1. Estimate excludes similar items such as mobilization, OH&P, tax, contingency, or indirect costs.
2. Enclosed UV system piping may be incorporated into a larger building, such as a new Solids Handling Building.
3. Electrical and control system costs are excluded from analysis as they are likely to be similar for either type of UV system.

The enclosed vessel UV system as estimated in **Table 6-17** assumes seven reactors. The enclosed modules allow for the disinfection system to be pressurized. The UV system can be located above grade in a mechanical building as long as sufficient head exists to provide full pipe flow through the system. This configuration provides for treatment of the approximate 2050 maximum hour flow of 30 MGD with one redundant reactor. To allow maintenance of each module individually, this system is configured with the reactors in parallel, with valves to isolate each module off common influent and effluent manifolds. This allows for the isolation and maintenance of each reactor individually while allowing four reactors to remain in service.

6.5.4 Recommended Effluent Disinfection System

The operations and maintenance costs for either open channel or enclosed vessel UV systems are not likely to be significantly different and are not a factor when comparing both systems. The major difference between these systems is the capital cost. An enclosed vessel UV system typically carries a higher equipment cost relative to open channel equipment. As shown in **Tables 6-16** and **6-17**, the in-channel system is expected to be less expensive than the enclosed system.

There are potential benefits of an enclosed pipe UV system that should be considered. An enclosed system would allow for complete enclosure of the effluent system between the outfall and the secondary clarifiers (consisting of approximately 50 feet of elevation difference), such that the outfall system could be allowed to slightly pressurize during future high flow events. This could allow for increased capacity of the outfall piping. Further, an enclosed system could offer much more flexibility in the location of the disinfection facility or integration of the equipment into a larger facility.

Based on this analysis, it is recommended that the City budget for the enclosed vessel UV system, which may provide additional benefits compared to an open channel system, but also provides a conservative capital cost that would allow an open channel system to be further considered in the future design. An enclosed vessel UV system is further developed for implementation in **Chapter 8**.

6.6 SUMMARY OF ANALYSES

In the previous chapters, the primary drivers for WWTP improvements were identified. This includes the significant growth that is expected in the City during the planning period. The existing WWTP does not provide adequate capacity to support the expected level of growth as currently configured. Further, the age of much of the existing WWTP infrastructure has exceeded its useful life and necessitates improvements for continued reliable treatment. The pending nitrogen limit posed by the PSNGP is also a major consideration in planning improvements to the WWTP. Secondary treatment expansion has the largest potential footprint impact, and the specific challenges of the WWTP site require any secondary treatment strategy to rely on emerging or developmental technologies. This requirement will preclude a complete guarantee of continually achieving a stringent effluent nitrogen limit. CFR-DAS is the recommended approach as it offers the lowest cost, the highest likelihood of success, and provides the most flexibility to allow for future process modifications as the current emerging technologies become better understood. To support the CFR-DAS system and satisfy the other drivers for improvements, a new headworks facility will be constructed in addition to new aeration basins uphill from the existing secondary clarifiers. A new solids handling facility consisting of a belt dryer system will be constructed on the lower portion of the site, and the effluent chlorine disinfection system will be replaced with UV disinfection.

7 | EVALUATION OF WWTP SOLIDS HANDLING ALTERNATIVES

7.1 INTRODUCTION

The goal of this chapter is to evaluate and select the solids handling process for the City of Lynnwood's (City) Wastewater Treatment Plant (WWTP) that best meets the City's defined set of criteria. The solids handling process, as defined herein, includes all process elements from the storage of waste activated sludge (WAS) from the liquid stream to final off-site biosolids disposal. This chapter is organized to chronologically follow the evaluation process performed and includes the following:

- Existing Sewage Sludge Incinerator (SSI) – Review of the existing SSI.
- Solids Handling Process Sizing – Definition of projected solids production for the solids handling process sizing.
- Existing WWTP Site – Definition of footprint available for the solids handling process.
- Stage I Evaluation Criteria – Establishment of review criteria with criteria definition and scoring.
- Capital and Life-Cycle Cost Basis – Definition of cost basis used in the evaluation herein.
- Stage I Evaluation – Identification and review of high-level solids handling process alternatives and associated site plans.
- Stage II Evaluation Criteria – Establishment of review criteria with criteria definition and scoring for Stage II evaluation
- Stage II Evaluation – Technology selection, including individual unit processes, for the top two ranked solids handling processes identified during Stage I.

The evaluation of technologies in this chapter shall not be construed as an endorsement of any specific technology manufacturer(s) or supplier(s). The evaluation herein is intended to achieve two main goals: 1) provide a planning-level assessment of the applicable solids handling options available to the City and in conformance with City objectives at the WWTP site; and 2) make a recommendation for the solids handling process and associated technologies for the WWTP site for planning purposes.

7.2 EXISTING SEWAGE SLUDGE INCINERATOR

The City operates and maintains an SSI to handle solids produced from the primary and secondary treatment processes. The City's history with incineration began in 1962 when it installed the first municipal fluidized bed SSI in North America, a 4-foot-diameter unit per *Wastewater Solids Incineration Systems Manual of Practice 30, Water Environment Federation* (WEF MOP 30). In 1989, the original SSI was replaced with the current 9.5-foot-diameter, 860 pounds per hour design capacity system. The design capacity was never reached in practice and a subsequent upgrade in 1994 was implemented to increase the capacity to 750 to 800 pounds per hour. Per the *Wastewater Comprehensive Plan Update* (BHC Consultants, 2012), the facility operators believe the

SSI's sustained capacity was 688 pounds per hour, or approximately 86 percent of its original design capacity.

In 2020, Chavond Berry Engineering Corp (CBE) performed a review to determine SSI capacity, which was estimated at 620 pounds per hour. The complete SSI capacity review by CBE is provided in **Appendix E**. The analysis was based on City-provided data on SSI operation and monthly dewatered sludge data from 2019 and 2020. From the data provided, an SSI feed solids percentage of 21 percent was selected, with an 84 percent volatile fraction, and 10,000 British Thermal Units (BTU) per pound lower heating value (LHV). CBE performed a heat balance assuming a low exhaust temperature of 1,500 degrees Fahrenheit, and 140 percent excess air, in line with actual SSI operations in 2019 and 2020. The excess air percentage was higher than typical and indicated that the SSI had a theoretical maximum sludge burning capacity of 620 pounds per hour, and a recommended practical operational capacity of 527 lb/hr. The analysis performed is sensitive to the estimated LHV and the sludge feed concentration. The analysis performed was only a spreadsheet-based analysis and does not account for design parameters such as air distribution or ratio of freeboard to bed, which may be less than optimal due to the SSI's design. Per CBE, minimal increases in SSI capacity may be achieved by increasing the temperature of hot air between the primary heat exchanger and the wind box; however, significant increases in capacity would likely not be achievable without a new SSI. Overall, it is CBE's assessment that the current SSI is in an operable condition and can provide service for the next 10 years with the assumption that it is operated and maintained as designed and within its capacity bounds.

Operating and maintaining the current SSI presents several challenges that cannot be captured by a heat balance assessment. The challenges associated with operating and maintaining the SSI can be grouped into the following three main categories:

- Limited Access – The SSI equipment is located within an existing building that offers limited access to the equipment itself and impedes access of larger construction equipment potentially required for SSI repair (i.e., cranes, lifts, scaffolding).
- Aging Equipment – The SSI equipment, piping, and components often require replacement and/or refurbishment. Given the age of the system, replacing such parts often requires custom and/or specialty fabrication and installation. Such replacement parts often trigger extended SSI shutdowns due to long part/equipment lead times and significant, unplanned expenditures for the City, which must dispose of dewatered sludge offsite when the SSI is offline.
- Sludge Storage and Feed Limitations – Wasting from the secondary clarifiers feeds into a 45,000-gallon preconcentration tank for thickening. WAS is then mixed with primary sludge prior to dewatering. This process operates continuously, and there is no ability to store wasted solids. Wasting can be stopped for short periods, but solids build up in the secondary clarifiers, ultimately resulting in National Pollutant Discharge Elimination System permit violations for total suspended solids (TSS). Furthermore, dewatered sludge can be fed to the SSI at two locations. However, the dewatered sludge pumps are currently unable to deliver to both SSI feed locations due to piping configuration and sludge dryness. As a result, reaching full SSI design capacity has been challenging in practice.

The above challenges are further compounded by the annual operation and maintenance (O&M) costs for the SSI, which are estimated to be approximately $630,000 (2021 US Dollars). This cost includes consumables (fuel, oil, and sand), electricity, regulatory compliance and testing, annual repair costs, and hauling costs. The largest annual cost is hauling of liquid sludge for the annual 2-week scheduled shutdown and any emergency hauling required when the SSI is taken out of service for unplanned repairs. The costs associated with emergency hauling alone are estimated at approximately $175,000, but this figure can vary widely depending on the number of emergency repairs needed, resulting in unpredictable and significant financial risk to the City.

In addition to the above limitations associated with operating an aging SSI, the most significant risk for owning and operating an SSI is being subjected to the changing permitting landscape associated with incineration. The existing SSI will likely exceed capacity by the early 2030's based on the updated flow projections outlined in this Facility Plan (Plan). The City has made considerable investments over the years to repair and upgrade the SSI. Major upgrades, or even a new SSI, would likely be necessary to maintain capacity in the long term. Per 40 CFR 60 Subpart LLLL, such improvements will trigger the facility to meet newer, more stringent emissions standards than those to which the facility is currently held. Additionally, these emissions standards are subject to change in the future, and would likely only become more stringent based on the current trends in the regulatory environment.

Given the considerations described in this section regarding operational challenges, aging equipment, and exposure to both financial and permitting risks, sludge incineration was not further considered in detail as a solution for the new WWTP solids handling process. Neither upgrading the incinerator, nor replacing it in kind, will alleviate the financial and permitting limitations associated with SSIs.

7.3 SOLIDS HANDLING PROCESS SIZING

Chapter 6 outlines the detailed evaluation of liquid stream processes. For the solids handling process evaluation it was assumed that the liquid stream will not include primary clarification, thus resulting solely in the production of WAS. Modeled solids production rates from the **Chapter 6** liquid stream process evaluation are summarized in **Table 7-1**.

Table 7-1. Projected Solids Production

Parameter	*Units*	2019	2026	2030	2040	2050
Average Annual WAS Production	*lb/mo*	290,000	340,000	360,000	440,000	500,000
Average Annual WAS Production at 1.0%	*MG/mo*	3.44	4.03	4.35	5.24	6.01
Average Annual WAS Production at 2.0%	*MG/mo*	1.72	2.01	2.18	2.62	3.00
Maximum Month WAS Production	*lb/mo*	310,000	360,000	390,000	470,000	540,000
Maximum Month WAS Production at 1.0%	*MG/mo*	3.74	4.35	4.72	5.67	6.51
Maximum Month WAS Production at 2.0%	*MG/mo*	1.87	2.18	2.36	2.84	3.26

Table Notes:

1. WAS production volumes rounded to the nearest 10,000 gallons.
2. WAS production was conservatively estimated based on 1.05 lbs WAS per 1.0 lb influent BOD based on the projected influent BOD values in **Chapter 4**.

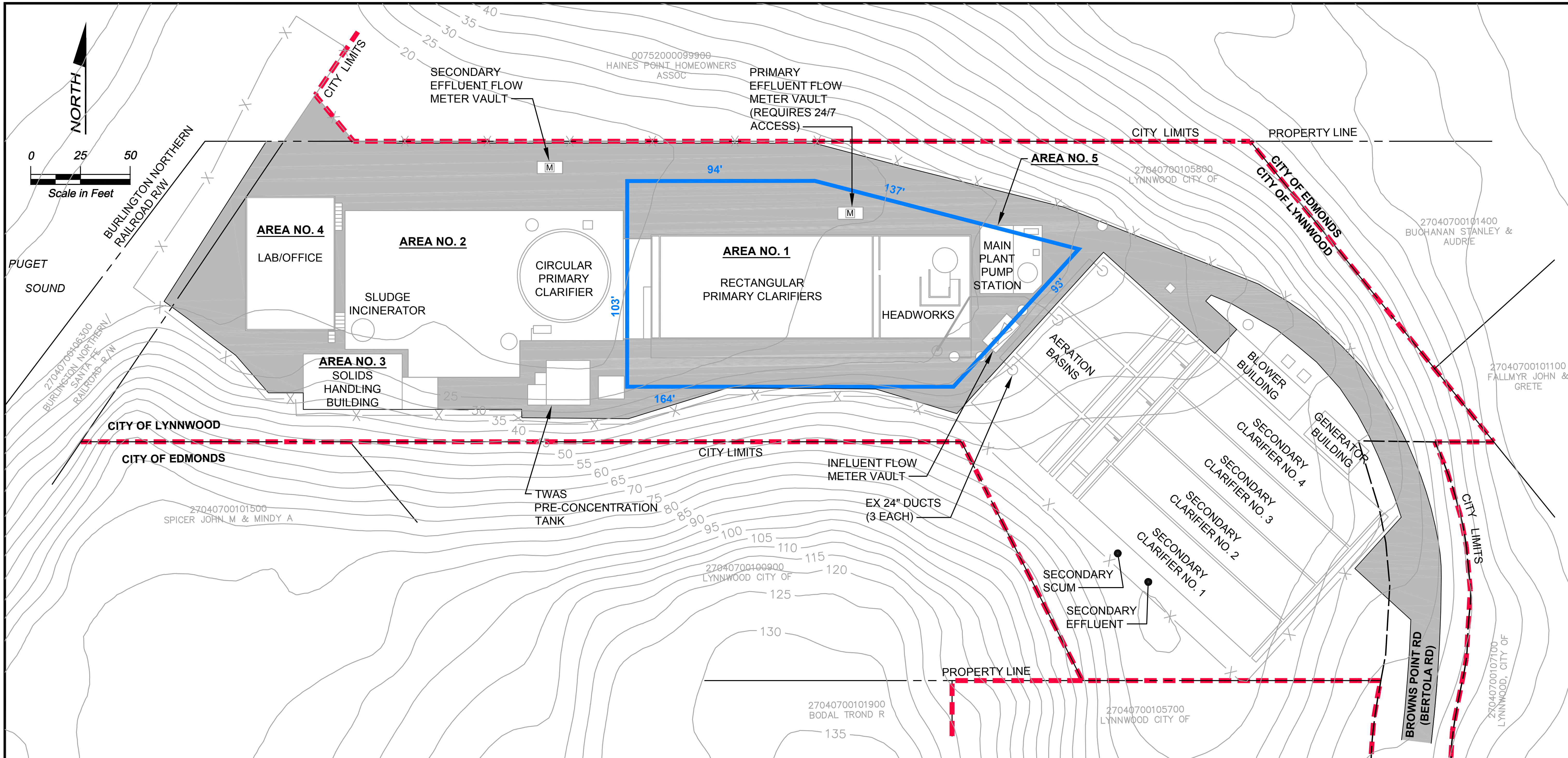
The ability to process the 30-year projected maximum month WAS production at 2 percent at 3.26 million gallons (MG) per month was used as the solids handling process sizing criterion. This equates to 18,100 dry pounds per day (lbs/day), or 108,513 gallons per day of 2-percent WAS. This production rate is conservatively assumed to be 24 hours a day and 7 days a week with the solids handling processes being sized to process the solids with 85 percent uptime (fully operational at full capacity for 310 days per year).

It is assumed that prior to secondary treatment, the liquid stream process will include, at a minimum, influent grit removal and 6 mm screening. Biosolids volatile content was assumed to be 80 percent, with typical being in the 80 to 85 percent range for the liquid stream processes discussed in **Chapter 6**. Given their likely minimal fraction of the solids load, specific load impacts of fats, oils, and grease (FOG) and scum were not included in the **Table 7-1** values. However, FOG and scum impacts on the operation and maintenance of the solids handling process were considered.

7.4 EXISTING WWTP SITE

The existing WWTP site is very constrained site as described in **Chapter 5**. It is only accessible via a steep and narrow access road (Bertola Road) through a single-family residential neighborhood. The current site does not offer easy turnaround access for large vehicles, including trucks and trailers for hauling of materials, biosolids, and chemicals. The existing site plan is shown in **Figure 7-1**.

The blue outline in **Figure 7-1** demarcates the footprint assigned to the future solids handling process. This area overlaps existing WWTP Area No. 1, which includes the in-plant pump station, the headworks, and the rectangular primary clarifiers. At the time of the evaluation herein, this area was identified for locating the solids handling process as it allows for the construction of sequencing of the liquid stream improvements described in **Chapter 6** while keeping the SSI in operation. The solids handling footprint also accounts for emergency vehicle access lanes to be maintained to the SSI building (Area No. 2) and the effluent disinfection/lab and office building (Area No. 4). The blue outline area is likely to change in shape and possibly location as the liquid stream and solids handling processes are defined in more detail.



LEGEND

SITE BOUNDARY	(red dashed line)
PROPOSED FOOTPRINT	(blue line)

Map Source:

This drawing was created from a variety of record drawing and site visit information.

bhc CONSULTANTS

Solids Processing Site Plan

Lynnwood Facility Plan

June 2022

Figure **7-1**

7.5 STAGE 1 EVALUATION CRITERIA

The City considered multiple criteria for the evaluation of solids handling processes and ultimately settled on 11 criteria that were then weighted based on relevance to the City's long-term objectives and the WWTP's site constraints. The criteria fall into two main categories: quantitative and qualitative. Quantitative criteria were based on specific numeric information that could be scored directly. Qualitative criteria were either pass/fail or were intended to capture a comparative overall assessment of the alternative evaluated. Lastly, these criteria were applied holistically to each alternative evaluated for replacing the entirety of the solids handling process and were not applied to individual processes and sub processes within each alternative. The 11 criteria used for the evaluation herein, and associated weight in parentheses, are as follows:

- Technology Capital Cost (15 Percent)
- Footprint (15 Percent)
- Nutrient Side Stream (10 Percent)
- Truck Traffic (10 Percent)
- Technology 30-year O&M Cost (10 Percent)
- Regulatory (10 Percent)
- Proven Technology (10 Percent)
- Staffing (5 Percent)
- Process Complexity (5 Percent)
- Carbon Dioxide (CO_2) Generation (5 Percent)
- Total Energy Use (5 Percent)

7.5.1 Stage I Criteria Definition

This section describes each alternatives evaluation criterion, its basis, and how its scoring was applied to each alternative. Criteria were evaluated based on a score from 1 to 5 with a score of 5 being the best and a score of 1 being the worst. The criteria were qualitative and quantitative with the difference between the two being that for the quantitative criteria, manufacturers were required to provide specific and detailed numerical information that could be compared by linearly interpolating between the alternatives to receive a calculated score and rank. Conversely, qualitative criteria were evaluated on the same scale, but with scores either being pass (5) or fail (1) or being attributed based on best engineering judgement and/or indirect numerical values provided by the manufacturers. The 11 evaluation criteria selected by the City are described in detail as follows.

Technology Capital Costs (15 Percent). This quantitative criterion includes the total average capital cost for each alternative's technology (i.e., equipment packages), including sub-processes. The average capital cost for each unit process technology within the solids handling alternatives were added together for the total average technology capital cost for each alternative. This capital cost is for equipment only and does not include the capital costs associated with facilities designed to house the equipment, power supply, utilities, structures, etc. The technology capital costs assume construction in 2021. The lower the capital costs, the higher the score.

Footprint (15 Percent). This quantitative criterion was used to determine whether alternatives were to fit within the highlighted area in **Figure 7-1**. Alternatives were assigned a score of 1 if they did not fit within the footprint, and a score of 5 if they did fit. This criterion was either a pass (5) or a fail (1). Layouts for each alternative were based on single-story facilities and were conservatively sized based on the largest footprint required by manufacturers for each unit process of each alternative. For smaller equipment, including pumps, thickeners, and dewatering equipment, a minimum of 3 feet of spacing between equipment was used to determine the necessary footprint.

Nutrient Side Stream (10 Percent). This qualitative criterion was used to compare the alternatives based on each alternative's potential for return of nutrients in side stream flows to the plant headworks. This criterion was included as significant nutrient loads returned to the headworks will negatively affect the liquid stream process(es) described in **Chapter 6**, thus increasing capital and O&M costs outside of the solids handling process. Alternatives were assigned a score of 5 if they produce side stream flows with low nutrient content (i.e., no side stream nutrient removal would be required) and a score of 1 if side stream flows contain high levels of nutrients (i.e., side stream nutrient removal would be required).

Truck Traffic (10 Percent). This quantitative criterion was defined as the number of trucks per week needed for biosolids disposal assuming a truck capacity of 25 wet tons of biosolids. Given the constrained and steep access to the site via a residential neighborhood, truck access to the site has been a consistent operational and cost risk to the City. Often, under poor weather conditions, trucks are unable to access the site, limiting WWTP operations. Therefore, minimizing the amount of truck traffic to the site is one of the City's primary concerns. This criterion does not account for other truck traffic associated with WWTP operations (i.e., chemical deliveries, equipment delivery, etc.). As part of the evaluation, each technology was required to submit an estimated biosolids production in dry pounds per day. These values were converted to wet tons per week assuming 24 hours, 7 days a week operation and 85 percent uptime. The lower the number of trucks, the higher the score.

Technology 30-Year O&M Costs (10 Percent). This quantitative criterion included the 2021 value of the average 30-year technology only O&M costs assuming an effective 3-percent annual interest rate. The average annual O&M costs for each unit process within the solids handling alternatives were added together for the total average technology O&M cost for each alternative. O&M costs include electricity, natural gas, chemicals, staffing, and an annual maintenance cost. The annual maintenance cost is equal to 2 percent of the initial capital investment. The 30-year O&M costs do not include equipment replacement costs. The lower the O&M costs, the higher the score.

Regulatory (10 Percent). This qualitative criterion was used to assess the solids handling alternatives ease of permitting. The U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) have strict guidance for biosolids disposal, while the Puget Sound Clean Air Agency (PSCAA) administers air emissions. Each alternative was evaluated based on permitting feasibility and ease. Alternatives were assigned a score from 1 to 5 based on the number of permit requirements and difficulty in obtaining permits, with a score of 1 being attributed to solids handling processes that will require complex permitting efforts and a score of 5 being attributed to the alternatives for which a streamlined permitting process is anticipated.

Proven Technology (10 Percent). This qualitative criterion was based on the number of installations of a technology and its history of use in the wastewater industry in the United States. Each manufacturer was required to submit a reference list for installations within the United States. A score of 1 indicates a low number of installations and/or minimal application in the industry and a score of a 5 indicates a high number of installations with a long track record in the industry.

Staffing (5 Percent). This quantitative criterion was used to compare the alternatives based on the estimated number of full-time employees (FTEs) needed to operate and maintain the solids handling system for each alternative. Staffing levels were based on a combination of engineering judgement, typical staffing needs for established processes, and manufacturer input. Each manufacturer was required to provide a staffing needs estimate using FTEs as a basis. The lower the number of FTEs required, the higher the score.

Process Complexity (5 Percent). This qualitative criterion was used to gauge the overall process complexity of each alternative based on the alternative's need for subprocesses or subsystems necessary to support the solids handling process. The more complex the process requirements are, the lower the score.

CO_2 Generation (5 Percent). This qualitative criterion was based on the annual natural gas consumption and the annual truck traffic for each alternative as indirect indicators of CO_2 generation. There are several other sources of CO_2 for each alternative; however, truck traffic and natural gas consumption are likely to be the two primary sources of CO_2 emissions. Detailed calculated projections and modeling of CO_2 emissions were not performed given the preliminary nature of technology information available at the time of preparation of this Plan. Furthermore, electrical power consumption was not included as electricity generation in the Puget Sound region is generally a low carbon process, and carbon emissions from electricity production are expected to fall in the future. The lower truck traffic and natural gas consumption, the higher the score.

Total Energy Use (5 Percent). This quantitative criterion was based on the total energy use of each alternative, measured in kilowatts. Energy use was calculated based on average kilowatt-hours (kWh) per year for electricity and converting the estimated natural gas use from million BTU per hour to kWh using a conversion factor of 293.07 kWh per million BTU. The lower the total average annual energy use, the higher the score.

7.6 TECHNOLOGY CAPITAL COST AND LIFE-CYCLE COSTS BASIS

All costs developed for evaluation of alternatives are in 2021 dollars. The capital costs reflect a Class 5 opinion of probable cost (applicable for 0 to 2 percent design) as defined by the American Association of Cost Engineers (AACE) and have an expected accuracy range of -50 percent to +100 percent. Capital costs were developed using pricing from vendor quotes, comparison to construction cost data for similar project work, and RS Means online construction cost data. The costs presented herein represent technology costs for the purpose of comparison and only include the costs for major equipment. Where the technology requires the construction of a separate structure, such as a tank, the costs were included. The assumptions made for such non-equipment costs were $2.50 per gallon for concrete tank construction (includes excavation, formwork, materials, and labor); $105 per square foot (sf) for aluminum tank covers (material only); and

$1,000 per cubic yard (CY) for structural concrete (includes excavation, formwork, materials, and labor).

The following costs are excluded from the evaluation herein:

- Engineering, planning, and permitting.
- Engineering services during construction and construction management.
- Mobilization, demobilization, temporary facilities, startup, and testing.
- Bonds and insurance.
- Contractor overhead and profit.
- Contingency.
- Sales tax.
- Process piping, ducting, valves, and utilities.
- Materials and labor for proposed building(s).
- Civil site work, including demolition and grading.

Annual O&M costs were based on the average annual labor to operate and monitor the process improvements, utilities, chemicals, and equipment part replacement. The annual O&M costs were converted to a 30-year net present value in 2021 dollars based on an assumed interest rate of 5 percent and inflation rate of 2 percent, for an effective annual interest rate of 3 percent. Life-cycle cost was calculated as the sum of the 30-year O&M cost and the technology capital cost, both in 2021 dollars. The following assumptions were used to develop the O&M costs:

- Labor rate of $50 per hour.
- Electricity rate of $0.086 per kWh.
- Natural gas rate of $1.00 per therm.
- Maintenance cost at 2 percent per year of the equipment purchase price.
- Emulsion polymer cost of $2.50 per pound.
- 12.5-percent liquid sodium hypochlorite solution cost of $0.50 per gallon.
- 93-percent sulfuric acid cost of $8.00 per gallon.
- 50-percent sodium hydroxide cost of $3.00 per gallon.
- Biosolids disposal cost of $85.00 per wet ton.

The opinions of probable cost herein are based on the perception of current conditions at the project location. These opinions reflect professional opinion of costs at the time this Plan was prepared and are subject to change as the project design progresses. The Engineer has no control over variances in the cost of labor, materials, equipment, and services provided by others, or contractor’s means and methods of executing the work or of determining prices bidding or market conditions, practices, and bidding strategies. As a result, actual construction costs may vary from the costs presented herein.

7.7 STAGE I EVALUATION

Stage I of the evaluation included reviewing all available solids handling technologies that could meet the future capacity demands and might conceivably fit within the site boundaries. The Stage I evaluation was intended as an initial screen designed to cast the widest net without eliminating potentially suitable technologies and/or processes. As a result, the following five alternatives for the solids handling process were developed:

- Alternative 1 – Enhanced Anaerobic Digestion
- Alternative 2 – Vapor Recompression Drying
- Alternative 3 – Gasification
- Alternative 4 – Heat Drying
- Alternative 5 – Autothermal Thermophilic Aerobic Digestion

7.7.1 Shared Unit Processes

Each solids handling process alternative was developed around the above technology types, yet the alternatives shared several common unit processes. Given that these shared unit processes were identical in type and sizing for each alternative, they are described separately in the following sections.

7.7.1.1 WAS EQUALIZATION

To build in operational flexibility while equalizing varying WAS production, WAS equalization tankage was included as the first unit process shared among all solids handling alternatives. This tankage would normally provide equalization of WAS but also could be used to provide emergency aerobic storage of WAS during an outage of any downstream solids handling processes. Sizing the tankage for the emergency storage condition is more conservative than sizing for WAS equalization, and as such, storage of the 2050 peak week assuming a thickened WAS solids concentration of 4 percent (**Section 7.7.1.2**) was used for sizing the tank. As a result, the tankage required is a 45-foot-diameter tank with a 35-foot side water depth (SWD) and 5 feet of freeboard. For Alternative 5, the required tank diameter is 35 feet with a 35-foot SWD and 5 feet of freeboard. The tank is assumed to be a cast-in-place circular concrete tank with a cone bottom and an aluminum cover to retain heat, contain odor, and allow for a connection to the odor control system. During the infrequent scenario in which the tankage is used for emergency aerobic storage of WAS, some aerobic digestion of sludge is likely; however, this reduction in solids was not considered to be conservative for the sizing of downstream facilities and equipment. Two main tank configurations were considered as follows:

- **Option A – Mechanical mixing/aeration in a concrete tank**. This alternative includes the space-saving Landia AirJet system that relies on a pair of externally mounted centrifugal pumps equipped with venturi injection nozzles that entrain air in the hydraulically mixed contents of the tank. This system requires minimal footprint and no equipment (other than the nozzles and associated piping) within the tank; therefore, the tank does not need to be taken out of service to maintain the mixing system.

- **Option B – Aeration blowers with diffusers in a concrete tank**. This alternative includes the installation of aeration blowers supplying air to a network of coarse bubble diffusers installed on the floor of the concrete tank. This alternative will require an additional footprint to house the blowers, blower electrical/controls, and low-pressure air piping. This alternative also will require the periodic replacement of diffusers, which will require the tank to be taken out of service.

A summary of these two alternatives is provided in **Table 7-2**.

Table 7-2. WAS Equalization Tank Alternatives

	Option A	Option B
Uptime	85%	85%
Annual Operating Hours	7,450	7,450
Airflow Requirement (scfm)	0	1,665
Total Motor HP	40	150
Electricity Use (kW)	29.8	111.9
Annual Electricity Use (kWh)	222,222	833,333
Staffing Requirement (FTEs)	0.0125	0.0125
Footprint (sf)	2,376	2,563
Total 2021 Technology Capital Cost (rounded to $10,000)	$1,420,000	$1,550,000
2021 O&M Cost (rounded to $10,000)	$20,000	$80,000
30-Year O&M (2021 dollars, rounded to $100,000)	$400,000	$1,600,000
30-Year Life-Cycle Cost (2021 dollars, rounded to $100,000)	**$1,800,000**	**$3,200,000**

Both alternatives considered can be installed with a metal tank system, in place of a concrete tank, which will reduce the capital costs listed in **Table 7-2**. The reduced tank requirements associated with Alternative 5 will decrease the 30-year life-cycle cost (LCC) of Option A and B by $0.9M and $1.8M, respectively. Option A was selected as the basis for the evaluation herein given its relative simplicity, its significantly lower LCC, its compact footprint, and the ability to fully maintain the system without having to empty the storage tank. Based on this selection, the total 30-year LCC associated with the WAS equalization process is $1.8M.

7.7.1.2 THICKENING

Thickening is used to thicken the WAS and reduce the sludge volume and flow rate handled in downstream processes. Thickening reduces the necessary sizes of equipment and improves sludge dewaterability. It should be noted that gravity thickening of WAS to 1 to 2 percent concentration is considered in various liquid stream alternatives, which is separate from the mechanical thickening discussed in this section. Paired with the WAS equalization tank, each solids handling alternative includes mechanical thickening to increase the WAS concentration from 2 percent to a conservatively estimated 4 percent. Thickening equipment was conservatively sized to accommodate 1-percent WAS (**Table 7-1**) as an additional conservative measure to protect against possible liquid stream process upsets and/or changes in WAS concentration. It is possible that the thickened WAS concentration could be as high as 6 percent, but 4 percent was used because it is typically achievable with WAS only sludge with most thickening technologies regardless of the sludge characteristics. Increased solids content in the WAS equalization tank will increase mixing requirements for the tank, but these are offset by the savings in the reduced footprint of the overall process.

Thickening can be achieved either as an in-line or as a recuperative process. In-line thickening includes a direct feed to the thickener that delivers thickened sludge directly to the WAS equalization tank. Recuperative thickening includes a recycle loop between the thickener and the tank, the volume of which is used to buffer fluctuations in the WAS solids concentrations. Recuperative thickening offers more operational flexibility and, once the tank has achieved the desired %WAS, it only needs to be operated as needed to bring the solids concentration back up to the desired range (4 percent). The thickening process will be connected to odor control for foul air evacuation from the equipment and thickening room.

The evaluation herein considered disk (Huber), rotary drum (Andritz), rotary screen (FKC), and centrifuge (Centrisys) thickening systems. The three former options typically require an estimated 10 pounds of polymer per dry ton of solids, while centrifuge thickeners typically require an estimated 0.5 pounds per ton. A comparison and summary of the thickening options considered is presented in **Table 7-3**.

Table 7-3. Thickening Alternatives

Type	Disk	Rotary Drum	Rotary Screen	Centrifuge
Uptime	85%	85%	85%	85.0%
Operating Hours per Year	7,450	7,450	7,450	7,450
Manufacturer Provided Polymer Dose	5 - 10	8 - 12	< 15	0 - 0.5
Polymer Dose (lb/ton)	10	10	10	0.5
Annual Polymer Use (lb)	33,055	33,055	33,055	1,653
Total Motor HP	6.50	7	10	64
Electricity Use (kW)	4.8	4.8	7.5	12.4
Annual Electricity Use (kWh)	36,111	22,222	55,556	92,146
Thickened Solids Concentration (%)	4 – 6	4	4 – 6	4
Estimated Solids Capture (%)	95	95	90+	90 - 95
Staffing Requirement (FTEs)	0.0125	0.0125	0.0125	0.0125
Footprint (sf)	1,050	900	1,050	625
Total 2021 Technology Capital Cost (rounded to $10,000)	$640,000	$380,000	$420,000	$1,390,000
2021 Annual O&M Cost (rounded to $10,000)	$100,000	$90,000	$100,000	$40,000
30-Year O&M (2021 dollars, rounded to $100,000)	$2,000,000	$1,800,000	$2,000,000	$800,000
30-Year Life-Cycle Cost (2021 dollars, rounded to $100,000)	**$2,600,000**	**$2,200,000**	**$2,400,000**	**$2,200,000**

The thickening process will consist of fully redundant equipment with two thickeners, two flocculation tanks, two feed pumps, two discharge pumps, and two polymer make down units. The thickening process will be connected to odor control for foul air evacuation from the thickening equipment and thickening room.

Technology capital costs for thickening range from $380,000 to $1,390,000, with the rotary drum thickener being the lowest capital cost option. The 30-year O&M costs range from $0.8M to $2.0M, with centrifuge thickening having the lowest O&M costs, primarily due to low polymer demand. Despite the variance in capital and O&M costs over 30 years, the 30-year LCC range was tight at $2.2M to $2.6M. Rotary screen thickening was selected as the basis of this evaluation due to its more conservative life-cycle cost and because of the City's familiarity with the rotary screen manufacturer. Based on this selection, the total 30-year LCC associated with the shared thickening unit process is $2.4M.

7.7.1.3 DEWATERING

Each alternative, except for Alternatives 2, will require a dewatering process. Dewatering is the process by which excess water from the thickened sludge is removed by mechanical means, resulting in the production of dewatered sludge (DS) that can be further processed for additional volume reduction. Three dewatering technologies were considered: screw press (FKC), rotary press (Fournier), and centrifuge (Centrisys). Screw press and rotary press use an estimated 25 pounds of polymer per ton of sludge and can produce an estimated 15-percent DS concentration processing WAS only, and an estimated 20 percent with a sludge that has been digested. Centrifuges typically require an estimated 20 pounds of polymer per ton and can produce 20-percent DS processing WAS only. A summary of the dewatering technologies evaluated is provided in **Table 7-4**.

Table 7-4. Dewatering Alternatives

Type	Rotary Press	Screw Press	Centrifuge
Equipment Capacity (dry lbs/day)	20,880	18,100	35,640
Uptime	85.0%	85.0%	85.0%
Annual Operating Hours	7,451	7,451	4,452
Manufacturer Provided Polymer Dose	10 - 12	< 30	18 - 22
Polymer Dose (lb/ton)	25	25	20
Annual Polymer Use (lb)	82,638	82,638	66,110
Total Motor HP	32	7.5	50
Electricity Use (kW)	2.6	5.6	14
Annual Electricity Use (kWh)	23,139	41,673	126,148
Dewatered Solids % Range from Manufacturer	15 - 16	16 - 20	17 - 20
Dewatered Solids % Used in Analysis	15.5	18.0	18.5
Estimated Solids Capture (%)	96	92+	90 - 95
Staffing Requirement (FTEs)	0.025	0.025	0.025
Footprint (sf)	1,400	1,375	500
Total 2021 Technology Capital Cost (rounded to $10,000)	$800,000	$910,000	$870,000
2021 Annual O&M Cost (rounded to $10,000)	$230,000	$230,000	$200,000
30-Year O&M (2021 dollars, rounded to $100,000)	$4,500,000	$4,500,000	$3,900,000
30-Year Life-Cycle Cost (2021 dollars, rounded to $100,000)	**$5,300,000**	**$5,400,000**	**$4,800,000**

Screw press dewatering was selected as the basis of this evaluation due to the City's familiarity with the equipment that is currently installed at the WWTP. The dewatering process will consist of two fully redundant screw presses, feed pumps, flocculation tanks, and polymer make down units. The dewatering process will be connected to odor control for foul air evacuation from the dewatering equipment, conveyors, and dewatering room.

Capital costs for dewatering are in a relatively close range from $800,000 to $910,000, with the rotary press being the lowest capital cost option. The 30-year O&M costs range from $3.9M to $4.5M with centrifuge having the lowest O&M costs, primarily due to low polymer demand. The 30-year LCC range ranges from $4.8M to $5.4M. Screw press dewatering was selected as the basis of this evaluation due to its more conservative life-cycle cost and because of the City's familiarity with the equipment and matching existing equipment. Screw press dewatering is the most conservative approach as a DS concentration of 15 percent requires downstream equipment to be sized for the worst-case sludge dewaterability, making downstream processes more conservatively sized. Based on this selection, the total 30-year LCC associated with the shared dewatering unit process is $5.4M.

7.7.1.4 DEWATERED SLUDGE STORAGE

Downstream of the dewatering process, DS must be stored and mixed to attenuate solids production peaks and give the process the ability to dewater while downstream processes are temporarily offline for maintenance. Given the simplicity of this unit process and the lack of significant differences among manufacturers and types of storage, multiple options were not considered. The DS storage process assumed for the evaluation herein includes a 53 CY live-bottom hopper, discharge screw, and one DS piston pump sitting below the hopper. The DS pump will discharge DS either to the downstream processes as required or to a truck/trailer for off-site disposal. At 15-percent solids, the hopper provides 1.3 days of storage. Schwing Bioset was used as the basis for the evaluation herein, with an estimated 2021 capital cost of $610,000. The annual 2021 O&M cost was estimated at $20,000, which equates to a 30-year O&M cost of $400,000 in 2021 dollars. The 30-year life-cycle cost is $1,000,000.

7.7.1.5 SOLIDS HANDLING PROCESS ODOR CONTROL

Odor control is an important aspect of solids handling, especially due to the residential setting of the WWTP. Each alternative is expected to produce typical foul odors. It is assumed that two-stage chemical scrubbing followed by activated carbon is used for odor control as it is considered the best available control technology (BACT) by PSCAA; therefore, it will be the easiest to permit. An air discharge permit will be required for odor control emissions. Two-stage chemical scrubbing uses sulfuric acid to remove odorous compounds in the first stage, and sodium hydroxide and hypochlorite in the second stage. Activated carbon acts as a final polishing step, absorbing any remaining odorous compounds to ensure that the WWTP minimizes its odor output. The summary of estimated odor control costs and footprints is presented in **Table 7-5**.

Table 7-5. Odor Control Cost and Footprint Estimates

Airflow Rate	Two-Stage Chemical Scrubber Cost	Two-Stage Chemical Scrubber Footprint	Activated Carbon Polishing Cost	Activated Carbon Polishing Footprint
0 – 10,000 scfm	$35 - $65 per scfm	3’ – 6’ diameter vessels	$25 - $30 per scfm	3’ – 14’ diameter vessel
10,000 – 20,000 scfm	$25 - $35 per scfm	5’ – 10’ diameter vessels	$15 - $20 per scfm	12’ – 14’ vessels
20,000+ scfm	$20 - $25 per scfm	8’ – 14’ diameter vessels	$10 - $15 per scfm	Varies

The high end of the ranges in **Table 7-5** for both cost and footprint were utilized to be conservative. Costs and footprint information are based on 2021 input from BioAir Solutions, which based the provided information on its extensive installation base across the United States.

The five alternatives varied in their range of airflow rates, but all fell within the 10,000 to 20,000 standard cubic feet per minute (scfm) range, except for heat drying which varied from 12,000 to 27,000 scfm. Specific estimates for each alternative are provided in the respective alternatives’ sections. Chemical use for odor control is expected to be significant, with unit costs described in **Section 7.6**. The following chemical consumptions were used based on similarly sized facilities in the region:

- 93-percent sulfuric acid at 0.5 gallons per year per scfm.
- 50-percent sodium hydroxide at 0.5 gallons per year per scfm.
- 12.5-percent sodium hypochlorite at 10.0 gallons per year per scfm.

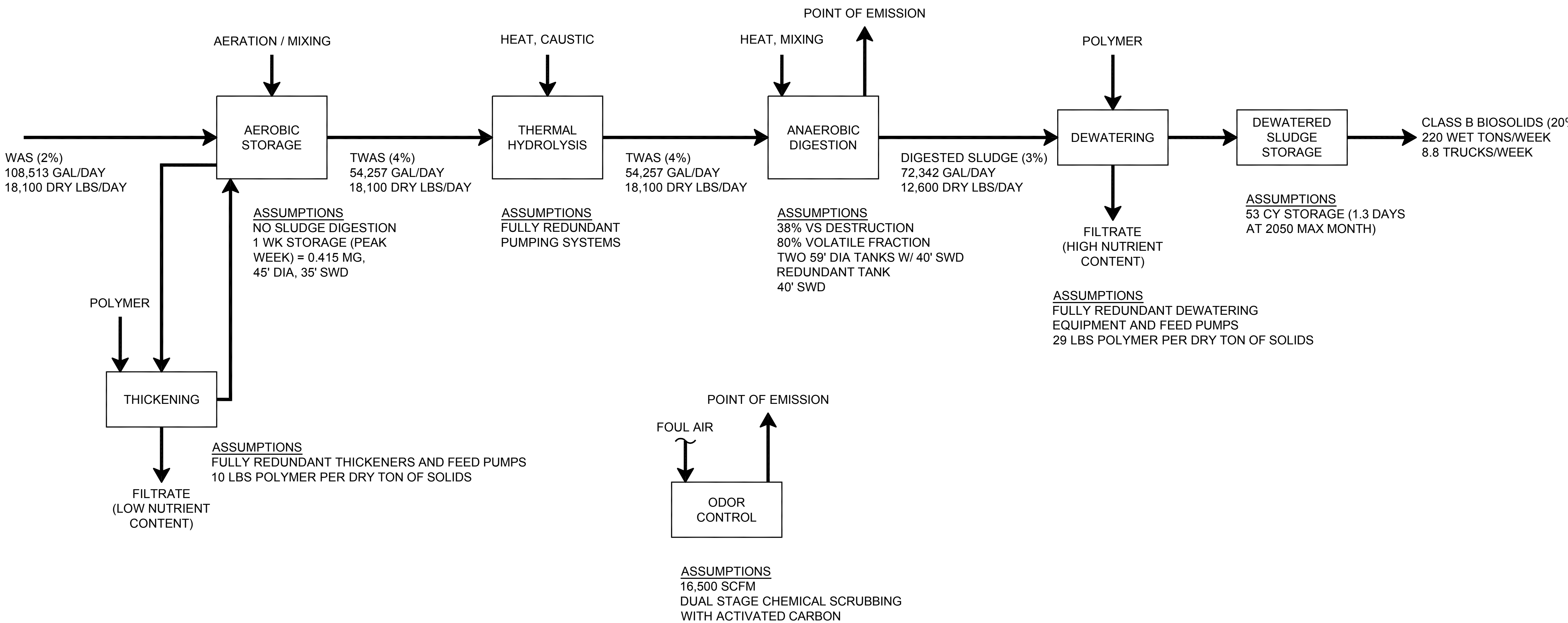
The size of the odor control system will vary between each alternative, but is assumed to be consistent with respect to the shared unit processes discussed in **Section 7.7.1**. The WAS equalization tank will produce an estimated 6,500 scfm of foul air with an additional 5,000 scfm included to account for ancillary sources of foul air, including thickening equipment, dewatering equipment, DS storage, and DS conveyance. The total foul air rate of ancillary sources is estimated at 11,500 scfm. O&M and capital costs associated with odor control, odor control chemicals, and odor control chemical storage are included in the technology costs for each of the five alternatives evaluated.

7.7.2 Alternative 1 – Enhanced Anaerobic Digestion

Anaerobic digestion is a commonly used solids stabilization process that produces Class B biosolids. Mesophilic microorganisms thrive in the sludge, which is typically heated to 35 degrees Celsius, and break down organic matter converting it to biogas. Biogas typically contains approximately 65-percent methane, 35-percent carbon dioxide, and traces of hydrogen gas and hydrogen sulfide. Biogas can be scrubbed to remove water vapor and hydrogen sulfide, with the resultant gas burned to provide heat to maintain digester temperature. In some instances, biogas is used to produce both heat and electricity through combined heat and power (CHP); however, CHP was not considered in this analysis as life-cycle costs are generally unfavorable in the Pacific Northwest due to relatively low electricity prices. Anaerobic digestion traditionally receives primary sludge and waste activated sludge. Primary sludge is typically more digestible as the raw organic material present has not yet been converted to microorganisms. WAS is more difficult to digest, as it consists largely of living microorganisms that are more difficult to break down. The recommended liquid stream improvements in **Chapter 6** do not utilize primary clarification, thus primary sludge is not available as a substrate for the anaerobic digestion process, eliminating the potential of traditional anaerobic digestion.

Enhanced anaerobic digestion relies on hydrolysis to lyse the microbial cellular structures and enhance the biodegradable carbon content of the WAS. The hydrolysis process works by applying heat and/or chemicals to the WAS to break open the cells. The basis of this evaluation is the CNP Pondus process, which uses both heat and sodium hydroxide to hydrolyze WAS using chemical thermal hydrolysis. The addition of sodium hydroxide reduces the amount of heat required for hydrolysis. Hydrolysis processes have the added benefit of reducing digester foaming. The schematic process flow diagram for Alternative 1 is shown in **Figure 7-2**, with a site layout shown in **Figure 7-3**.

WAS is pumped to the WAS equalization tank (45-foot diameter, hydraulically mixed/aerated) from the liquid stream process(es). Recuperative thickening (rotary screen) is used to maintain a solids concentration of 4 percent in tank. The 4-percent WAS is transferred to the chemical thermal hydrolysis process, where caustic and heat are added to increase WAS digestibility. From chemical thermal hydrolysis, hydrolyzed WAS is then pumped to two anaerobic digesters. Biogas produced is sent to a boiler to heat the digesters and the chemical thermal hydrolysis process using heat exchangers. Excess biogas is sent to a flare. The flare and boiler are both considered points of emission, but due to the small size (less than 10 Metric Million British Thermal Units per hour (MMBTU/hr)), significant air permitting will likely not be required. Digested sludge is then dewatered (screw press) to produce a Class B biosolid at a minimum 20-percent solids content, which is feasible with any of the dewatering technologies discussed in **Section 7.7.1**. Digested sludge is expected to be more dewaterable than undigested WAS, improving the DS solids content from 15 percent to an estimated 20 percent with screw presses. Enhanced anaerobic digestion includes connections to the solids handling odor control system; 5,000 scfm was assumed for the digester support equipment in addition to the odor control connections to ancillary equipment.



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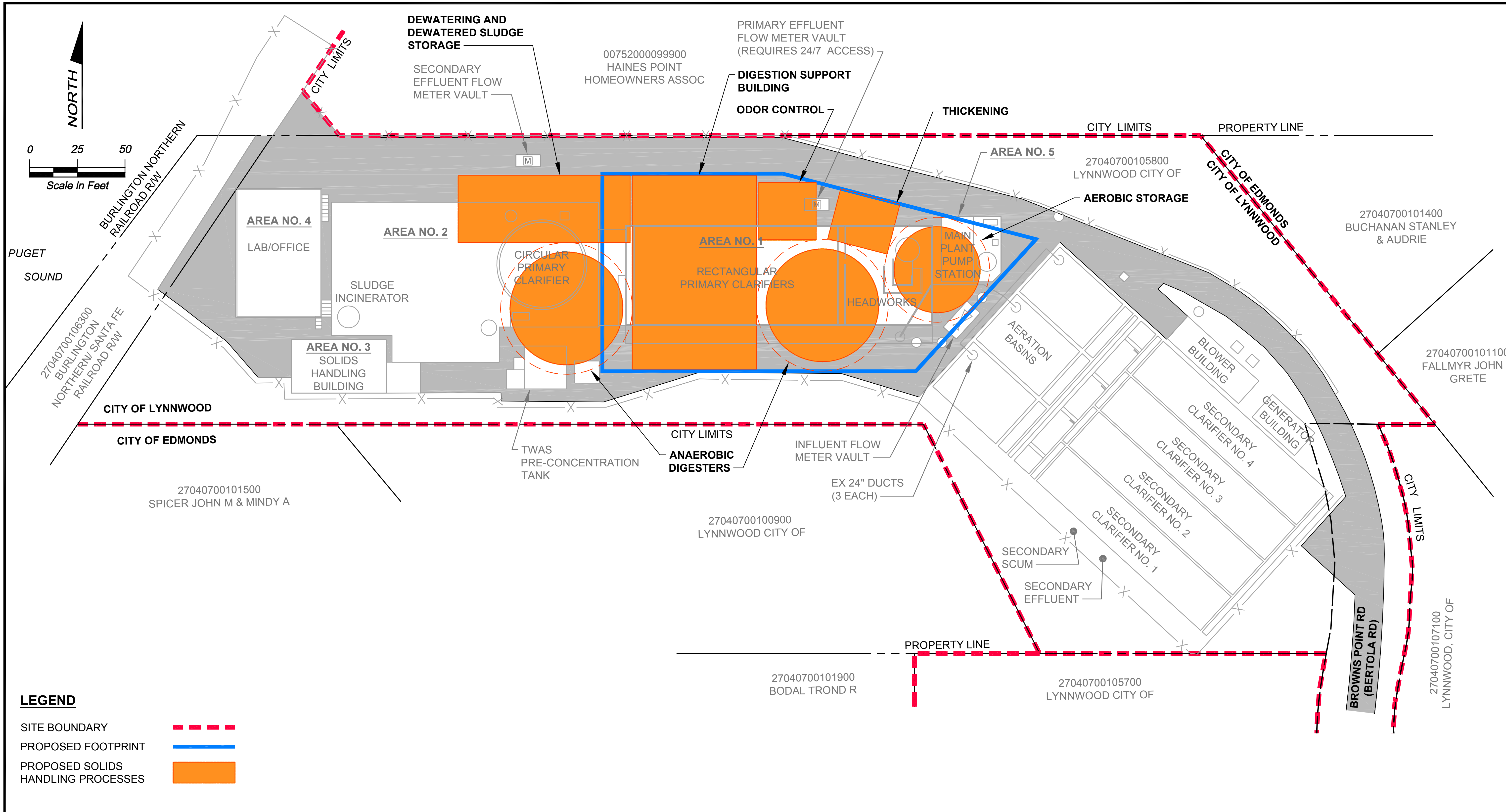
Enhanced Anaerobic Digestion Schematic, Alternative 1

Lynnwood Facility Plan

June 2022

Figure **7-2**



Map Source:

This drawing was created from a variety of record drawing and site visit information.

Enhanced Anaerobic Digestion Layout, Alternative 1
Lynnwood Facility Plan
June 2022

Figure 7-3

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Alternative 1 includes two fully redundant digesters, which are assumed to operate with a 100 percent uptime due to the difficulty of stopping and starting the process. The digesters are assumed to be cast-in-place concrete 60-foot-diameter digesters with a cone bottom and a 40-foot SWD, resulting in a solids retention time (SRT) of 15 days at 2050 maximum month WAS production. Each digester includes a dual membrane cover for biogas collection with the associated gas collection and gas safety piping and equipment. The digesters are assumed to be mixed hydraulically. A digester support building, preliminarily sized at 6,175 square feet (sf), is included to house mixing pumps, recirculation pumps, chemical thermal hydrolysis equipment, heat exchangers, boilers, and gas safety equipment. In addition to the digester support building, structures will be required to house the thickening process, the odor control system, and the dewatering/sludge storage. Such structures and buildings are not included in the costs provided herein. **Figure 7-3** illustrates the proposed layout of the major equipment and structures associated with enhanced anaerobic digestion. All tanks, including anaerobic digesters and WAS equalization, are shown with a 5-foot buffer around the tanks to account for additional clearances and tank appurtenances. A detailed summary of the design criteria for enhanced anaerobic digestion is shown in **Table 7-6**.

Table 7-6. Enhanced Anaerobic Digestion Technology Summary

Parameter	Value
Uptime	100.0%
Yearly Operating Hours	8,766
Annual Natural Gas Use (therm/yr)	0
Total Motor HP	120
Electricity Use (kW)	108.0
Digester Equipment Annual Electricity Use (kWh)	946,601
Odor Control Annual Electricity Use (kWh)	565,873
Annual Biogas Production (scfm)	45
Annual 50% Sodium Hydroxide Requirement (Pondus) (gal/year)	52,596
Annual 93% Sulfuric Acid Requirement (Odor Control) (gal/year)	7,758
Annual 50% Sodium Hydroxide Requirement (Odor Control) (gal/year)	7,626
Annual 12.5% NaOCl Requirement (Odor Control) (gal/year)	164,363
Foul Air Production (scfm)	16,500
Digested Sludge Concentration (%)	2 - 2.5%
Digested Sludge Flow Rate (gpm)	38
Digested Sludge Loading (lbs/hr)	633 - 792
Staffing Requirement (FTEs)	2
Footprint (sf)	6,175
Sludge Production (dry lbs/day)	12,598
Biosolids Production @ 20% TS (wet tons/week)	220
Trucks per Week	8.82

The cost summary of Alternative 1 is provided in **Table 7-7**.

Table 7-7. Alternative 1 Cost Summary

Parameter	Cost
Total 2021 Technology Capital Cost (rounded to $10,000) [2]	**$15,140,000**
2021 Enhanced Anaerobic Digestion Technology Capital Cost (rounded to $10,000)	$10,870,000
Hydrolysis Equipment (rounded to $1,000)	$2,220,000
Concrete Tankage (rounded to $1,000)	$4,806,000
Digester Heating Equipment (rounded to $1,000)	$787,000
Digester Mixing Equipment (rounded to $1,000)	$364,000
Digester Covers (rounded to $1,000)	$2,513,000
Gas Storage/Safety Equipment (rounded to $1,000)	$178,000
2021 Odor Control Equipment (rounded to $10,000)	$910,000
2021 WAS Equalization Capital Cost (rounded to $10,000)	$1,420,000
2021 Thickening Capital Cost (rounded to $10,000)	$420,000
2021 Dewatering Capital Cost (rounded to $10,000)	$910,000
2021 DS Storage Capital Cost (rounded to $10,000)	$610,000
2021 O&M Cost (rounded to $10,000)[2]	**$2,230,000**
2021 Enhanced Anaerobic Digestion Equipment O&M Cost (rounded to $10,000)[1]	$1,630,000
2021 Odor Control O&M Cost (rounded to $10,000)	$230,000
2021 WAS Equalization O&M Cost (rounded to $10,000)	$20,000
2021 Thickening O&M Cost (rounded to $10,000)	$100,000
2021 Dewatering O&M Cost (rounded to $10,000)	$230,000
2021 DS Storage O&M Cost (rounded to $10,000)	$20,000
30-Year O&M (2021 dollars, rounded to $100,000) [3]	**$43,700,000**
30-Year Life-Cycle Cost (2021 dollars, rounded to $100,000) [3]	**$58,800,000**

Notes:
1. Includes biosolids disposal costs.
2. 2021 US Dollars rounded to nearest $10,000.
3. 2021 US Dollars rounded to nearest $100,000.

Costs in **Table 7-7** were developed using the cost criteria and assumptions listed in **Section 7.6** combined with manufacturer proposals/quotes and engineering judgement. Costs were developed in 2021 US Dollars. The technology cost for enhanced anaerobic digestion is $10.9M with an annual O&M cost of $1.6M. When combined with the other processes shown in **Figure 7-2**, the total equipment 2021 capital cost to implement Alternative 1 is $15.1M, with an annual O&M cost of $2.2M, for a 30-year LCC of $58.8M.

7.7.2.1 ALTERNATIVE 1 CRITERIA ASSESSMENT

This section describes how Alternative 1 performed against each criterion and summarizes general advantages and disadvantages of the alternative.

1. **Technology Capital Cost (15 Percent)** – The total technology capital cost for Alternative 1 in 2021 US dollars is estimated at $15.1M. This number is based on WAS equalization in concrete tanks with mechanical mixing and aeration, rotary screen thickening, CNP Pondus thermal hydrolysis, concrete anaerobic digesters, and screw press dewatering.

2. **Footprint (15 Percent)** – Anaerobic digestion requires a significant footprint for tankage and ancillary equipment and does not fit within the allotted footprint (**Figure 7-3**). It is possible that the necessary space could be made available by creating a building with multiple floors, but this will add complexity and cost. Phasing also can be explored where a single digester is constructed and brought online, then the existing incinerator building demolished to make space for the second digester.
3. **Nutrient Side Stream (10 Percent)** – Enhanced anaerobic digestion by its nature produces high quantities of ammonia and soluble phosphate. This nutrient load will largely end up in the dewatering filtrate stream and recycled to the plant headworks. The liquid stream process will need to be able to accommodate this increase in nitrogen loading, or side stream treatment will be necessary.
4. **Truck Traffic (10 Percent)** – Alternative 1 will generate an estimated 8.8 trucks per week of Class B biosolids based on 2050 maximum month sludge production.
5. **Technology 30-Year O&M Cost (10 Percent)** – The 30-year O&M cost in 2021 US dollars is estimated at $43.7M. The highest cost item is sludge disposal, which is due to the high volume and low solids concentration of the final product.
6. **Regulatory (10 Percent)** – The regulatory burden associated with Alternative 1 is expected to be low, with standard PSCAA permits required for odor control, boilers, and flare. The WWTP will likely be covered under the Washington State Biosolids General Permit.
7. **Proven Technology (10 Percent)** – Anaerobic digestion is a commonly used and well proven solids stabilization technology in the wastewater industry. Thermal hydrolysis is a well understood and commonly used process that enhances and stabilizes the biological digestion process.
8. **Staffing (5 Percent)** – An estimated 2.0 full-time employees are needed to operate and maintain all the unit processes associated with enhanced anaerobic digestion.
9. **Process Complexity (5 Percent)** – Multiple subprocesses are needed to support enhanced anaerobic digestion. Biogas handling is complex and requires a significant investment in safety features.
10. **CO_2 Generation (5 Percent)** – Natural gas is typically not needed to support enhanced anaerobic digestion during normal operation. A natural gas connection to the boilers is required for startup and to ensure heating of digesters during process upsets. Such natural gas consumption was not included in the CO_2 generation. Alternative 1 has the highest truck traffic at 8.8 trucks per week, which contribute to Alternative 1's CO_2 generation.
11. **Total Energy Use (5 Percent)** – Enhanced anaerobic digestion has low energy use at an average of 215 kilowatts (kW) due to minimal aeration needs and minimal natural gas demands.

The major advantages of Alternative 1 are:

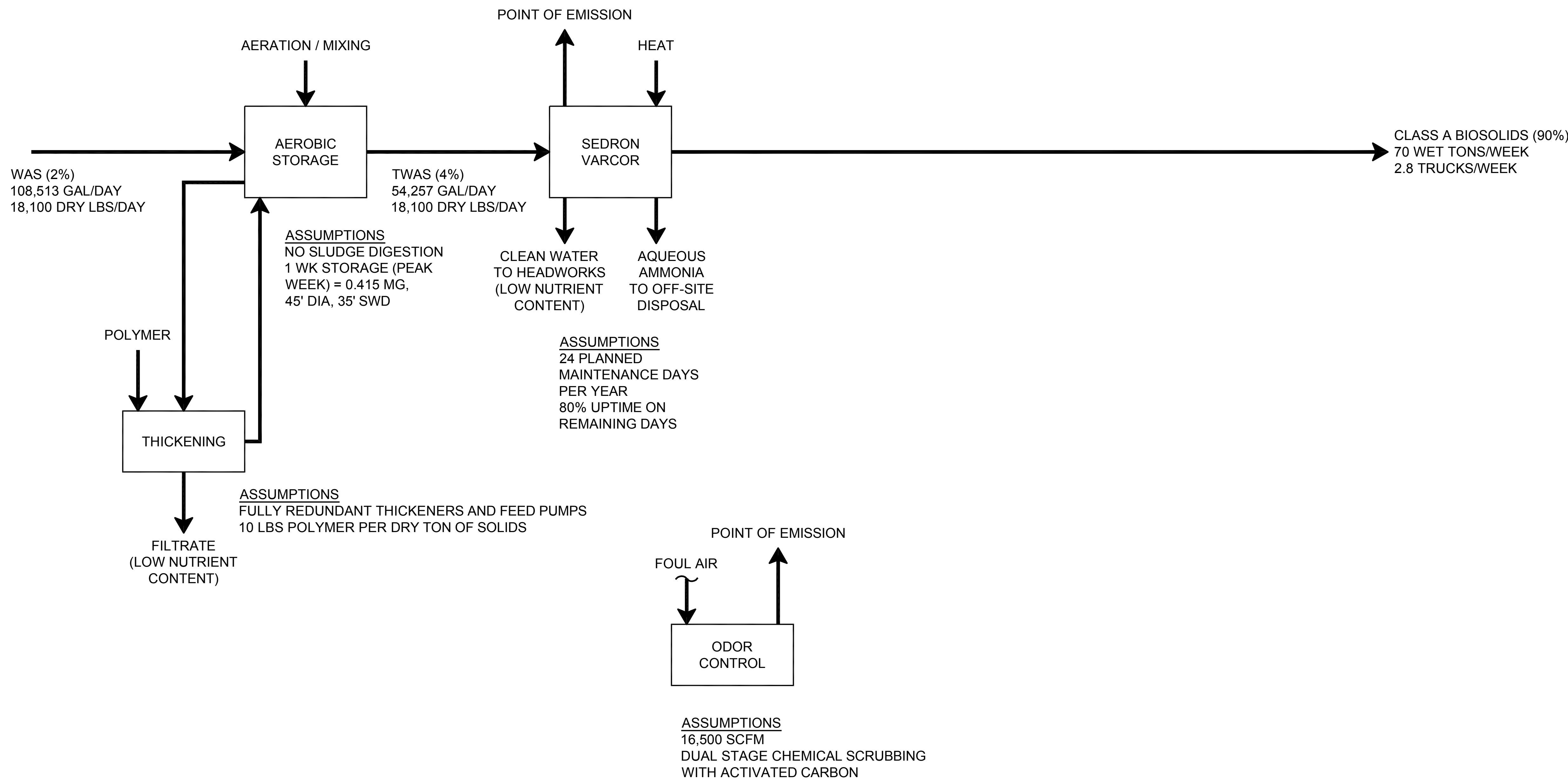
- Proven technology;
- Few regulatory requirements; and
- Low energy use.

The major disadvantages of Alternative 1 are:

- High volume of solids disposal required/elevated truck traffic;
- Complex process;
- Unable to fit in desired footprint; and
- High O&M costs.

7.7.3 Alternative 2 – Vapor Recompression Drying

Vapor recompression drying is a novel indirect heat drying technology that uses a series of heated disks to evaporate water and produce 90-percent Class A biosolids. Vapor recompression dryers can accept sludge with solids content as low as 2 percent, and thus do not require dewatering. Initially, liquid sludge (2 to 6 percent) is degassed and heated using a heat exchanger. Thereafter, the heated sludge is sprayed onto the heated disks. The disks slowly rotate, rapidly drying the sludge on the surface with excess sludge being collected in a trough below before being recirculated. On the downward motion, the disk contacts a scraper which removes the dried solids that are collected from each individual disk/scraper and conveyed to a discharge point with a slow-moving drag-chain style conveyor. Steam and air from the drying process are pulled through a compressor, which pressurizes the air and steam, thus increasing the temperature. The hot air and steam pass through a distillation tower, which removes evaporated water and aqueous ammonia. Aqueous ammonia can be disposed of offsite, and the water, low in TSS and nutrients, can be recycled to the headworks. Compressed steam leaves the distillation tower and is used to heat the disks. As vapor recompression drying has not been previously approved by Ecology for biosolids treatment at a municipal WWTP and is not identified in the *Criteria for Sewage Works Design* (Ecology, August 2008) or "Orange Book," it may be considered "new and developmental technology," as defined by Section G1-5.4.1 of the Orange Book, unless Ecology will consider the technology to fall under the umbrella of thermal drying. As such, the technology typically is required to be thoroughly tested in a full-scale or representative pilot installation before approval can be given for construction and installation of the technology. The schematic process flow diagram for Alternative 2 is shown in **Figure 7-4**, with a site layout shown in **Figure 7-5**.



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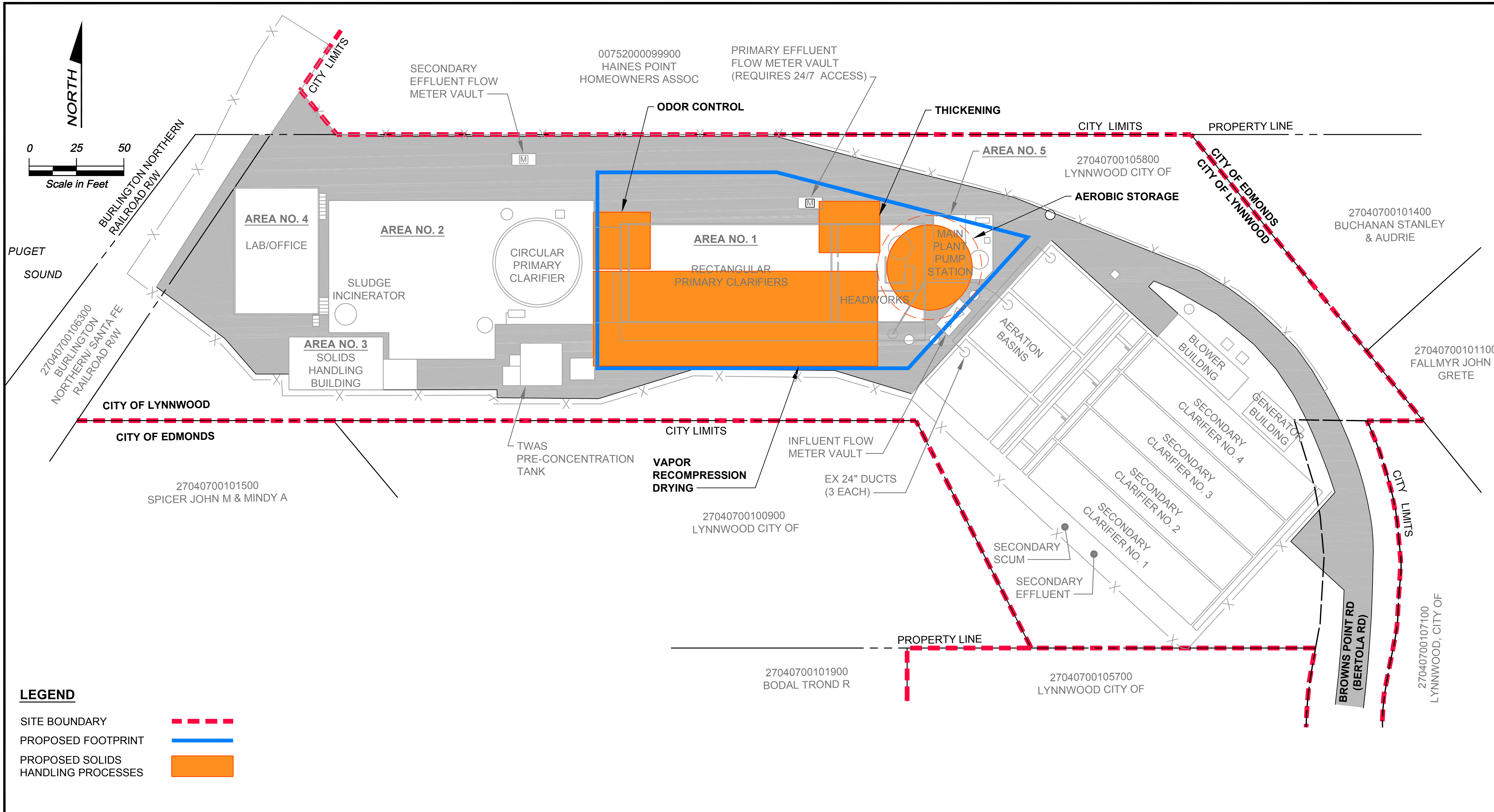
Vapor Recompression Drying Schematic, Alternative 2

Lynnwood Facility Plan

June 2022

Figure

7-4



Map Source:

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Vapor Recompression Drying Layout, Alternative 2
Lynnwood Facility Plan
June 2022

Figure
7-5

As shown in **Figure 7-4**, WAS is pumped to the WAS equalization tank (45-foot diameter, hydraulically mixed/aerated) where recuperative thickening (with rotary screen) is used to maintain a solids concentration of 4 percent. Thickened WAS is pumped directly to the vapor recompression dryer. Class A biosolids (>90-percent total solids) are produced with an estimated 2.8 trucks per week. As dewatering is not required, no dewatering or dewatered sludge storage is required. Vapor recompression drying requires 24 planned maintenance days per year, with an assumed 85 percent uptime on remaining days, resulting in a total uptime of 79.4 percent.

Alternative 2 includes a large 150-foot by 50-foot facility to house the entire vapor recompression process. The footprint shown for this facility includes tankage and equipment for receiving the sludge through final Class A biosolids storage for off-site disposal. In addition to the vapor recompression building, structures will be required to house the thickening process and odor control system. Such structures and buildings are not included in the costs provided herein. The WAS equalization tank is shown with a 5-foot buffer around the tank to account for additional clearances and tank appurtenances. A detailed summary of the design criteria for vapor recompression drying is shown in **Table 7-8**.

Table 7-8. Vapor Recompression Drying Technology Summary

Parameter	Value
Uptime	79.4%
Yearly Operating Hours	6,962
Natural Gas Use (MMBTU/hr)	1.21
Annual Natural Gas Use (therm/yr)	88,704
Electricity Use (kW)	302
Vapor Recompression Dryer Annual Electricity Use (kWh)	2,100,000
Odor Control Annual Electricity Use (kWh)	565,873
Total Energy Use (kWh/30 years)	153,829,835
Operating Temperature (°F)	Unknown
Annual 93% Sulfuric Acid Requirement (Odor Control) (gal/year)	7,758
Annual 50% Sodium Hydroxide Requirement (Odor Control) (gal/year)	7,626
Annual 12.5% NaOCl Requirement (Odor Control) (gal/year)	164,363
Dryer Foul Air Production (CFM)	5,000
Other Foul Air Production (CFM)	11,500
Total Foul Air Production (CFM)	16,500
Dried Biosolids Concentration (%)	90
Sludge Production (dry lbs/day)	18,100
Biosolids Production (wet tons/week)	70
Trucks per Week	2.8
Staffing Requirement (FTEs)	3
Footprint (sf)	7,500

The cost summary of Alternative 2 is provided in **Table 7-9**.

Table 7-9. Alternative 2 Cost Summary

Parameter	Cost
Total 2021 Technology Capital Cost [2]	**$9,250,000**
2021 Vapor Recompression Dryer Equipment Capital Cost	$6,500,000
2021 Odor Control Equipment Capital Cost	$910,000
2021 WAS Equalization Capital Cost	$1,420,000
2021 Thickening Capital Cost	$420,000
2021 Annual O&M Cost [1, 2]	**$1,400,000**
2021 Vapor Recompression Dryer Equipment O&M Cost	$1,040,000
2021 Odor Control O&M Cost	$240,000
2021 WAS Equalization O&M Cost	$20,000
2021 Thickening O&M Cost	$100,000
30-year O&M Cost[3]	**$27,400,000**
30-year Life Cycle Cost[3]	**$36,700,000**

Notes:

1. Includes biosolids disposal costs.
2. 2021 US Dollars rounded to nearest $10,000.
3. 2021 US Dollars rounded to nearest $100,000.

The Sedron Varcor system was used as the basis of the criteria and costs shown in **Tables 7-8** and **7-9**. Costs in **Table 7-9** were developed using the cost criteria and assumptions listed in **Section 7.6** combined with manufacturer proposals/quotes and engineering judgement. Costs were developed in 2021 US Dollars. The technology cost for vapor recompression drying is $6.5M, with an annual O&M cost of $1.0M. When combined with the other processes shown in **Figure 7-4**, the total equipment 2021 capital cost to implement Alternative 2 is $9.3M, with an annual O&M cost of $1.4M, for a 30-year LCC of $36.7M.

7.7.3.1 ALTERNATIVE 2 CRITERIA ASSESSMENT

This section describes how Alternative 2 performed against each criterion and summarizes general advantages and disadvantages of the alternative.

1. **Technology Capital Cost (15 Percent)** – The total technology capital cost for Alternative 2 in 2021 US dollars is estimated at $9.3M. This number is based on WAS equalization in concrete tanks with mechanical mixing and aeration, rotary screen thickening, and Sedron's Varcor vapor recompression dryer. Dewatering and DS storage are not required with vapor recompression.
2. **Footprint (15 Percent)** – Vapor recompression drying requires minimal space for ancillary equipment and fits within the allotted footprint (**Figure 7-5**).
3. **Nutrient Side Stream (10 Percent)** – Vapor recompression drying produces high quantities of aqueous ammonia; however, this is planned to be disposed of offsite. Costs of aqueous ammonia disposal were not included in the evaluation herein. The "filtrate" returned to the

headworks is low in nutrient content and is not expected to have a detrimental impact on the liquid stream process.

4. **Truck Traffic (10 Percent)** – Alternative 2 will generate an estimated 2.8 trucks per week of Class A biosolids based on 2050 maximum month sludge production.
5. **Technology 30-Year O&M Cost (10 Percent)** – The 30-year O&M cost in 2021 US dollars is estimated at $27.4M. Staffing and maintenance are the highest costs; however, some savings is realized through the omission of dewatering and DS storage.
6. **Regulatory (10 Percent)** – As vapor recompression drying is a new technology, there are possibly some regulatory hurdles to gain Ecology approval. PSCAA permitting is not expected to be required for the vapor recompression process other than for odor control. The WWTP will likely be covered under the Washington State Biosolids General Permit.
7. **Proven Technology (10 Percent)** – Vapor recompression drying is a new technology that has seen successful pilot tests; however, no full-scale installations for handling municipal sludge are currently online in the United States.
8. **Staffing (5 Percent)** – An estimated 3.0 full-time employees are needed to operate and maintain all the unit processes.
9. **Process Complexity (5 Percent)** – Vapor recompression drying uses complex equipment, including large compressors, heat exchangers, and distillation towers, some of which are not conventionally used in wastewater facilities. Complexity is offset by the exclusion of dewatering and dewatered sludge storage.
10. **CO_2 Generation (5 Percent)** – Alternative 2 uses some natural gas to maintain temperature in the system, with most of the heat load provided by compression and expansion of gasses. The 2.8 trucks per week required for sludge hauling contribute to Alternative 2's CO_2 generation.
11. **Total Energy Use (5 Percent)** – Energy use is driven by the large compressors and natural gas use for heating. Alternative 2 uses an estimated average of 617 kW.

The major advantages of Alternative 2 are:

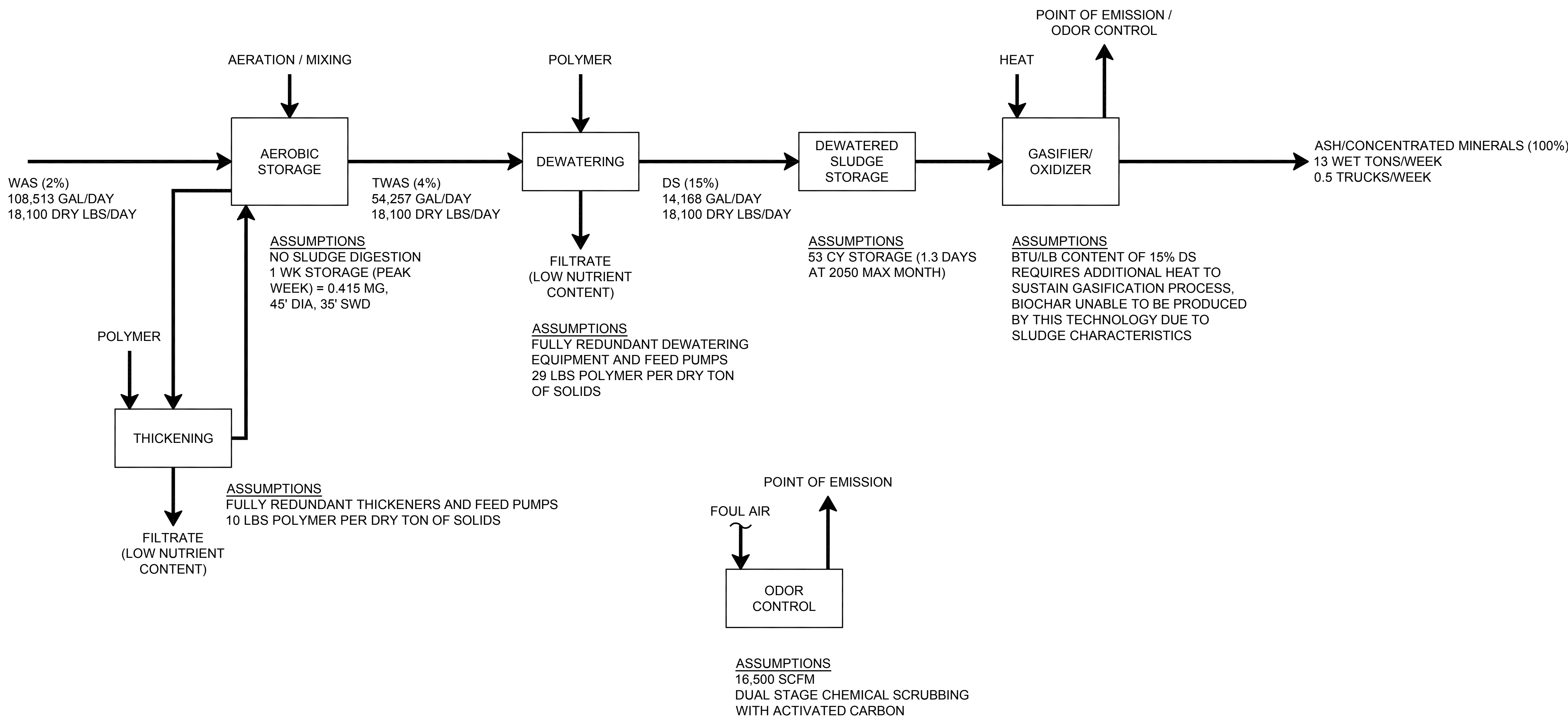
- No dewatering stage needed, can accept liquid sludge as low as 2 percent;
- Low truck traffic; and
- Can fit in allotted footprint.

The major disadvantages of Alternative 2 are:

- New technology;
- Untested at full scale at municipal sewage facilities; and
- High staffing requirement due to atypical equipment and maintenance of numerous scrapers.

7.7.4 Alternative 3 – Gasification

Gasification is a thermochemical process for converting biomass into a synthetic gas (syngas) and char in an oxygen starved environment and without an open flame. Depending on residence time and how much oxygen is added to the process, gasification can produce either a biochar or an ash product. Ecoremedy's Fluid Lift Gasification process was used as the basis for evaluating gasification. The process relies on a recirculating loop of dried solids that are mixed with incoming DS to produce a gasifier feed stock that meets the gasifier fuel specification (typically the feed stock target is 60 to 65 percent total solids). The DS is dried using a high temperature rotary drum dryer. The feed stock is then distributed onto a slow-moving grate within the gasifier. In the absence of oxygen, the material on the grate is subjected to controlled heat that releases syngas and other volatile fractions from the sludge. The syngas is collected and then conveyed to an oxidizer which adds a regulated amount of oxygen to completely thermally oxidize the material. The heat from this step is then used to heat the rotary drum dryer. An induced draft fan pulls the heated air stream through the entire process (gasifier, oxidizer, and dryer). Material that is not converted to syngas is then collected at the bottom of the gasifier and conveyed for off-site disposal. The gasifier heat (natural gas consumption) and moving grate can be adjusted as needed to produce either ash or biochar. The difference between the two is primarily the resulting carbon content. The system also can tailor the carbon content of the biochar to meet any end use biochar specifications. The schematic process flow diagram for Alternative 3 is shown in **Figure 7-6**, with a site layout shown in **Figure 7-7**.



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Gasification Schematic Alternative 3

Lynnwood Facility Plan

June 2022

Figure 7-6

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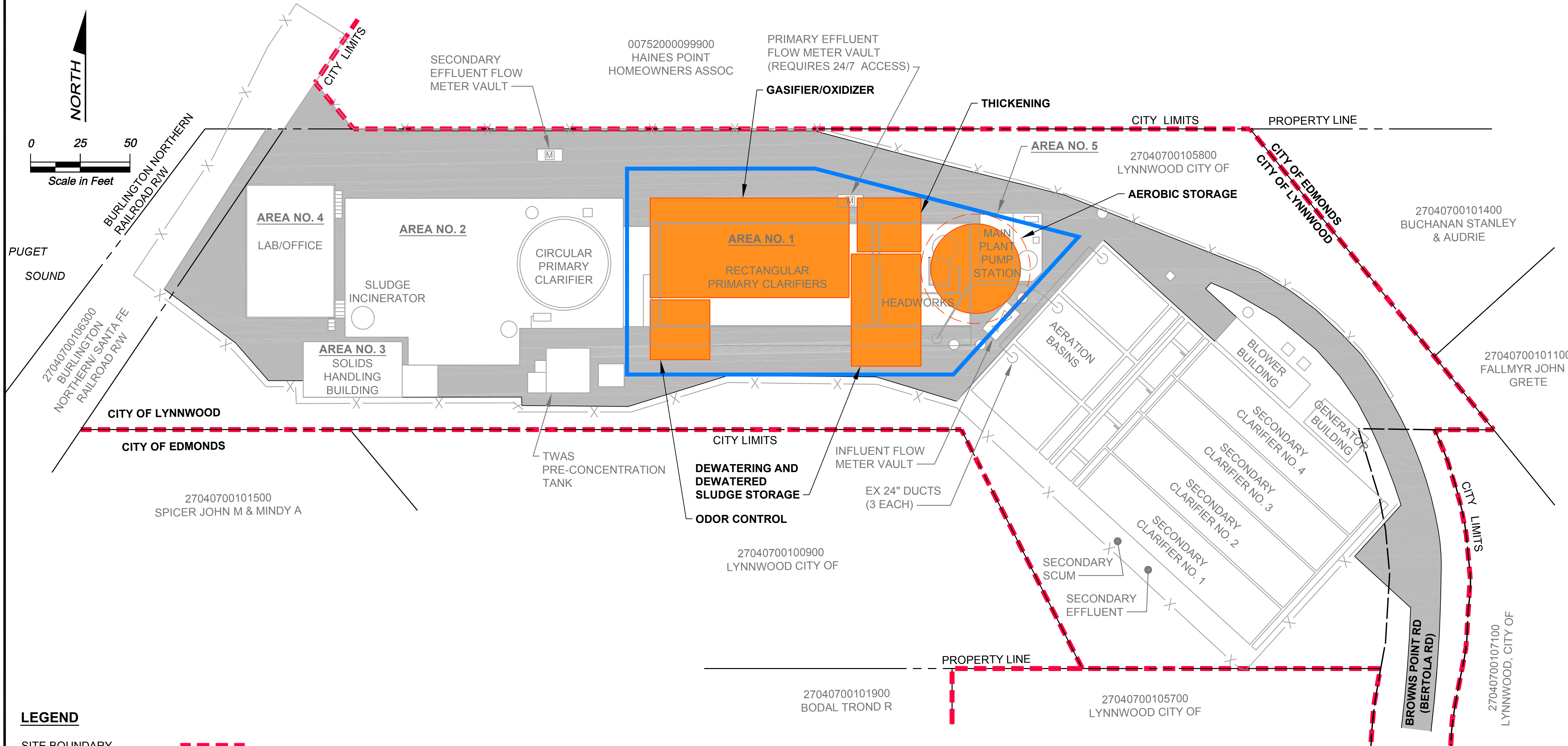

LEGEND

SITE BOUNDARY

PROPOSED FOOTPRINT

PROPOSED SOLIDS HANDLING PROCESSES

Map Source:

This drawing was created from a variety of record drawing and site visit information.

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Gasification Layout Alternative 3

Lynnwood Facility Plan

June 2022

Figure

7-7

As shown in **Figure 7-6**, WAS is pumped to the WAS equalization tank (45-foot diameter, hydraulically mixed/aerated) from the liquid stream process(es). Recuperative thickening (rotary screen) is used to maintain a solids concentration of 4 percent in WAS equalization. The 4-percent WAS is then dewatered and stored in the DS storage system before being fed to the gasification process. The gasification process is highly dependent on the energy content of the sludge, which is measured in BTU per wet pounds. For this analysis, a lower heating value of 7,500 BTU/lb was assumed, but it is recommended that this value be verified in a lab once a representative sludge sample can be provided. The energy content of the sludge is a function of the sludge itself and the solids concentration. The estimated energy content at 15-percent solids is on the threshold for a self-sustaining gasification process. The addition of screenings collected at the headworks would add enough energy to the process for a self-sustaining gasification process; however, this would only be permitted by Ecology in the ash production mode. To produce biochar, an estimated 0.2 MMBTU/hr of additional energy is required, which was assumed to be in the form of natural gas for this analysis, resulting in significantly higher natural gas consumption in the biochar operating mode. If a centrifuge was used to provide 20-percent dewatered sludge, the gasification process would likely be self-sustaining for both biochar and ash operating modes without the addition of external energy.

The gasification process converts a significant amount of the carbon present in the sludge to carbon dioxide. In the ash production scenario, more carbon dioxide is emitted to the atmosphere, as the inherent energy of the carbon is converted to syngas. The biochar operating mode produces a final product with about 60-percent carbon content, which can be adjusted to meet any end use biochar specifications. Ash production mode results in an estimated 0.5 trucks per week, which is increased to 0.6 trucks per week of biochar at 60-percent carbon content.

Alternative 3 includes a large 100-foot by 50-foot facility to house the gasification process downstream of DS storage. In addition to the gasification building, structures will be required to house the thickening process, dewatering process, odor control system, and DS storage. Such structures and buildings are not included in the costs provided herein. The WAS equalization tank is shown with a 5-foot buffer around the tank to account for additional clearances and tank appurtenances. A detailed summary of the design criteria for gasification is shown in **Table 7-10**.

Table 7-10. Gasification Technology Summary

Parameter	Biochar	Ash
Uptime	85.0%	85.0%
Yearly Operating Hours	7,451	7,451
Natural Gas Use (MMBTU/hr)	0.24	0.04
Annual Natural Gas Use (therm/yr)	19,184	3,447
Electricity Use (kW)	110	110
Gasification Annual Electricity Use (kWh)	816,549	816,549
Odor Control Annual Electricity Use (kWh)	565,873	565,873
Total Energy Use (kWh/30 years)	57,444,576	44,342,413
Annual 93% Sulfuric Acid Requirement (Odor Control) (gal/year)	7,758	7,758
Annual 50% Sodium Hydroxide Requirement (Odor Control) (gal/year)	7,626	7,626
Annual 12.5% NaOCl Requirement (Odor Control) (gal/year)	164,363	164,363
Foul Air Production (scfm)	16,500	16,500
Dried Biosolids Concentration (%)	98	98
Biosolids Production (dry lbs/day)	4,512	3,552
Biosolids Production (wet tons/week)	16	13
Trucks per Week	0.6	0.5
Staffing Requirement (FTEs)	1.5	1.5
Footprint (sf)	5,000	5,000

The cost summary of Alternative 3 is provided in **Table 7-11**.

Table 7-11. Alternative 3 Cost Summary

Parameter	Biochar	Ash
Total 2021 Equipment Capital Cost [2]	**$19,170,000**	**$19,170,000**
2021 Gasification Equipment Capital Cost	$14,900,000	$14,900,000
2021 Odor Control Equipment Capital Cost	$910,000	$910,000
2021 WAS Equalization Capital Cost	$1,420,000	$1,420,000
2021 Thickening Capital Cost	$420,000	$420,000
2021 Dewatering Capital Cost	$910,000	$910,000
2021 DS Storage Capital Cost	$610,000	$610,000
2021 Annual O&M Cost[1, 2]	**$1,210,000**	**$1,180,000**
2021 Gasification Equipment O&M Cost	$610,000	$580,000
2021 Odor Control O&M Cost	$230,000	$230,000
2021 WAS Equalization O&M Cost	$20,000	$20,000
2021 Thickening O&M Cost	$100,000	$100,000
2021 Dewatering O&M Cost	$230,000	$230,000
2021 DS Storage O&M Cost	$20,000	$20,000
30-Year O&M Cost[3]	**$23,700,000**	**$23,100,000**
30-Year Life-Cycle Cost[3]	**$42,900,000**	**$42,300,000**

Notes:
1. Includes biosolids disposal costs.
2. 2021 US Dollars rounded to nearest $10,000.
3. 2021 US Dollars rounded to nearest $100,000.

The Ecoremedy Fluid Lift gasification system was used as the basis of the criteria and costs shown in **Tables 7-10** and **7-11**. The ash operating mode was selected as the basis for this evaluation moving forward. Costs in **Table 7-11** were developed using the cost criteria and assumptions listed in **Section 7.6** combined with manufacturer proposals/quotes and engineering judgement. Costs were developed in 2021 US Dollars. The technology cost for gasification is $14.9M with an annual O&M cost of $0.6M. When combined with the other processes shown in **Figure 7-6**, the total equipment 2021 capital cost to implement Alternative 3 is $19.2M, with an annual O&M cost of $1.2M, for a 30-year LCC of $42.3M. Biochar production mode results in an annual O&M cost increase of $30k in 2021 US Dollars due to increased disposal cost and natural gas use, which increases the 30-year LCC by $0.6M.

7.7.4.1 ALTERNATIVE 3 CRITERIA ASSESSMENT

This section describes how Alternative 3 performed against each criterion and summarizes general advantages and disadvantages of the alternative.

1. **Technology Capital Cost (15 Percent)** – The total technology capital cost of gasification in 2021 US dollars is estimated at $19.2M. This number is based on WAS equalization in concrete tanks with mechanical mixing and aeration, rotary screen thickening, screw press dewatering, DS storage, and Ecoremedy's Fluid Lift gasification.

2. **Footprint (15 Percent)** – The compact gasification process and associated support equipment can fit within the allotted footprint.
3. **Nutrient Side Stream (10 Percent)** – Side stream flows will be produced by both the thickening and dewatering processes, but neither is expected to produce a significant nutrient load.
4. **Truck Traffic (10 Percent)** – Alternative 3 generates an estimated 0.5 trucks of exceptional quality (EQ) Class A biosolids per week based on 2050 maximum month sludge production.
5. **Technology 30-Year O&M Cost (10 Percent)** – The 30-year O&M cost in 2021 dollars is estimated at $23.1M. Maintenance is the highest cost, due to the annual maintenance cost of 2 percent of the equipment purchase price.
6. **Regulatory (10 Percent)** – PSCAA permitting will be required and may be challenging to obtain given the WWTP location and surrounding topography. The WWTP will likely not require an Ecology biosolids permit when producing ash, as it can be disposed of in a landfill. Shall biochar be produced, and as Ecology classifies biochar as a biosolid, the WWTP would likely be covered under the Washington State Biosolids General Permit.
7. **Proven Technology (10 Percent)** – As a general chemical process, gasification is well understood and widely used. Gasification has seen very limited use for solids handling at municipal WWTPs.
8. **Staffing (5 Percent)** – An estimated 1.6 full-time employees are needed to operate and maintain the process.
9. **Process Complexity (5 Percent)** – Gasification requires several complex processes, as well as material handling challenges due to the back mixing required.
10. **CO_2 Generation (5%)** – Natural gas is only needed to start up the process, but otherwise the dryer and oxidizer are self-sustaining. Ash requires 0.5 trucks per week for sludge hauling. This criterion does not account for CO_2 emissions from the gasification process.
11. **Total Energy Use (5 Percent)** – Energy use is low at an estimated average 211 kW based on minimal natural gas needs and the few large motors needed to operate the process.

The major advantages of Alternative 3 are:

- Compact footprint;
- Low truck traffic; and
- Low energy use.

The major disadvantages of Alternative 3 are:

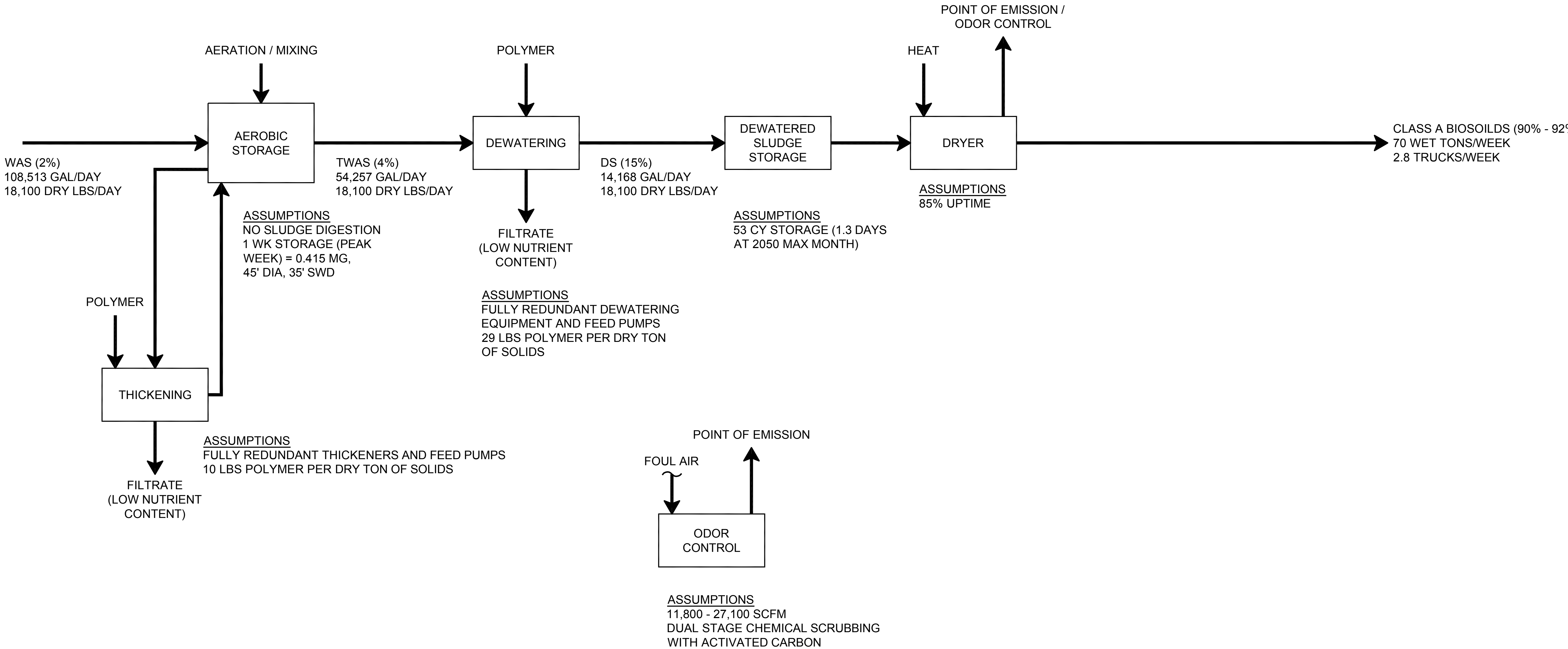
- Limited number of municipal sludge installations;
- Complex permitting requirements; and
- High capital costs.

7.7.5 Alternative 4 – Heat Drying

Heat drying is a commonly used process that uses heat to evaporate water from dewatered sludge to produce a Class A biosolids at a solids concentration of 90 percent or greater. Dryers work by heating water, air, or thermal oil with a natural gas boiler and using the heated fluid to dry solids. Dryers can be either indirect or direct. Direct dryer installations at wastewater facilities in the region have been primarily belt dryers. Belt dryers use convection heat and distribute extruded sludge on a conveyor belt. As the conveyor belt travels through the dryer, the extruded sludge dries when it meets the heated air that is supplied and recirculated throughout the system. Belt dryers typically use boilers and a heat exchanger to heat the air used for sludge drying, which is typically at low temperatures in the range of 300 to 400 degrees Fahrenheit. Indirect dryers use paddles, hollow flights, or disks that contact the sludge. A heated fluid, typically steam or oil, is pumped through the rotating assembly and the shell of the dryer. Alternative 2, vapor recompression drying, can be considered a form of indirect drying due to its use of heated rotating disks to dry the sludge; however, due to the vapor recompression technology and the ability to accept non-dewatered sludge, it was considered in its own separate category. Dryers that use heat from the biological process (e.g., Bioforcetech BioDryer) were considered, but are not included in this analysis due to the excessive footprint requirements making them inapplicable to the WWTP site limitations (**Figure 7-1**). The analysis herein includes four established dryer manufacturers as the basis of evaluation: Huber (direct, belt), Komline Sanderson (indirect, paddle wheel), Kruger (direct, belt), and Centrisys (direct, compact belt).

The basis of this evaluation is a 15-percent dewatered sludge feed to the dryer. Several manufacturers noted that this is a relatively low solids concentration, but it is unlikely that higher solids content could be achieved with WAS alone, unless a centrifuge was used. Increasing the solids content of the feed sludge to approximately 20 percent helps to reduce the amount of water the dryer needs to evaporate, which reduces both energy consumption and dryer footprint. The Centrisys compact belt dryer is most favored with this increase because at 15-percent solids, it will require a back mixing system to ensure a stable drying process. At 20 percent, no back mixing is needed, and the dryer size can be reduced by approximately 10 percent. Standard belt dryers and paddle wheel dryers see a similar reduction in footprint, reduced natural gas and electricity use, and a 5 percent savings in capital cost; however, as these dryers can operate with feed sludge of 15 percent or lower, the benefits of a centrifuge become minimized. For the purposes of this Plan, 15 percent has been selected as the basis of evaluation as it is a more conservative approach and allows the City to keep the dewatering technology it currently operates. Should the City opt to rely on a centrifuge for dewatering, it will reduce the costs associated with the heat drying alternatives.

The schematic process flow diagram for Alternative 3 is shown in **Figure 7-8**, with a site layout shown in **Figure 7-9**.



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Heat Drying Schematic Alternative 4

Lynnwood Facility Plan

June 2022

Figure 7-8

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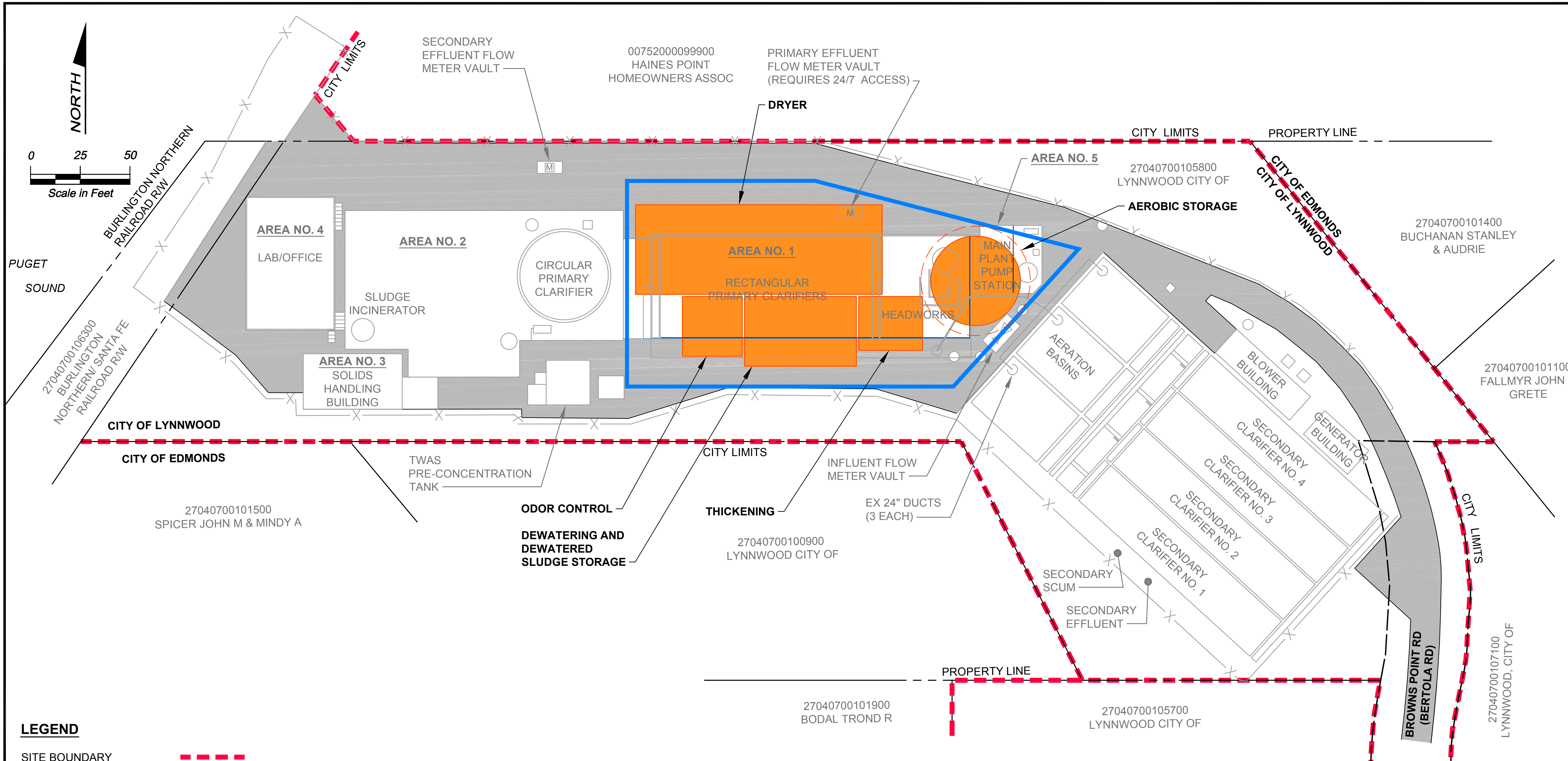

LEGEND

- SITE BOUNDARY
- PROPOSED FOOTPRINT
- PROPOSED SOLIDS HANDLING PROCESSES

Map Source:

This drawing was created from a variety of record drawing and site visit information.

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Heat Drying Layout Alternative 4
Lynnwood Facility Plan
June 2022

Figure
7-9

As shown in **Figure 7-8**, WAS is pumped to the WAS equalization tank (45-foot diameter, hydraulically mixed/aerated) from the liquid stream process(es). Recuperative thickening (rotary screen) is used to maintain a solids concentration of 4 percent in the WAS equalization tank. The 4-percent WAS is then dewatered and stored in the DS storage system. Dewatered sludge, at 15 percent solids, is fed directly to the dryer, which uses heat from a natural gas boiler to evaporate water and produce a final product with 90 percent or higher solids content. The dryer uptime is based on the yearly operating hours provided by the manufacturer, which represents the minimum necessary to meet 2050 maximum month sludge production. The boiler is below 10 MMBTU/hr; therefore, significant air permitting will likely not be required. However, the resulting odor control exhaust, in combination with non-dryer sources shown in **Figure 7-8**, are expected to require an air permit, as described previously. The necessary foul air flow rate depends highly on the dryer type and manufacturer. Foul air associated with drying sludge is known for its odors, thus it is important to include sufficient foul air treatment capacity.

As shown in **Figure 7-9**, Alternative 4 includes a large 125-foot by 45-foot facility to house the dryer and its subsystems. The footprint shown is based on the largest footprint dryer, which is the Huber belt dryer. In addition to the dryer building, structures will be required to house the thickening process, dewatering process, odor control system, and DS storage. Such structures and buildings are not included in the costs provided herein. The WAS equalization tank is shown with a 5-foot buffer around the tank to account for additional clearances and tank appurtenances. A detailed summary of the design criteria for heat drying is shown in **Table 7-12**.

Table 7-12. Heat Drying Technology Summary

Parameter	Value			
Type	**Belt**	**Paddle Wheel**	**Belt**	**Compact Belt**
Uptime	92.0%	85.6%	91.6%	85.0%
Yearly Operating Hours	8,064	7,500	8,030	7,451
Natural Gas Use (MMBTU/hr)	5.94	5.68	7.23	7.78
Annual Natural Gas Use (therm/yr)	505,826	449,777	613,081	612,266
Dryer Electricity Use (kW)	142	172	129	182
Dryer Annual Electricity Use (kWh)	1,145,088	1,290,000	1,035,870	1,356,100
Odor Control Annual Electricity Use (kWh)	898,538	404,685	438,775	929,404
Total Energy Use (kWh/30 years)	455,495,637	413,177,519	541,518,170	550,446,448
Operating Temperature (°F)	< 293	385	< 338	194
Annual 93% Sulfuric Acid Requirement (Odor Control) (gal/year)	12,319	5,548	6,015	12,742
Annual 50% Sodium Hydroxide Requirement (Odor Control) (gal/year)	12,110	5,454	5,913	12,526
Annual 12.5% NaOCl Requirement (Odor Control) (gal/year)	260,988	117,544	127,446	269,953
Dryer Foul Air Production (CFM)	14,700	300	1,294	15,600
Other Foul Air Production (CFM)	11,500	11,500	11,500	11,500
Total Foul Air Production (CFM)	26,200	11,800	12,794	27,100
Dried Biosolids Concentration (%)	92	92	92	92
Sludge Production (dry lbs/day)	18,100	18,100	18,100	18,100
Biosolids Production (wet tons/week)	69	69	69	69
Trucks per Week	2.8	2.8	2.8	2.8
Staffing Requirement (FTEs)	2	2	2	2
Footprint (sf)	5,625	2,200	5,525	2,500

The cost summary of Alternative 4 is provided in **Table 7-13**.

Table 7-13. Alternative 4 Cost Summary

Parameter	Value			
Type	**Belt**	**Paddle Wheel**	**Belt**	**Compact Belt**
Total 2021 Equipment Capital Cost [2]	**$7,740,000**	**$7,920,000**	**$9,180,000**	**$8,220,000**
2021 Dryer Equipment Capital Cost	$3,330,000	$3,910,000	$5,110,000	$3,770,000
2021 Odor Control Capital Cost	$1,050,000	$650,000	$710,000	$1,090,000
2021 WAS Equalization Capital Cost	$1,420,000	$1,420,000	$1,420,000	$1,420,000
2021 Thickening Capital Cost	$420,000	$420,000	$420,000	$420,000
2021 Dewatering Capital Cost	$910,000	$910,000	$910,000	$910,000
2021 DS Storage Capital Cost	$610,000	$610,000	$610,000	$610,000
2021 Annual O&M Cost[1, 2]	**$1,910,000**	**$1,690,000**	**$1,870,000**	**$2,070,000**
2021 Dryer Equipment O&M Cost	$1,180,000	$1,150,000	$1,320,000	$1,320,000
2021 Odor Control O&M Cost	$360,000	$170,000	$180,000	$380,000
2021 WAS Equalization O&M Cost	$20,000	$20,000	$20,000	$20,000
2021 Thickening O&M Cost	$100,000	$100,000	$100,000	$100,000
2021 Dewatering O&M Cost	$230,000	$230,000	$230,000	$230,000
2021 DS Storage O&M Cost	$20,000	$20,000	$20,000	$20,000
30-Year O&M Cost[3]	**$37,400,000**	**$33,100,000**	**$36,700,000**	**$40,600,000**
30-Year Life-Cycle Cost[3]	**$45,100,000**	**$41,000,000**	**$45,900,000**	**$48,800,000**

Notes:
1. Includes biosolids disposal costs.
2. 2021 US Dollars rounded to nearest $10,000.
3. 2021 US Dollars rounded to nearest $100,000.

Costs in **Table 7-13** were developed using the cost criteria and assumptions listed in **Section 7.6** combined with manufacturer proposals/quotes and engineering judgement. Costs were developed in 2021 US Dollars. The technology cost for heat drying is $4.0M, with an annual O&M cost of $1.2M. The capital and O&M costs are based on an average of the four dryers evaluated. When combined with the other processes shown in **Figure 7-8**, the total equipment 2021 capital cost to implement Alternative 4 is $9.3M, with an annual O&M cost of $1.9M, for a 30-year LCC of $45.2M.

7.7.5.1 ALTERNATIVE 4 CRITERIA ASSESSMENT

This section describes how Alternative 4 performed against each criterion and summarizes general advantages and disadvantages of the alternative.

1. **Technology Capital Cost (15 Percent)** – The total technology capital cost of heat drying in 2021 US dollars is estimated at $8.3M, which is an average of the four dryer vendor packages. This number is based on WAS equalization in concrete tanks with mechanical mixing and aeration, rotary screen thickening, screw press dewatering, DS storage, and a heat dryer.
2. **Footprint (15 Percent)** – The dryer process and support equipment can fit within the allotted footprint.

3. **Nutrient Side Stream (10 Percent)** – Side stream flows will be produced by both the thickening and dewatering processes, but neither is expected to produce a significant nutrient load.
4. **Truck Traffic (10 Percent)** – Alternative 4 will generate an estimated 2.8 trucks per week of Class A biosolids based on 2050 maximum month sludge production.
5. **Technology 30-Year O&M Cost (10 Percent)** – The 30-year O&M cost in 2021 US dollars is estimated at $37M, which is an average of the four dryer vendor packages. The largest O&M cost is natural gas, which is needed to provide heat for the drying process.
6. **Regulatory (10 Percent)** – Permitting for heat drying is expected to be feasible given multiple municipal sludge drying facilities in the region use this technology and because Ecology considers heat drying a proven technology. PSCAA will require a permit for discharge of exhaust air, which will pass through an odor scrubber. The WWTP will likely be covered under the Washington State Biosolids General Permit.
7. **Proven Technology (10 Percent)** – Heat drying has been used extensively at municipal WWTPs with several installations in the region.
8. **Staffing (5 Percent)** – An estimated 2.1 full-time employees are needed to operate and maintain the process.
9. **Process Complexity (5 Percent)** – Heat dryers are somewhat complex due to the need for boilers and heat recirculation systems. Dryers are also highly sensitive to the solids concentration of feed sludge and prefer consistent dewatering performance.
10. **CO_2 Generation (5 Percent)** – Significant quantities of natural gas are needed to operate heat dryers. This is partially offset by the low truck traffic required at 2.8 trucks per week.
11. **Total Energy Use (5 Percent)** – Energy use at an estimated average 1,983 kW is high due to the large quantities of natural gas needed to operate the heat drying process.

The advantages of Alternative 4 are:

- Low truck traffic;
- Proven technology with several local installations;
- Permitability; and
- Low technology capital costs.

The disadvantages of Alternative 4 are:

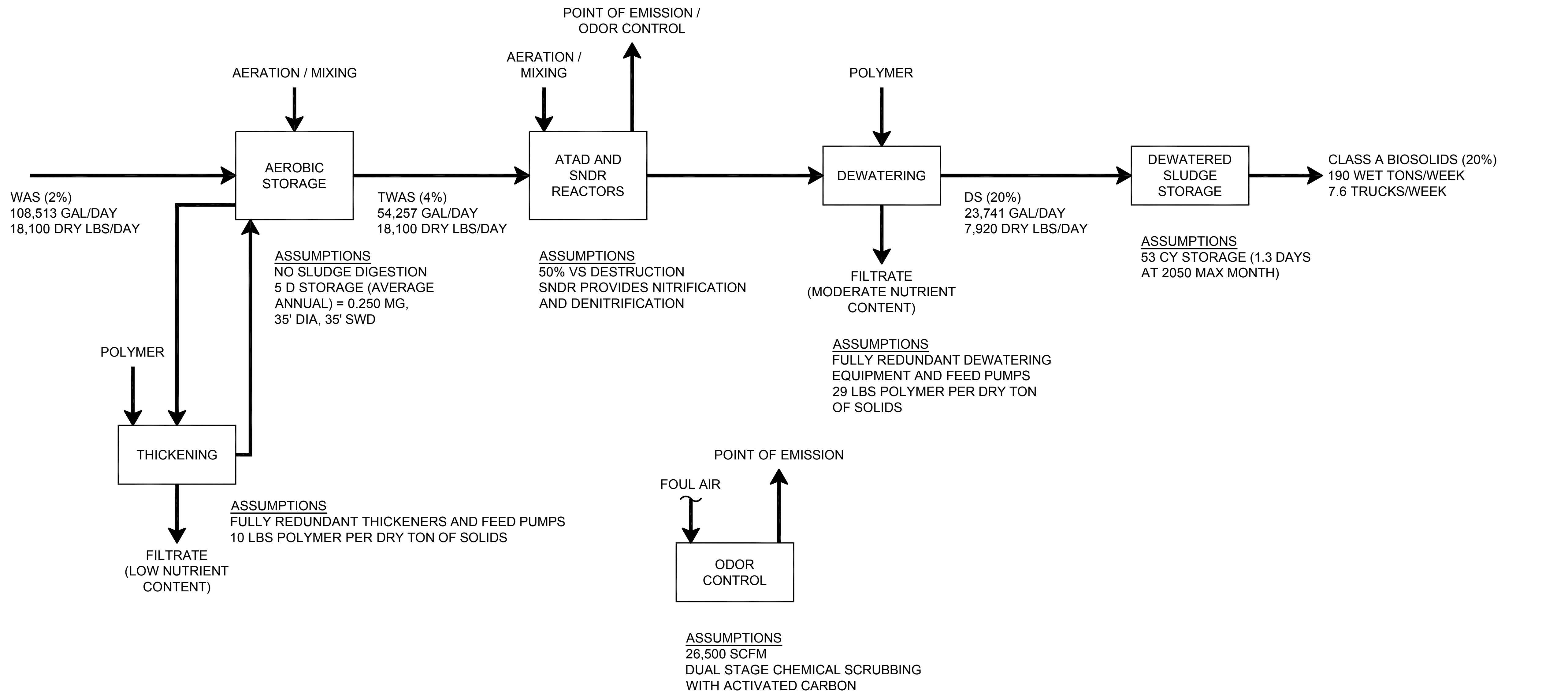
- Large carbon footprint and high natural gas use; and
- High O&M cost.

7.7.6 Alternative 5 – Autothermal Thermophilic Aerobic Digestion

The final alternative considered was autothermal thermophilic aerobic digestion (ATAD). ATAD is an advanced method of aerobic digestion at high temperatures, which allows significant volatile solids reduction (VSR) to be achieved at a short SRT, which greatly reduces the digestion tankage volume compared to other digestion methods. The resulting VSR reduces solids loading to the downstream solids handling processes. Ultimately, the process was evaluated as a standalone biological sludge treatment process like Alternative 1 due to site layout constraints for coupling with other solids handling systems.

ATAD, like all aerobic digestion processes, promotes endogenous decay of thickened WAS through oxidation of volatile solids. Comparable to conventional aerobic digestion, compressed air diffused into the sludge provides dissolved oxygen for use as the electron acceptor in the microbial oxidation reduction process. Oxidizing volatile solids release heat. Unlike conventional aerobic digestion, the heat is retained in the reactor from the digestion of substrate through covers and insulation. The generated heat creates a biochemical condition that leads to considerably higher reaction rates, but the ammonia generated through endogenous decay is not oxidized. The high reaction rates result in lower detention times in comparison to traditional aerobic digestion and high-rate anaerobic digestion processes. Within the aerated and mixed ATAD reactor, the temperature will stabilize between 55 and 70 degrees Celsius, which is the thermophilic operating range. The process does not require any additional external heat source and is therefore termed “autothermal.” The ATAD system can generate Class A biosolids in approximately 8 to 12 days SRT, depending on operations. The decreased SRT results in reduced reactor volume and is the primary reason why ATAD has been utilized. However, newer installations are often retrofits of existing aerobic digestion systems that were approaching capacity.

The schematic process flow diagram for Alternative 5 is shown in **Figure 7-10**, with a site layout shown in **Figure 7-11**.



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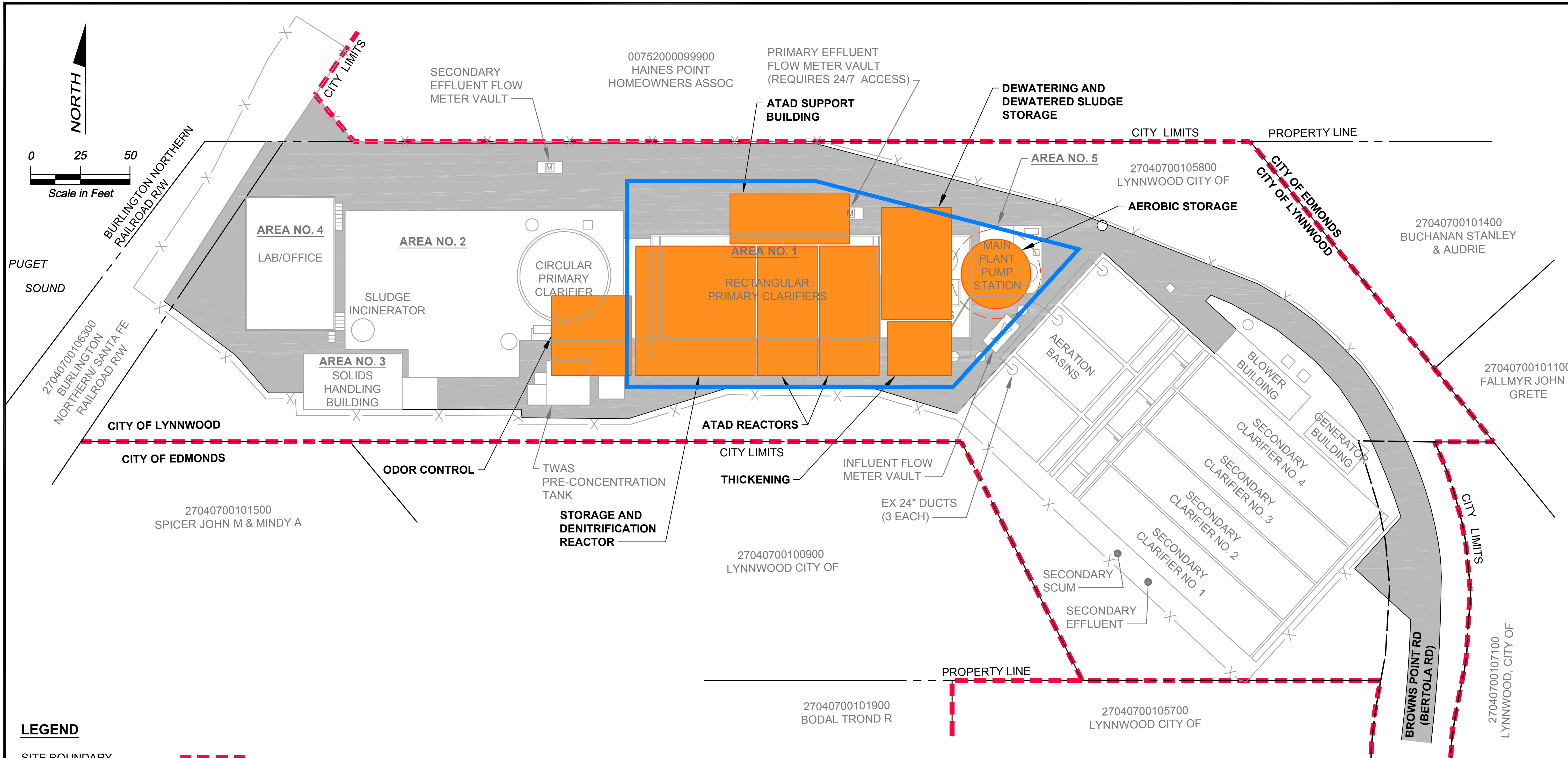
Autothermal Thermophilic Aerobic Digestion Schematic, Alternative 5

Lynnwood Facility Plan

June 2022

Figure **7-10**



LEGEND

SITE BOUNDARY	red dashed line
PROPOSED FOOTPRINT	blue line
PROPOSED SOLIDS HANDLING PROCESSES	orange fill

Map Source:

This drawing was created from a variety of record drawing and site visit information.

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Autothermal Thermophilic Aerobic Digestion Layout, Alternative 5
Lynnwood Facility Plan
June 2022

Figure **7-11**

As shown in **Figure 7-10**, WAS is pumped from the liquid stream process to the WAS equalization tank (45-foot diameter, hydraulically mixed/aerated). Recuperative thickening (rotary screen) is used to increase the WAS solids content to 4 percent. Thickened WAS then enters the ATAD process. The layout for ATAD is illustrated in **Figure 7-11**. The two ATAD reactors measure 65 feet by 30 feet, with the simultaneous nitrification/denitrification reactor measuring 65 feet by 60 feet. The WAS equalization tank is shown with a 5-foot buffer around the tank to account for additional clearances and tank appurtenances. The ATAD reactors are insulated and covered with aluminum covers to hold in heat. The ATAD support building, sized at 60 feet by 25 feet, houses all the necessary pumps, foam busters, blowers, and control panels necessary to maintain the ATAD process.

Thermal Process Systems' ThermAer ATAD system was used as the basis for evaluating ATAD. Most ATAD systems installed are proprietary systems, and ThermAer has approximately 40 installations in the United States. The ThermAer ATAD process operates in semi-batch mode, using two identical reactors that operate sequentially where one is decanted then filled, while the other aerates a retained volume achieving solids destruction. Due to the inclusion of a second ATAD reactor, the size of the upstream WAS equalization tank was reduced from 45 feet to 35 feet, as maintenance activities can be coordinated around the batch operation of ATAD, reducing the emergency aerobic storage volume used to size the WAS equalization tank. The ATAD reactors were assumed to achieve a volatile solids destruction of 50 percent, consistent with typical ATAD operation.

The ATAD process does not nitrify the digested sludge as the high temperatures are unable to support nitrifier growth. ThermAer includes a simultaneous nitrification/denitrification reactor downstream of the ATAD reactors, which uses low dissolved oxygen concentrations to nitrify and denitrify the sludge, reducing nutrient recycle to the plant headworks. ATAD processed sludge is typically recommended to be held and allowed to cool to improve dewaterability, which is also achieved in the simultaneous nitrification/denitrification reactor. The sludge is finally discharged from the system for dewatering and hauling. Due to the digested nature of the sludge, improved dewaterability is realized, with an estimated 20-percent solids content of Class A biosolids with a screw press. A detailed summary of the design criteria for ATAD is shown in **Table 7-14**.

Table 7-14. ATAD Technology Summary

Parameter	Value
Uptime	85.0%
Yearly Operating Hours	8,766
Total Motor HP	380
Electricity Use (kW)	219.1
ATAD Annual Electricity Use (kWh)	1,920,485
Odor Control Annual Electricity Use (kWh)	908,827
Annual 93% Sulfuric Acid Requirement (Odor Control) (gal/year)	12,460
Annual 50% Sodium Hydroxide Requirement (Odor Control) (gal/year)	12,248
Annual 12.5% NaOCl Requirement (Odor Control) (gal/year)	263,976
Foul Air Production (scfm)	26,500
Staffing Requirement (FTEs)	1
Footprint (sf)	9,360
Sludge Production (dry lbs/day)	10860
Biosolids Production @ 20% TS (wet tons/week)	190
Trucks per Week	7.60

The cost summary of Alternative 5 is provided in **Table 7-15**.

Table 7-15. Alternative 5 Cost Summary

Parameter	Cost
Total 2021 Equipment Capital Cost[2]	**$12,210,000**
2021 ATAD Equipment Capital Cost	$7,790,000
ThermAer Equipment Package	$3,676,000
Concrete Tankage	$3,501,000
Tank Covers	$615,000
2021 Odor Control Equipment Cost	$1,060,000
2021 WAS Equalization Capital Cost	$1,420,000
2021 Thickening Capital Cost	$420,000
2021 Dewatering Capital Cost	$910,000
2021 DS Storage Capital Cost	$610,000
2021 Annual O&M Cost[1, 2]	**$2,000,000**
2021 ATAD Equipment O&M Cost	$1,260,000
2021 Odor Control O&M Cost	$370,000
2021 WAS Equalization O&M Cost	$20,000
2021 Thickening O&M Cost	$100,000
2021 Dewatering O&M Cost	$230,000
2021 DS Storage O&M Cost	$20,000
30-Year O&M Cost[3]	**$39,200,000**
30-Year Life-Cycle Cost[3]	**$51,400,000**

Notes:
1. Includes biosolids disposal costs.
2. 2021 US Dollars rounded to nearest $10,000.
3. 2021 US Dollars rounded to nearest $100,000.

Costs in **Table 7-15** were developed using the cost criteria and assumptions listed in **Section 7.6** combined with manufacturer proposals/quotes and engineering judgement. Costs were developed in 2021 US Dollars. The technology cost for ATAD is $7.8M, with an annual O&M cost of $1.3M. When combined with the other processes shown in **Figure 7-10**, the total equipment 2021 capital cost to implement Alternative 5 is $12.2M, with an annual O&M cost of $2.0M, for a 30-year LCC of $51.4M.

7.7.6.1 ALTERNATIVE 5 CRITERIA ASSESSMENT

This section describes how Alternative 5 performed against each criterion and summarizes general advantages and disadvantages of the alternative.

1. **Technology Capital Cost (15 Percent)** – The total technology capital cost for ATAD in 2021 US dollars is estimated at $12.2M. This number is based on a 35-foot-diameter WAS equalization in a concrete tank with mechanical mixing and aeration, rotary screen thickening, ThermAer's ATAD process, and screw press dewatering.
2. **Footprint (15 Percent)** – As shown in **Figure 7-11**, the ATAD process fits within the allotted footprint, but the odor control system does not. The current space available would not be

able to fit a downstream solids handling process like a dryer in the future. It is possible that a building with multiple floors could address the footprint of the system, but that was not considered in this analysis.

3. **Nutrient Side Stream (10 Percent)** – The simultaneous nitrification/denitrification reactor removes a significant load of nitrogen that is released during the aerobic digestion process. As much of this nutrient load is treated before dewatering, there is not expected to be a significant load of nutrients returned to the headworks. A process upset in this reactor could have consequences of reduced nutrient removal efficacy in the main liquid stream process.
4. **Truck Traffic (10 Percent)** – Alternative 5 will produce an estimated 7.6 trucks per week of Class A biosolids based on 2050 maximum month sludge production.
5. **Technology 30-Year O&M Cost (10 Percent)** – The 30-year O&M cost in 2021 dollars is estimated at $39.2M. The highest cost item is biosolids disposal, which is due to the high volume and low solids concentration of the final product.
6. **Regulatory (10 Percent)** – The regulatory burden associated with ATAD is expected to be low. PSCAA will require a permit for odor control, and the WWTP will likely be covered under the Washington State Biosolids General Permit.
7. **Proven Technology (10 Percent)** – ATAD is a known and understood solids handling process, but it is not very common, with few installations in the region.
8. **Staffing (5 Percent)** – An estimated 1.0 full-time employee is needed to operate and maintain all the unit processes associated with ATAD.
9. **Process Complexity (5 Percent)** – The ATAD process is simple compared to anaerobic digestion (no biogas handling, boilers, heat exchangers, etc.) but is more complex than non-digestion processes as it includes both digestion and side stream treatment.
10. **CO_2 Generation (5 Percent)** – No natural gas is needed to support ATAD. However, truck traffic is high at 7.6 trucks per week.
11. **Total Energy Use (5 Percent)** – Alternative 5 has a low annual energy use of 359 kW due to no natural gas requirement. Energy use for Alternative 5 is driven primarily by aeration.

The advantages of Alternative 5 are:

- Class A biosolids production with low detention times;
- Few complex regulatory requirements;
- Low energy use; and
- Sludge dewaterability may increase.

The disadvantages of Alternative 5 are:

- Process complexity;
- High potential for odor;
- Nutrient side stream potential with process upset of a storage nitrification/denitrification reactor (SNDR) tank; and
- Large footprint.

7.7.7 Stage I Evaluation Scoring Matrix

The five main alternatives, having been evaluated against the 11 evaluation criteria, were assigned individual scores for each criterion. The individual scores were then totaled, accounting for the criterion's weight, into an overall score for the alternative. The scoring matrix is provided in **Table 7-16**.

Table 7-16. Stage 1 Evaluation Scoring Matrix

Criteria	Unit of Measure		Weight	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5	
				Enhanced Anaerobic Digestion		Vapor Recompression Drying		Gasification		Heat Drying		ATAD	
				Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Technology Capital Costs	Average Cost, Millions of 2021 USD		15%	$15.1	2.5	$9.3	4.6	$19.2	1.0	$8.3[1]	5.0	$12.2	3.6
Footprint	1 (fail) or 5 (pass)		15%	1	1	5	5	5	5	5	5	1	1
Nutrient Side Stream	1 - 5	1 – High Side Stream Nutrient Content 5 – Low Side Stream Nutrient Content	10%	1		5		5		5		3	
Truck Traffic	Trucks per Week[2]		10%	8.8	1.0	2.8	3.9	0.6	5.0	2.8	4.0	7.6	1.6
Technology 30-yr O&M Costs	Average Cost, Millions of 2021 USD		10%	$42	1.0	$27	4.2	$24	5.0	$37[1]	2.1	$39	1.6
Regulatory	1 - 5	1 – Most Permit Requirements 5 – Least Permit Requirements	10%	5		3		1		4		5	
Proven Technology	1 - 5	1 – Few Number of Installations 5 – High Number of Installations	10%	5		1		3		5		4	
Staffing	No. of FTEs		5%	2.0	3.4	3.0	1.4	1.6	4.1	2.1	3.2	1.0	5.0
Process Complexity	1 - 5	1 – High Process Complexity 5 – Low Process Complexity	5%	1		3		2		3		2	
CO_2 Generation	1 - 5	1 – High CO_2 Production 5 – Low CO_2 Production	5%	4		3		4		2		4	
Total Energy Use	kW		5%	215	5.0	617	4.1	211	5.0	1,983	1.3	359	4.7
Total			**100%**	**2.5**		**3.7**		**3.6**		**4.0**		**3.0**	

Notes:

1. Average cost of for dryer options per **Section 7.7.5**.
2. Based on a truck capacity of 25 wet tons.

The major conclusions that can be drawn from the Stage I evaluation are the following:

- Vapor recompression drying and heat drying were the two alternatives with the overall highest score. The relatively compact footprint and low truck traffic paired with the lowest capital costs make these two alternatives the highest scoring. Given their score, these two alternatives warranted further in-depth evaluation as part of the Stage II Evaluation.
- ATAD and enhanced anaerobic digestion both achieve significant solids destruction, but because the final product is only dewatered, biosolids disposal costs are significant. Alternatives that achieve high volume reduction (i.e., minimal water in final product) have significantly lower biosolids disposal costs and truck traffic.
- Gasification has significant regulatory hurdles that may prove challenging to overcome. While low O&M costs are realized due to low energy inputs, the life cycle costs are relatively high, as gasification has the highest capital cost. Gasification does have the potential of being the most energy neutral alternative depending on the LHV of the incoming sludge and whether ash or biochar is produced.

7.8 STAGE II EVALUATION

The objective for the second stage of the evaluation herein is to select between either the vapor recompression drying (Alternative 2) or the heat drying (Alternative 4) solids handling process. Whereas Alternative 2 is based on a single technology, Alternative 4 encompassed four dryer types; therefore, it will require further evaluation to define the optimal dryer type to compare against Alternative 2. Additionally, as part of the Stage II evaluation, the addition/integration of pyrolysis into the process was considered as a potential future option to further reduce truck traffic leaving the site.

7.8.1 Future Pyrolysis Integration

Pyrolysis was considered as a future add-on process that would add the ability of converting dried biosolids (75 to 90 percent) to biochar, and EQ Class A biosolids at >95-percent total solids. Dry cake, with a minimum solids content of 75 percent is conveyed to pyrolysis unit(s), which thermally decomposes the dried cake in the absence of oxygen. Pyrolysis produces both syngas and biochar and requires temperatures of 600 to 1,000 degrees Fahrenheit; however, the syngas produced by pyrolysis can be used to provide sufficient heat to sustain the process. Natural gas is needed during startup, but once operational, the heat generated from syngas is sufficient to maintain pyrolysis. Depending on the application, there is often excess heat that can be used elsewhere – such as in a shared hydronic loop. Due to the high temperatures of the pyrolysis process, several emerging contaminants (notably PFAS) are destroyed and not present in the final product. The sizing and design criteria for pyrolysis are summarized in **Table 7-17**.

Table 7-17. Pyrolysis Technology Summary

Parameter	Value
Uptime	85.6%
Yearly Operating Hours	7,500
Natural Gas Use (MMBTU/hr)	0.027
Annual Natural Gas Use (therm/yr)	2,112
Annual Electricity Use (kWh)	495,480
Total Energy Use (kWh/30 years)	15,359,571
Annual 93% Sulfuric Acid Requirement (Odor Control) (gal/year)	0
Annual 50% Sodium Hydroxide Requirement (Odor Control) (gal/year)	1,875
Foul Air Production (scfm)	0
Dried Biosolids Concentration (%)	100
Biosolids Production (dry lbs/day)	8,761
Biosolids Production (wet tons/week)	31
Trucks per Week	1.2
Staffing Requirement (FTEs)	0.25
Footprint (including feed hopper, pumps, etc.) (sf)	5,600

The Bioforcetech P3 pyrolysis units were used as the basis of the criteria and costs shown in **Tables 7-17** and **7-18**. Per the manufacturer, the system is designed to be operated 7,500 hours per year, which equates to an uptime of 85.6 percent. As pyrolysis requires a minimum of 75-percent dry cake, it can expand solids handling capacity by requiring less water evaporation in the upstream drying process, which is sized to produce 90-percent dried cake. Pyrolysis further reduces the volume of solids and reduces hauling and truck traffic at the WWTP, reducing the heat dryer truck traffic from 2.8 to 1.2 trucks per week. Biochar, being an EQ Class A biosolid, can be disposed of at a lower cost than conventional Class A or B biosolids and it can be sold for a commercial value to offset operational costs. This is because, as EQ biosolids are defined as such by meeting certain residual pollutant concentrations, other Class A processes can meet EQ requirements. However, given the nature of the pyrolysis process by which residual pollutants are removed from the sludge due to the elevated temperature of the process, pyrolysis can increase the ability to achieve EQ Class A biosolid classification. Biochar can be used as a soil amendment due to its absorptive properties (like activated carbon). The market for biochar sales has not been fully developed and is in its infancy but is seeing growth due to increased financially viable end uses being developed in local and regional markets. The estimated 2021 pyrolysis capital cost and 2021 annual O&M costs are $3.9M and $150,000, respectively. These costs result in a 30-year life-cycle cost of 6.8M for the addition of the pyrolysis system. Included in these costs are dried cake storage (feed to pyrolysis system), conveyance, pyrolysis reactor, and associated pyrolysis reactor support systems. These costs do not include system modifications, equipment, and utilities required for the implementation of a shared hydronic loop with either vapor recompression drying or the heat dryers. These costs are based on assumptions listed in **Section 7.6** combined with manufacturer proposals/quotes and engineering judgement.

Table 7-18. Pyrolysis Cost Summary

Parameter	Cost
Total 2021 Equipment Capital Cost[2]	**$3,900,000**
2021 Pyrolysis Equipment Capital Cost	$3,900,000
2021 Annual O&M Cost[1, 2]	**$150,000**
2021 ATAD Equipment O&M Cost	$150,000
30-Year O&M Cost[3]	**$2,900,000**
30-Year Life-Cycle Cost[3]	**$6,800,000**

Notes:
1. Excludes biosolids disposal costs.
2. 2021 US Dollars rounded to nearest $10,000.
3. 2021 US Dollars rounded to nearest $100,000.

The advantages of adding pyrolysis to the process, whether vapor recompression drying, or heat drying are:

- Reduction of truck traffic by an additional 50 percent; and
- Produces biochar, a sustainable product with potential commercial value.

The disadvantages of adding pyrolysis to the process are:

- Increased O&M cost;
- Pyrolysis adds process complexity; and
- Permitting requirements.

The addition of pyrolysis is not initially justified because the added permitting requirements, process complexity, and capital/O&M costs do not outweigh the benefits of reducing already low truck traffic by an additional 50 percent. The addition of pyrolysis should be considered as a potential future expansion of the solids handling process to free up additional capacity of either vapor recompression drying or heat drying. Pyrolysis may also become attractive to the City in the future should its priorities change to include the desire to produce a sustainable and commercially viable byproduct such as biochar, or if biosolids regulations change to require removal of emerging contaminants such as PFAS. For this reason, Pyrolysis Integration was added as a criterion in the Stage II evaluation, per **Section 7.8.2**.

7.8.2 Stage II Criteria

The Technology Capital Costs, Footprint, Technology 30-Year O&M Costs, Total Energy Use, and Process Complexity criteria utilized in Stage I were retained, albeit weighted differently. These criteria were scored similarly to the Stage I evaluation. New and specific criteria were developed for the Stage II evaluation, with criteria for Alternatives 2 and 4 that scored the same in Stage I being removed to ensure a more meaningful evaluation. The following new criteria were added for the Stage II evaluation:

- **Inlet DS Concentration Sensitivity (10 Percent).** The inlet sludge solids concentration can greatly affect equipment sizing. This qualitative criterion is based on the solids concentration for optimal equipment design and operation, as well as the sensitivity to fluctuations in the feed sludge solids concentration. Alternatives were assigned a score between 1 and 5, with low scores indicative of high inlet DS solids concentration requirements and high sensitivity to changes, while a high score indicated the ability to operate at a lower DS concentration.

- **Dewatering Requirement (10 Percent).** This qualitative criterion is based on the need for dewatering in the alternative. Alternatives that require dewatering are assigned a score of 1, while a score of 5 was assigned if dewatering was not necessary.
- **Pyrolysis Integration (5 Percent).** This qualitative criterion is based on the ability of an alternative to integrate with a future pyrolysis process. Alternatives were assigned a score of 1 if integration with pyrolysis was considered infeasible and/or highly complex, and a score of 5 if pyrolysis was considered highly feasible and/or less complex. The additional costs of incorporating pyrolysis into the process are not included in the Stage II evaluation.

The eight Stage II Evaluation criteria and their associated weights are as follows:

- Technology Capital Cost (20 Percent)
- Footprint (15 Percent)
- Technology 30-year O&M Cost (15 Percent)
- Total Annual Energy Use (15 Percent)
- Process Complexity (10 Percent)
- Inlet DS Concentration Sensitivity (10 Percent)
- Dewatering Requirement (10 Percent)
- Pyrolysis Integration (5 Percent)

7.8.3 Stage II Evaluation Matrix

After evaluating the alternatives against the eight evaluation criteria, each was assigned an individual score for each criterion. The individual scores were then totaled, accounting for the criterion’s weight, into an overall score for the alternative. The scoring matrix is provided in **Table 7-19**.

Table 7-19. Stage II Evaluation Scoring Matrix

Criteria	Description		Weight	Alternative 4								Alternative 2	
				Huber		Komline-Sanderson		Kruger		Centrisys		Sedron	
				Belt Dryer		Paddle Wheel Dryer		Belt Dryer		Compact Belt Dryer		Vapor Recompression Dryer	
				Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Technology Capital Costs	Average Cost, Millions of 2021 USD		20%	$7.7	5.0	$7.9	4.5	$9.2	1.2	$8.2	3.7	$9.3	1.0
Footprint	Footprint of Dryer and Ancillary Equipment, sf		15%	11,800	1.0	8,400	5.0	11,700	1.1	8,700	4.6	10,900	2.1
Technology 30-Year O&M Costs	Average Cost, Millions of 2021 USD		15%	$37.4	2.0	$33.1	3.3	$36.7	2.2	$40.6	1.0	$27.4	5.0
Total Annual Energy Use	Natural Gas and Electrical Power Converted to kW		15%	1,835	1.9	1,617	2.4	2,109	1.2	2,199	1.0	585	5.0
Process Complexity	1 - 5	1 – High Process Complexity 5 – Low Process Complexity	10%	3		4		3		3		2	
Inlet DS Concentration Sensitivity	1 - 5	1 – High Sensitivity to DS Concentration 5 – Low Sensitivity to DS Concentration	10%	3		5		4		1		5	
Dewatering Requirement	1 or 5	1 – Yes 5 – No	10%	1		1		1		1		5	
Pyrolysis Integration	1 - 5	1 – Infeasible/More Complex Integration 5 – Feasible/Less Complex Integration	5%	2		1		3		5		1	
Total			**100%**	**2.5**		**3.6**		**1.9**		**2.5**		**3.3**	

Technology Capital Costs (20 Percent). Total 2021 US Dollar heat dryer equipment costs, including all unit processes identified in the previous sections, ranged from $7.7M to $9.2M, with the Huber belt dryer being the lowest capital cost and the Kruger belt dryer being the highest. The highest odor control requirements for the Centrisys compact belt dryer drove up capital costs for this alternative. The vapor recompression dryer has similar costs, estimated at $9.3M despite not requiring dewatering and dewatered sludge storage.

Footprint (20 Percent). The most compact alternative is the Komline-Sanderson paddle wheel dryer at approximately 8,400 sf. The next largest is the Centrisys compact belt dryer at 8,700 sf. The Huber and Kruger belt dryers will require almost twice the footprint at 11,800 and 11,700 sf, respectively. The estimated square footage required to support the vapor recompression dryer is 10,900 sf. These values represent the entire footprint of each alternative, including thickening, WAS equalization, and dewatering (if applicable).

Technology 30-Year O&M Costs (10 Percent). The Komline-Sanderson paddle wheel dryer has the lowest O&M costs at $1.7M per year for a 30-year LCC of $41.0M. Its compact footprint and low odor control requirements compared to other alternatives allow for reduced odor control and odor control chemical costs. The vapor recompression dryer, because it does not require dewatering and dewatering sludge storage, had the lowest O&M cost at $1.4M per year for a 30-year LCC of $36.7M.

Total Energy Use (15 Percent). Based on natural gas and power consumption, the vapor recompression dryer will consume 585 kW of power on average. While electricity use is higher than heat drying alternatives, the natural gas consumption is significantly lower, making vapor recompression drying best in terms of energy use. The highest energy user is the Centrisys compact belt dryer at a total annual energy use of 2,199 kW. As a result, the highest score was attributed to the vapor recompression dryer.

Process Complexity (10 Percent). The three belt dryers were assigned a score of 3 for moderate process complexity as the systems are comparable in terms of technology and equipment type. The Komline-Sanderson paddle wheel dryer scored higher given the relative lack of motors, fans, and other maintenance-intensive equipment. Vapor recompression drying uses complex equipment, including large compressors, heat exchangers, and distillation towers. Complexity is reduced through the exclusion of dewatering and DS storage, but the equipment is relatively complex and not commonly used in the municipal wastewater industry.

Inlet DS Concentration Sensitivity (10 Percent). The Huber and Kruger belt dryer require a minimum of 15-percent DS for operation with a near consistent solids feed. Large fluctuations in solids content may cause operational issues but can be mitigated with solids storage. The Centrisys compact belt dryer is sensitive to inlet DS solids concentration. Increasing to 20-percent solids allows the dryer performance to improve significantly, with no back mixing required. The paddle wheel dryer can be designed for lower than 15-percent DS solids concentration, although it does see benefits from increasing the solids concentration as with all dryers. The paddle wheel dryer can handle some fluctuations in feed solids concentration by changing the elevation of the dryer outlet weir, which affects the solids residency time in the dryer. Vapor recompression can accept solids in the form of sludge in the 2 to 6 percent range, thus not requiring dewatering. As a result, the paddle wheel and vapor recompression dryers performed the best regarding this criterion.

Dewatering Requirement (10 Percent). Dewatering is required for all heat dryers, whereas it is not required for vapor recompression drying. As a result, only vapor recompression drying received a score of 5.

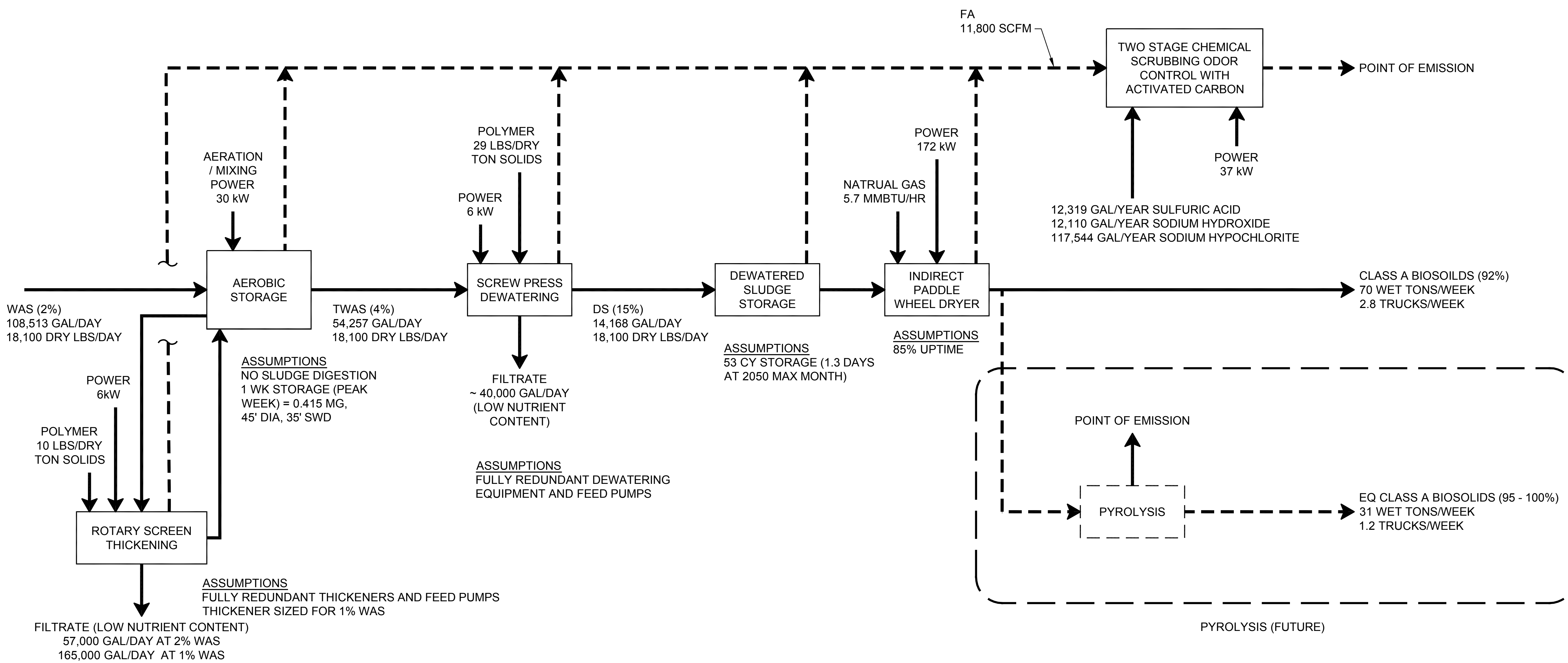
Pyrolysis Integration (5 Percent). Predisposing each dryer for the potential to share the hydronic loop with a future pyrolysis system is feasible and will allow for the WWTP to further reduce the respective truck traffic from each alternative by an additional 50 percent. As pyrolysis typically requires a feed in the 75-percent solids content range, it would extend the capacity of the dryers. The paddle wheel and vapor recompression dryer will be the most impacted by this upgrade, especially if done as an expansion later. This is mostly due to the heat source design for these two alternatives. The Centrisys compact belt dryer scored the highest as reducing the solids production to 75 percent, rather than 90 percent, will greatly reduce the size and costs of the dryer system. Such reductions may not be achievable in the other belt dryers; hence they did not score as high.

7.9 RECOMMENDATION AND CONCLUSION

In this chapter, a complex two-stage evaluation has been presented to define the solids handling process that will allow the City to meet its capacity needs at the existing WWTP site through 2050. The goal was to identify a core solids handling process and the preferred technology type for each unit process and establish the associated capital, O&M, and LCC costs. The process began with the Stage I evaluation: a full review of applicable technologies that resulted in an evaluation of enhanced anaerobic digestion, vapor recompression drying, gasification, heat drying, and ATAD. The addition of pyrolysis also was considered for the heat and vapor recompression technologies. The result of the Stage I evaluation indicated that the top two alternatives suitable for the City WWTP site and per the selected criteria were vapor recompression drying and heat drying. These alternatives (2 and 4) rose to the top of the evaluation in large part due to their lower footprint requirements and their ability to produce a >90-percent Class A biosolid, further resulting in reduced truck traffic from the site.

The second stage of this evaluation looked more in depth at vapor recompression drying and heat drying, using a revised set of criteria for a more focused evaluation relevant to these two technologies. Heat drying was broken out into three different types of dryers from four manufacturers (Huber, Kruger, Centrisys, and Komline-Sanderson), while vapor recompression drying was based on a single manufacturer (Sedron). The Komline-Sanderson paddle wheel dryer received the highest score of 3.6 in the Stage II evaluation. Its competitive capital and O&M costs, small footprint requirement, and minimal odor control requirements propelled this alternative ahead of its competition. The Komline-Sanderson dryer system’s relative simplicity and proven industry track record compensate for it being a less desirable candidate for the future expansion with a pyrolysis system, requiring greater modifications. The large footprint, elevated O&M costs, and sensitivity to variations in sludge feed resulted in lower scores for belt dryers (conventional and compact) based on the evaluation criteria. Finally, vapor recompression drying benefits significantly from not requiring a dewatering step. This reduces costs significantly and allows the technology to remain competitive with more established drying processes despite its novelty and relative process complexity.

Given the Stage I and II evaluation results summarized above, the process schematic and site plan of the recommended solids handling process with the Komline-Sanderson paddle wheel dryer are shown in **Figures 7-12** and **7-13**.



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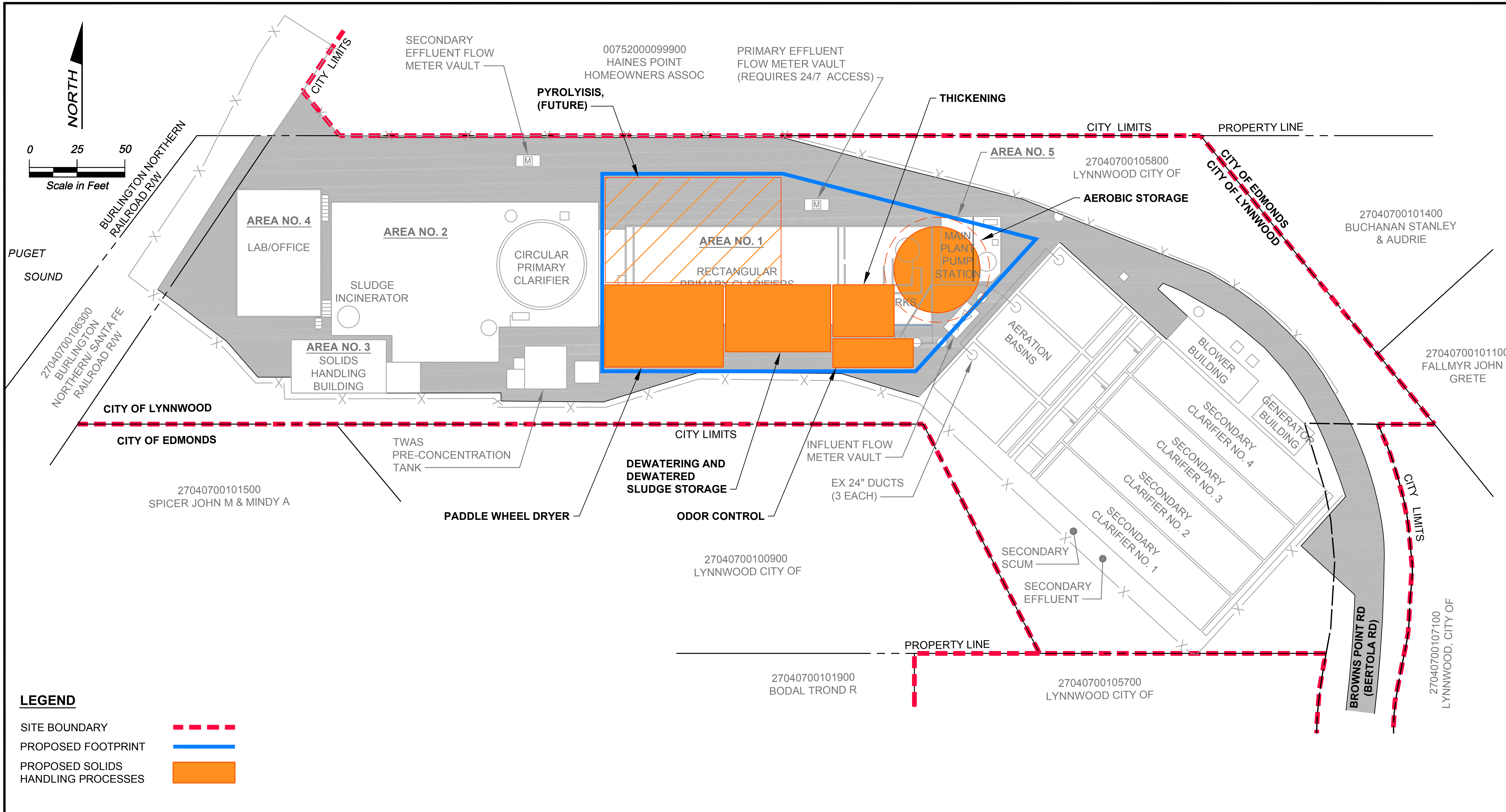
Indirect Paddle Wheel Dryer
Recommended Alternative Schematic

Lynnwood Facility Plan

June 2022

Figure **7-12**



Map Source:

This drawing was created from a variety of record drawing and site visit information.

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Indirect Paddle Wheel Dryer Recommended Alternative Layout

Lynnwood Facility Plan

June 2022

Figure **7-13**

To summarize the process illustrated in **Figure 7-13**, WAS is pumped from the secondary treatment system and equalized in a WAS equalization tank. The 45-foot-diameter WAS equalization tank is sized for the 2050 peak week of 2-percent WAS production, with a total volume of approximately 415,000 gallons. Mixing and aeration is achieved mechanically, using a recirculation pump with a nozzle and venturi. Recuperative thickening is used with two rotary screen thickeners (one duty, one standby) to increase solids content to a conservatively low 4 percent. From the WAS equalization tank, 4-percent WAS is pumped to two fully redundant screw presses for dewatering. Dewatered sludge at 15 percent is produced and conveyed to a 53 CY live bottom storage hopper (allowing for more than 1 day of 2050 maximum month sludge storage). It should be noted that dewatering and thickening performance and polymer use are heavily dependent on sludge characteristics; during final design, bench testing, pilot testing, or review of similar installations is recommended. Storage allows for minor maintenance activities on the dryer without taking any upstream solids handling processes offline and attenuates fluctuations in dewatered sludge production to ensure the dryer feed rate is consistent. The live bottom hopper discharges to one of two fully redundant piston pumps that feed the dewatered sludge to the dryer. The paddle wheel dryer, heated by a circulating loop of heated mineral oil using a natural gas boiler, dries the solids to produce Class A 90-percent biosolids. Dried biosolids are collected and then conveyed to a truck loadout for hauling and disposal offsite. Foul air is collected from the WAS equalization tank, thickeners, screw presses, DS storage hopper, dryer, and conveyors. A two-stage chemical scrubber removes odor from the collected air, passing it through an activated carbon filter for final polishing before discharge to atmosphere. Shall the City opt to add pyrolysis to the process to further reduce truck traffic leaving the site (by an estimated 50 percent), the pyrolysis system can be located as a packaged system in the area shown in **Figure 7-13**. Such a system will include dried cake storage (feed to pyrolysis system), conveyance, pyrolysis reactor, and associated pyrolysis reactor support systems.

The recommended solids handling process total 2021 US Dollar equipment cost is $7.9M, with an annual 2021 US Dollar O&M cost of $1.7M, and a total 30-year LCC of $41.0M. The recommended process, sized to meet the 2050 maximum month conditions with 85 percent uptime (310 days per year), will fit in the confined footprint at the site with fully redundant systems upstream of the dryer process. The recommended process is expected to produce, at the 2050 maximum month loadings, a maximum of 2.8 trucks per week of biosolids.

The addition of pyrolysis to the recommended heat drying alternative results in a total 2021 US dollar equipment cost of $11.8M with an annual 2021 US Dollar O&M cost of $1.7M, and a total 30-year LCC of $44.5M. These costs do not include the hydronic heating loop connection between the dryer and pyrolysis equipment. Biosolids disposal costs are reduced when compared with heat drying alone due to the reduction in solids production, which also results in slightly lower 1.2 trucks per week for biosolids hauling.

8 | RECOMMENDED IMPROVEMENTS

8.1 INTRODUCTION

This chapter presents the details for the proposed improvements to the City of Lynnwood's (City) wastewater treatment plant (WWTP). In general, these improvements include:

- Replacement of the existing preliminary treatment system with a new headworks located uphill from the existing secondary clarifiers;
- Removal of the primary treatment;
- New first and second stage aeration basins;
- Improvements to the existing aeration basins and secondary clarifiers;
- Replacement of the existing solids handling system with a facility, including an indirect dryer system; and
- Replacement of the existing effluent chlorination system with a new ultraviolet (UV) disinfection system.

This chapter is intended to provide sufficient detail that plans and specifications can be developed without substantial changes from the improvements described in this WWTP Facility Plan (Plan), as is required for Engineering Reports in accordance with Washington Administrative Code (WAC) 173-240-060 for municipal facilities. As the first step in the design phase, a preliminary design for all improvements recommended in this Plan will be performed due to the complexity of the improvements, additional information that may be gathered during the survey and geotechnical study to refine the site layouts, and any updates to regulatory requirements or City planning numbers that occur in the time between completion of this Plan and the start of the design phase.

8.1.1 Basis for Cost Development

O&M COST ESTIMATES

Annual operations and maintenance (O&M) costs are estimated for each major category of recommended improvements in this chapter. These costs are planning-level estimates of the O&M costs based on the projected average annual operating condition for each system. The costs do not include costs such as administrative, legal, laboratory, permitting, collection system O&M, or other recurring costs included in the total system operating cost.

Costs for each category of recommended improvements are analyzed at the projected average annual conditions based on the following categories.

Labor

The number of necessary full-time employees (FTEs) required for both the operation and maintenance of each system was based on a preliminary review of the *Northeast Guide for Estimating Staffing at Publicly and Privately Owned Wastewater Treatment Plants* (Northeast Guide) as produced by the New England Interstate Water Pollution Control Commission in November 2008. The Northeast Guide extends on the 1973 *Estimated Staffing for Municipal*

Wastewater Treatment Facilities guide produced by the US Environmental Protection Agency (EPA). The Washington State Department of Ecology (Ecology) has recommended the use of the Northeast Guide for the purposes of estimating staffing needs on other projects in recent years. A future staffing analysis is recommended to provide a detailed review of totalized staffing needs, but for the purposes of this Plan, approximated staffing values are provided based on the size and complexity of the proposed systems.

Annual staffing costs were assumed to be $104,000 per full-time employee.

Electrical

Electrical usage is estimated for each system based on the major motor loads, as well as the expected electrical loads associated with the buildings and other items for each system. Usage is estimated based on expected equipment motor loads and runtimes at the average annual condition.

Annual electrical costs were developed using the assumptions of an industrial cost for electricity of $0.086 per kilowatt-hour.

Natural Gas

Where applicable for specific systems (notably the dryer equipment for solids handling), natural gas usage has been estimated with cost calculated based on $1.00 per therm.

Chemicals

Where applicable for specific systems (such as supplemental carbon addition for denitrification in the secondary treatment system), the average annual volume, type, and cost of chemical are estimated.

Maintenance

Normal ongoing maintenance is expected to be completed using the labor estimated in the **Labor** category. Material expenses for normal maintenance related to replacement of short-lived items and wear parts, minor refurbishments, and other normal procedures needed to maintain the system were calculated based on a percentage of the system costs, as described for each system. These costs are conservatively estimated to allow for some complete equipment replacements in addition to normal refurbishments and rebuilds.

Biosolids Hauling

Biosolids hauling is specifically included as an operational cost for the solids handling system, as further discussed in that section.

Depreciation Costs for Complete System Replacement

To budget for the end of life complete replacement of treatment system components, annualized depreciation costs are sometimes included in the estimated ongoing annual costs. However, depreciation is difficult to accurately calculate for complex treatment systems, including many components with varying useful lifespans. Further, the assumption of in-kind replacement of equipment in the distant future may not be accurate as treatment objectives and methods will change. For the purposes of this Plan, the cost included in the **Maintenance** category for each treatment system is estimated conservatively to allow for some equipment replacements through the life of the system. Complete system replacement is not budgeted through annualized depreciation due to the unknown future strategies that will be available for both treatment and funding of improvements.

CAPITAL COST ESTIMATES

Capital costs are estimated for each major category of recommended improvements in this chapter. Cost estimates prepared by RH2 Engineering, Inc., (RH2) for projects in the Capital Improvement Plan (CIP) are considered to be Class 4 estimates based on standards established by the American Association of Cost Engineers (AACE) used for analysis of options. Class 4 estimates are described as generally being prepared with very limited information and subsequently have wide accuracy ranges. The typical accuracy range for this cost estimate class is from -30 percent to -15 percent on the low side and from +20 percent to +50 percent on the high side. The following general assumptions were made as part of estimating capital costs:

- Planning-level cost estimate is in 2021 US dollars with no escalation for inflation.
- Contractor overhead and profit is included in individual cost items.
- Washington State sales tax (WSST) is 10.4 percent.
- Indirect costs are included to capture costs associated with consultant fees for engineering design, permitting, services during construction, and commissioning. Indirect costs do not include owner costs. Indirect costs are included as 30 percent of the sum of the subtotal and WSST.
- Construction costs such as installation, contractor overhead and profit, etc. are embedded in the capital cost items.
- Contingency is included and is 30 percent of the sum of the subtotal and WSST. A 30-percent contingency is consistent with a Class 4 AACE Estimate.

Other assumptions for cost estimating specific to individual estimates are included in the respective capital cost discussions.

The opinion of probable planning-level cost herein is based on the current understanding of conditions at the project location. RH2 and BHC Consultants (BHC) have no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices, or bidding strategies. RH2 and BHC cannot and do not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown. The cost estimates provided reflect RH2's and BHC's professional opinions of costs at this time.

8.2 WWTP UPPER SITE PREPARATION

8.2.1 Introduction

To accommodate a new headworks and additional aeration basins, the WWTP footprint will need to be expanded. As noted in **Chapter 6**, the area uphill from the existing secondary clarifiers is the only feasible location for this expansion. This will require significant clearing and grading, realignment of the existing access road and influent gravity sewer piping, and rerouting of Outfall Creek piping. Due to the complexity of this site preparation, it is described in detail in this section separately from the proposed WWTP infrastructure improvements.

8.2.2 Description of Improvements

MAJOR EXCAVATION AND GRADING

The upper site topography is ravine-like with steep slopes and significant vegetation, including large trees. To begin the upper site preparation, clearing of the vegetation will be necessary. Removal of the vegetation will necessitate substantial sediment and erosion control measures, as well as temporary and permanent measures to ensure slope stability during excavation and grading. It is recommended that all clearing and grading work be completed during the summer months to reduce erosion concerns and minimize sediment transport via vehicles leaving the site. Permanent erosion control and slope stability measures should be implemented prior to the wet weather season.

Exhibit C-5 Upper Site Construction Grading Plan in **Appendix C** estimates the extents of excavation for the proposed headworks and basins. This approximation is conservative as it assumes open-cut excavation with temporary vertical shoring installed for the final 15 feet of the excavation of the headworks and basins. Clearing vegetation and final slope stabilization measures will need to occur well beyond the extents of the proposed excavation extents.

For conservative planning, it is assumed that excavation will impact Bertola Road and the influent sewer pipe within the road corridor and will require realignment. Further, the Outfall Creek pipe and structures must be realigned. These improvements are described later in this section.

A substantial amount of cut and fill will be required for the installation of the proposed infrastructure. There likely will not be substantial available space onsite for stockpiling of material, and as such, the majority of earth excavated will be transported from the WWTP and either stored for potential return and fill or disposed of offsite. Due to the nature of the surrounding residential area, it is unlikely that large storage or disposal sites will be identified close to the WWTP. Hauling of material could significantly impact the earthwork costs for the project, and the future design must consider strategies to reduce the earthwork through temporary shoring or other methods. Significant hauling trips of fill material on residential roads will also prompt consideration of potential road repairs or other off-site restoration should the heavy hauling vehicles detrimentally impact the local roads. The excavation and associated hauling could be significantly reduced with additional temporary shoring, which should be thoroughly analyzed during the future design.

The proximity of the residential houses, especially to the southwest of the proposed excavation area, should be considered with the future design to ensure impacts to these properties are minimized during construction. This may necessitate specific construction requirements for excavation and embankment compaction methods to prioritize slope stability and structural integrity of the surrounding properties.

Exhibit C-6 Upper Site Final Grading Plan in **Appendix C** shows the approximated final grading of the site once the headworks and basin construction is complete. **Exhibits C-7** and **C-8** provide the approximated cross sections of the temporary and final excavations assuming only the bottom 15 feet of the temporary excavation is vertically shored. A permanent retaining wall will be required on the south and west faces of the proposed basins to retain the existing steep slopes.

INFLUENT SEWER SYSTEM AND ACCESS ROAD

Exhibit C-9 Upper Site Preparation in **Appendix C** shows the approximated realignment of Bertola Road and the gravity influent pipe entering the WWTP relative to the proposed improvements. Bertola Road will be reconstructed north of the existing road and will require grading and shoring to establish a new road prism at this location. The new road must be constructed first, while the existing road remains in service.

The new influent pipe will follow the new Bertola Road alignment. A significant advantage this site configuration offers is that the headworks will be located at an elevation higher than the other treatment steps with all influent flow by gravity from the collection system, through the headworks, to the new aeration basins. Realignment of the new influent pipe will necessitate reconnection of the existing influent pipes from the City of Edmonds as shown in **Exhibit C-9**. Due to the steep gradient of the influent pipe, energy dissipation will need to be considered with the realignment of the influent pipe. This will likely necessitate a structure to dissipate and align influent flow into the headworks as shown in the exhibit.

Once the new road and influent pipe is complete, a temporary connection from the new pipe to the existing pipe will be necessary to reroute flow through the new pipe to the existing headworks. Once complete, the existing road and influent pipe can be removed and major site excavation can begin.

OUTFALL CREEK REALIGNMENT

Outfall Creek flows through the WWTP site from southeast to northwest. The open creek discharges to a catch basin and flows through 24-inch pipe to an outfall to Puget Sound. The existing piped section of the creek must be rerouted outside the footprint of the proposed headworks and basins as conceptually shown in **Exhibit C-9**. This will prompt substantial considerations as discussed in **Chapter 9**. However, to fully utilize the existing WWTP site to meet the needs of the planning period, realignment of the enclosed portion of Outfall Creek is imperative. This work would be completed in conjunction with the mass excavation of the upper site.

SITE STABILIZATION AND LANDSCAPING

Once excavation, shoring, and utility realignments are completed, plantings and other measures will be necessary to stabilize the site, offset the removal of the existing vegetation, and provide visual mitigation. This will consist of both temporary measures, such as erosion control measures for the excavated area until final structure construction can be completed, as well as final measures such as landscaping of areas that will not be disturbed by the future projects. The type, scope, and extents of these measures will be considered during the future design and adequate evaluation should be given to future access for landscape maintenance, which may be limited by the installation of the headworks and basins. Terracing of slopes or other methods of stabilization that allow for plantings should be considered. The proposed landscaping will be configured in a way that limits visibility of the proposed infrastructure from the surrounding residential community. Landscaping and stabilization methods will be reviewed by the local jurisdiction as discussed in **Chapter 9**.

UTILITY EXTENSIONS

As part of the upper site preparation, a new electrical service will be established. This work is further detailed in **8.7 Electrical and Control System Improvements**. Additionally, a larger gas line must be extended through the site from the mainline in 76th Avenue to support the future solids handling improvements. This extension is further discussed in **8.6 Solids Handling Improvements** and must be constructed during the upper site preparation.

8.2.3 Capital Cost

The proposed upper site improvements are not expected to change the ongoing operation and maintenance costs for the facility, and as such, the life-cycle costs are not provided. **Table 8-1** provides a summary of the estimated capital costs for preparation of the upper site as described in this section.

Table 8-1. Upper Site Preparation Capital Costs

Item No.	Description	Total Amount
1	Mobilization	$1,090,000
2	Clearing, Excavation, Shoring, Grading, and Resurfacing	$6,140,000
3	Below-Grade Utility Reconfiguration and Extension	$980,000
4	Outfall Creek Realignment	$2,000,000
5	New Electrical Service	$750,000
	Subtotal	**$10,960,000**
	Sales Tax (10.4%)	$1,140,000
	Construction Total	**$12,100,000**
	Indirect Costs (30%)	$3,630,000
	Planning-Level Contingency (30%)	$3,630,000
	Project Total	**$19,360,000**

1. **Mobilization:** Mobilization, contractor's temporary utilities and facilities, temporary bypass, and demobilization. The mobilization value is 10 percent of the total of items 2 through 5.

2. **Clearing, Excavation, Shoring, Grading, and Resurfacing:** Clearing of large trees and vegetation on the upper portion of the site; mass excavation and shoring as necessary for the construction of the proposed headworks and basins; final grading and construction of the realigned entrance road; and stabilization of all final surfaces
3. **Below-Grade Utility Reconfiguration and Extension**: Realignment of the influent sewer pipe to the proposed headworks, including an energy dissipation structure.
4. **Outfall Creek Realignment**: Realignment of the Outfall Creek pipe outside the footprint of the proposed headworks and basins.
5. **New Electrical Service**: New electrical service, including transformer and backup generator, to serve the new headworks and first stage basins. Electrical equipment costs are included in the secondary treatment cost items.

8.3 PRELIMINARY TREATMENT IMPROVEMENTS

8.3.1 Introduction

The existing headworks facility is undersized for 2050 peak hour flows and lacks adequate redundancy in preliminary treatment equipment as described in **Chapter 5**. Moreover, it is located at an elevation below the existing secondary clarifiers, meaning primary effluent must be pumped up the hill to facilitate secondary treatment. As stated previously, the only available space at the WWTP site is uphill of the secondary clarifiers. This area is the only viable location to construct a new headworks facility and will allow for reconfiguration of the hydraulic profile to provide gravity flow through the preliminary, secondary, and disinfection processes. This also will allow the footprint of the existing headworks, Main Plant Pump Station, and primary clarifiers to be reclaimed for other improvements.

8.3.2 Description of Improvements

LOADING CRITERIA

The headworks infrastructure will be designed to provide capacity for the 2050 peak hour flow of 30 million gallons per day (MGD). The headworks infrastructure must function adequately at significantly reduced flows as well. The future design should consider the range of possible flows to the headworks to ensure that, for example, influent channels maintain solids suspension at low flows while adequately passing peak flows. The analysis in this chapter serves to provide a basic size and layout of the headworks for the purposes of estimating capital costs.

CONFIGURATION

General

The proposed headworks will be housed in a two-floor concrete building. The upper level will house the screening equipment and channels, along with the grit removal equipment with the grit chambers located outdoors.

The lower level of the headworks will primarily serve as an extension of the exterior pipe gallery. This may include the flooded suction grit pumps, internal recycle valve manifold, return activated sludge valve manifold, and the aeration blowers and piping. These systems are described in greater detail in **8.4 Secondary Treatment Improvements.**

Figure 8-1 and **Figure 8-2** provide schematics of the upper and lower levels of the proposed headworks, respectively.

Figure 8-1 – Upper Level of New Headworks

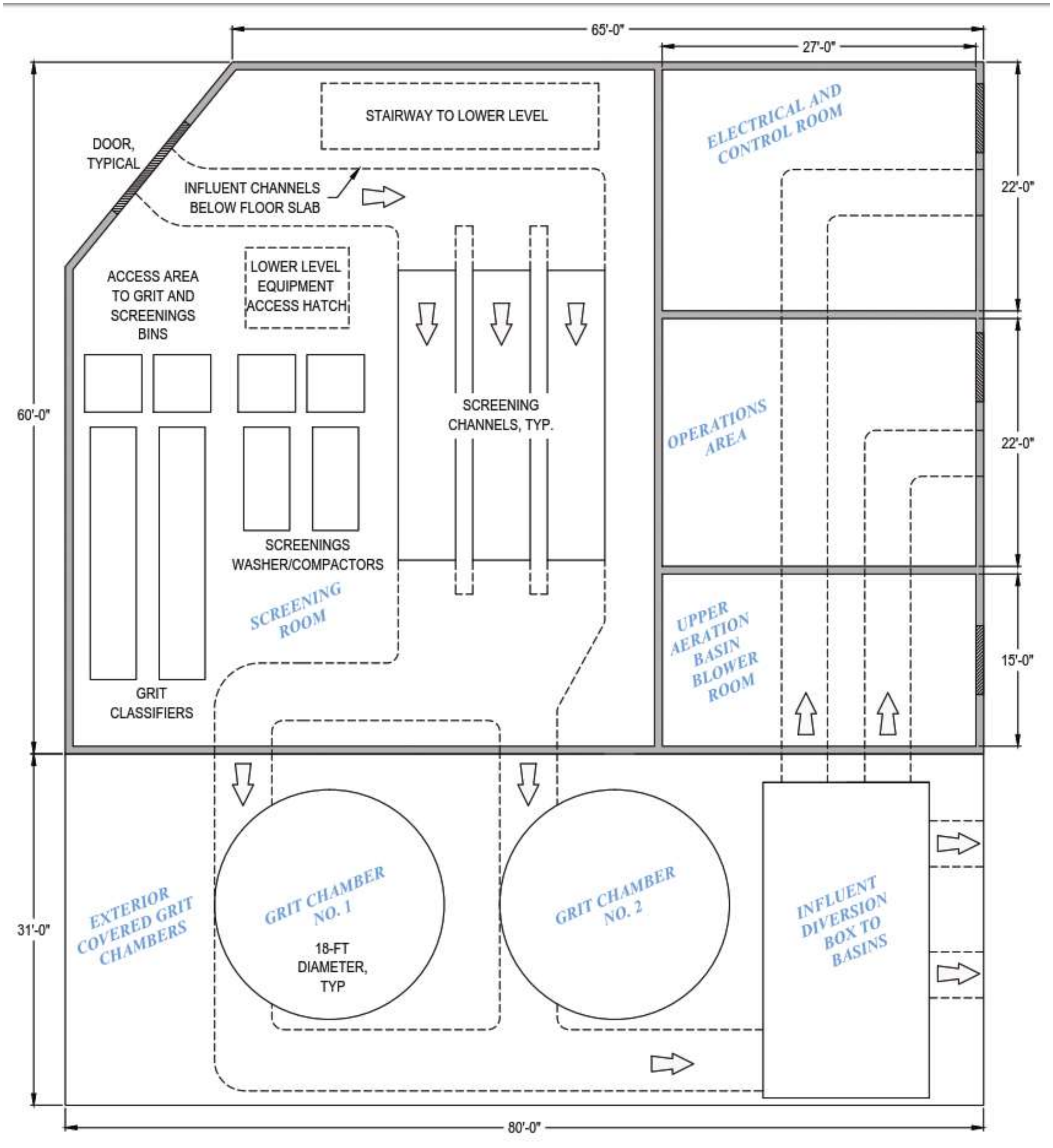
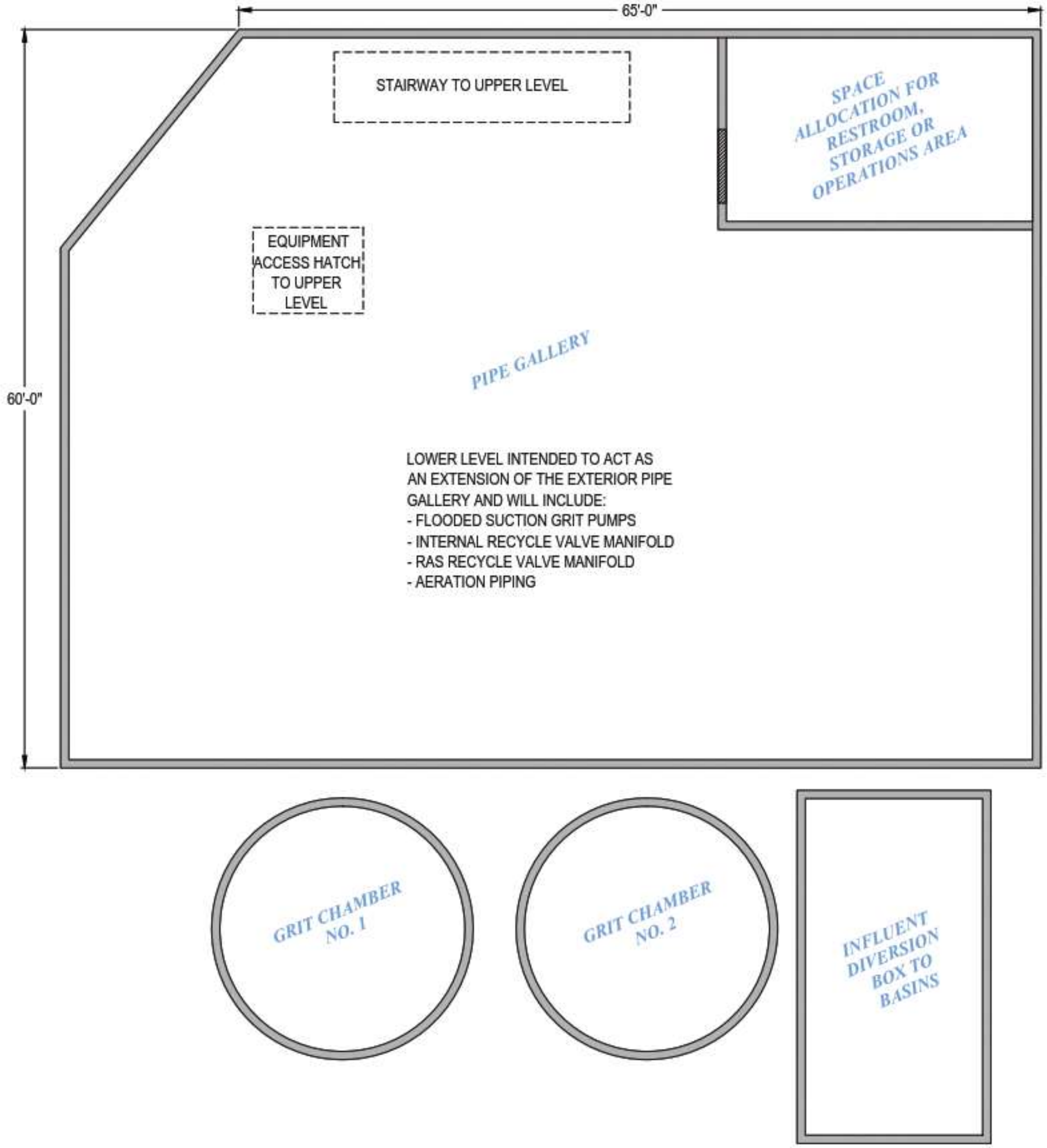


Figure 8-2 – Lower Level of New Headworks



Influent Metering

Metering of the influent will be completed with an open channel flow meter installed in a below-grade vault upstream of the headworks screening channels. This vault can be installed between any energy dissipation structure and the headworks in a manner that provides sufficient upstream and downstream pipe lengths to ensure accurate influent metering.

Screening System

Influent screening should be two-dimensional perforated plate screening to provide the higher screenings capture desired by operators compared to the existing one-dimensional bar screen. Two dimensional screens have reduced hydraulic capacity compared to one-dimensional screens and require a large screening area to accommodate flow. Continuous element perforated plate screens with 6 millimeter (mm) openings were reviewed for initial sizing and space planning for the headworks. It is estimated that a 5-foot-wide by 8-foot-deep screening channel with a 6 mm screen would provide a 30 MGD capacity. A second identical channel and screen would be included to provide full redundancy. For planning, a third channel is included and could be outfitted as a bypass channel, a manual screen, or in the future, a third mechanical screen could be installed.

Screenings will be conveyed via sluice from the two online screens to two washer/compactors sized to provide 100-percent redundancy at the projected screenings load. Each will discharge to a dedicated dumpster that can periodically be emptied. All dumpsters will be located towards the entrance such that they may easily be moved in and out of the building.

Multiple vendors can provide similar screening equipment for competitive bidding during design.

Grit Removal

Grit removal will consist of vortex-style grit chambers constructed of cast-in-place concrete. An 18-foot-diameter vortex grit chamber should provide capacity for 30 MGD. It is recommended that full redundancy of this system be provided with two 18-foot-diameter vortex grit chambers. Screened influent will then be split between both chambers and, normally, one chamber can be offline. Grit will be removed via flooded suction grit pumps located in the lower level of the headworks and pumped to two grit washer/classifiers, each dedicated to a grit chamber to provide redundancy. Each will discharge to a dedicated dumpster similar to the screenings equipment. Multiple vendors can provide similar equipment for competitive bidding during design.

Odor Control

Odor control will be required for the air removed from the upper level of the headworks and the influent channels, covered grit chambers, and distribution structures. It is likely that the odor control system will be similar to that proposed for the solids handling system, which is a dual stage chemical scrubber with an activated carbon polishing step; however, the future design should review other options for odor control at the headworks. The odor control likely will be located west of the proposed headworks and south of the secondary clarifiers. The odor control system point of emission will be regulated by the Puget Sound Clean Air Agency (PSCAA).

Other Considerations

Electrical

A new electrical service will be needed to serve the new headworks and additional basins as discussed in **8.7 Electrical and Control System Improvements**. The headworks will require a dedicated electrical room for motor control centers serving the equipment located at the new headworks and additional basins. This room will need to be separated from the main headworks building to ensure that the room is not a classified location per National Fire Protection Agency (NFPA) 820 and is suitable for motor control centers.

A new generator will be located near the headworks electrical room to provide backup power for the equipment in the new headworks and additional basins. The generator likely will be pad mounted with an outdoor-rated enclosure.

Operations Area

Due to the distance between the new headworks and the operations center at the lower end of the site, it is recommended that a small operations area be constructed within the headworks. This would likely include a work station, lockers, and a restroom. The final design will provide a layout of these facilities and they may need to be split between the upper and lower levels of the headworks.

Flow Splitting to Basins

The headworks must provide a diversion structure capable of evenly splitting flow between the online basins. This will likely consist of concrete structures between the lower level of the headworks and proposed basins with weir gates for directing flow to each online zone.

Lower Level Pipe Gallery

The lower level of the headworks is intended to serve primarily as a pipe gallery with valve manifolds for the internal recycle and return activated sludge (RAS) systems. These systems will be configured with options for discharge to multiple zones of the basins and will likely require both manual and automated valves and metering for this purpose. This equipment should be installed in an accessible location that the lower level of the headworks will provide.

RELIABILITY AND REDUNDANCY

The proposed preliminary treatment infrastructure is designed have complete redundancy at the 2050 peak hour flow condition. The screening system is sized such that one screen could handle this flow with the second screen providing 100-percent online redundancy. Similarly, each grit chamber is capable of individually processing the 2050 peak hour flow, such that the other would provide 100-percent online redundancy. Similarly, the ancillary equipment, such as the screenings washer/compactors, grit pumps, and classifiers, would all provide 100-percent redundancy.

EXPANDABILITY

Due to the physical constraints of the site, expanding the footprint of the proposed headworks in the future would be very difficult. However, the proposed headworks will be designed to provide capacity for the projected 2050 peak flow with a redundant influent screening channel and grit removal system. In the future, the three channels and two grit removal systems could be operated to further increase the hydraulic capacity of the headworks, although at a reduced level of redundancy. However, as the collection system redevelops to support growth, it is likely that sources of infiltration and inflow (I/I) can be reduced, which will reduce the peak flow to the headworks. As such, sizing the headworks for 30 MGD is likely conservative, and expanding the footprint of the headworks is unlikely to be needed until well beyond the planning period.

8.3.3 Environmental Impacts and Public Acceptability Review

The existing headworks/preliminary treatment system is undersized and requires some influent to bypass mechanical screening through a channel with manual screening during peak flow conditions. The proposed preliminary treatment improvements pose the significant environmental benefit of providing full redundancy at peak flow conditions to provide the screening and grit removal necessary to protect downstream treatment processes. This provides additional protection against a bypass of partially treated wastewater to the Puget Sound, which is a significant environmental concern posed by the peak wet weather flow to the WWTP.

A potential impact on public acceptability of any preliminary treatment system is the generation of odors if not properly contained and managed. The headworks will include odor control for this purpose.

8.3.4 Design Criteria

Table 8-2 provides a summary of the design criteria for the proposed preliminary treatment system.

Table 8-2. Preliminary Treatment System Design Criteria

Parameter	Value	Units
Loading Criteria		
Average Daily Flow (2050)	5.2	*MGD*
Peak Daily Flow (2050)	30.0	*MGD*
Screening Channels		
Quantity	3	#
Channel Width	60	*in*
Channel Depth	96	*in*
Influent Screening		
Screen Type and Configuration	Continuous element perforated plate	
Screen Quantity	2	#
Screen Openings	6.0	*mm*
Screen Capacity (each)	30.0	*MGD*
Screenings Washer/Compactor Quantity	2	#
Influent Grit Removal		
Configuration	Vortex	
Number of Grit Chambers	2	*#*
Grit Chamber Capacity (each)	30	*MGD*
Grit Pump Type	Flooded suction recessed impeller	
Grit Pump Capacity	250	*gpm*
Grit Classifier Quantity	2	*#*
Grit Classifier Screw Size	12	*in*
Odor Control		
Configuration	Dual stage chemical scrubbing	
Recommended Upper Level Air Exchanges	30 ac/hr	

The preliminary treatment system is sized to provide a 100-percent redundancy in screening and grit removal systems for the 2050 peak hour flow condition.

8.3.5 Life-Cycle Cost

DESIGN LIFE

The expected design life of the electrical and mechanical components of this system is approximated at 20 years, with some high wear items necessitating refurbishment or replacement on shorter intervals. The structural components of the system (tankage and buildings) and major piping systems are intended to last significantly longer, at least 40 years, and with proper maintenance could have an indefinite life.

O&M

A discussion of the expected ongoing O&M costs is provided by category as follows.

Labor

For preliminary treatment O&M needs a system of the City's size, and including mechanical screening, automated grit removal, and odor control, an average staffing level of 1 FTE is recommended for planning.

Electrical

Electrical service will be provided to all equipment and usage is estimated for the annual average operating condition. It should be noted that the future design may use natural gas for heating of the building; however, at this level, electrical power was assumed for all heating.

Chemicals

No significant continual chemical usage is expected for the preliminary treatment system.

Maintenance

Annual material expenses for normal maintenance procedures were calculated at 2 percent of the construction cost for the major mechanical and electrical systems used for preliminary treatment. This cost is estimated to cover landfill disposal of the screenings and grit generated at the headworks.

The estimated annualized O&M costs for the future secondary treatment system are summarized in **Table 8-3**.

Table 8-3. Preliminary Treatment Estimated Annual O&M Costs

Description	Total Amount
Labor for Operations and Maintenance	$104,000
Electrical	$94,000
Chemical	$0
Maintenance	$200,000
Total O&M *(Rounded up to nearest $10,000)*	**$400,000**

The total future preliminary treatment system annual O&M cost is expected to be approximately $400,000 in 2021 US dollars.

CAPITAL COST

The planning-level cost estimate for the planning, design, permitting, and construction of the future preliminary treatment system is provided in **Table 8-4**.

Table 8-4. Preliminary Treatment Estimated Capital Cost

Item No.	Description	Total Amount
1	Mobilization	$1,362,000
2	New Headworks	$13,620,000
	Structural	*$5,535,000*
	Mechanical	*$5,202,000*
	Odor Control	*$2,880,000*
	Subtotal	**$14,982,000**
	Sales Tax (10.4%)	$1,560,000
	Construction Total	**$16,542,000**
	Indirect Costs (30%)	$4,970,000
	Planning-Level Contingency (30%)	$4,970,000
	Project Total	**$26,482,000**

1. **Mobilization:** Mobilization, contractor's temporary utilities and facilities, temporary bypass, and demobilization. The mobilization value is 10 percent of the total of item 2.
2. **New Headworks:** New headworks building consisting of cast-in-place concrete lower level and concrete masonry unit upper level; cast-in-place influent screening channels in the upper level; outdoor, covered grit chambers and distribution structure and gates; mechanical equipment, including influent screens, screenings washer/compactors, grit paddle drives, classifiers, grit pumps, lower level pipe, and valve systems for internal recycle and RAS systems; heating, ventilation, and air conditioning (HVAC) and odor control systems; fire suppression; and monitoring and alarming equipment per NFPA 820.

8.4 SECONDARY TREATMENT IMPROVEMENTS

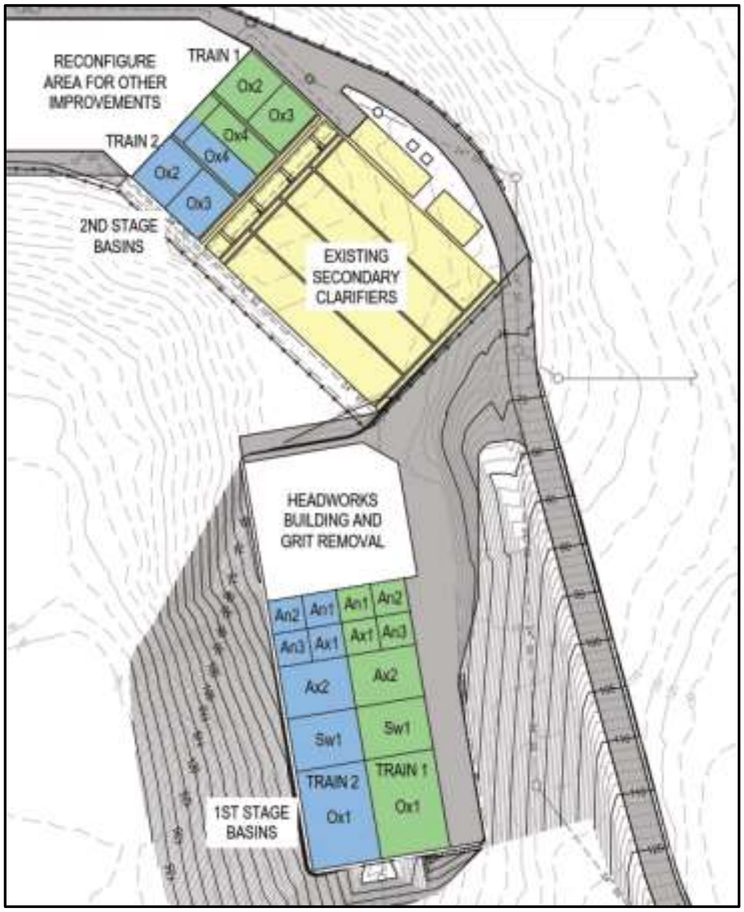
8.4.1 Introduction

Various approaches to the secondary treatment system improvements necessary to address deficiencies of the existing system and aging infrastructure, expand capacity, and meet potential Total Inorganic Nitrogen (TIN) reduction requirements were evaluated in **Chapter 6**. An approach that removes the existing primary clarifiers and expands aeration basin tankage, coupled with process control elements to facilitate a densified activated sludge in a continuous flow reactor configuration (CFR-DAS), was determined to have the highest likelihood of meeting the 2050 capacity and TIN reduction requirements. This is the recommended approach to secondary treatment and is described in detail in this section.

8.4.2 Description of Improvements

Figure 8-3 shows the basic layout of the new secondary treatment system providing the maximum amount of aeration basin tankage that can be supported by the existing site due to the topographical and other constraints noted in **Chapter 6**. The approximated maximum value of 3 million gallons (MG) of total aeration basin tankage was used in **Chapter 6** to analyze alternatives. A slightly reduced total size of 2.75 MG is used in this chapter for the conservative estimation of design criteria. If the future design can incrementally increase the proposed basin volume to 3 MG or beyond, this should be considered relative to the additional cost or other impacts.

Figure 8-3 – Proposed Secondary Treatment System



Note: Figure does not show proposed utilities interconnecting the 1st and 2nd stage basins

Figure 8-3 shows two identical trains consisting of anaerobic (Ax), anoxic (Ax), and aerobic or oxic (Ox) zones in the first stage activated sludge aeration basins and latter aerobic zones in the second stage basins. A swing (Sw) zone is also shown, which can be operated as aerobic or anoxic. The first stage basins will be in the available area on the upper site, and the second stage basins will be constructed within the footprint of the existing aeration basins. The new headworks, as discussed in **8.3 Preliminary Treatment Improvements** of this chapter, and the existing secondary clarifiers will be between the two stages of aeration basins. **Table 8-5** provides the approximate dimensions of the anaerobic, anoxic, and oxic zones within the proposed aeration basins.

Table 8-5. Approximate Dimensions of Proposed Aeration Basins

Zone	Length (ft)	Width (ft)	SWD (ft)	Area (ft²)	Volume (cf)	Rounded Volume (MG) Single Train	Rounded Volume (MG) Two Trains Total
First Stage Basins							
An1	19	12	24	228	5,472	0.04	0.08
An2	19	12	24	228	5,472	0.04	0.08
An3	19	12	24	228	5,472	0.04	0.08
Ax1	19	12	24	228	5,472	0.04	0.08
Ax2	26	39	24	1,014	24,336	0.18	0.36
Sw1	26	39	24	1,014	24,336	0.18	0.36
Ox1	60	39	24	2,340	56,160	0.42	0.84
Second Stage Basins							
Ox2	26	32	24	832	19,968	0.15	0.30
Ox3	26	32	24	832	19,968	0.15	0.30
Ox4 (Pax)	48	15	24	720	17,280	0.13	0.26
Basins Total						**1.38**	**2.75**

SWD – Side water depth

Table 8-6 provides the dimensions of the existing secondary clarifiers.

Table 8-6. Dimensions of Existing Secondary Clarifiers

Tank	Length (ft)	Width (ft)	SWD (ft)	Area (ft²)	Volume (MG)
Each (4)	120	24	14	2,880	0.30
Secondary Clarifiers Total				**11,520**	**1.21**

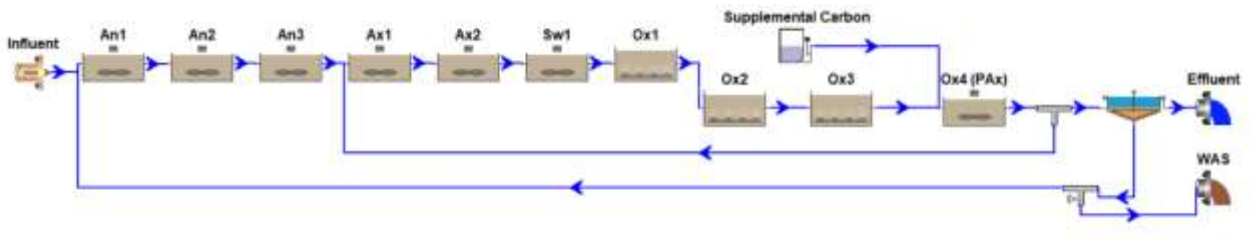
BIOWIN MODEL ANALYSIS

General

To evaluate potential secondary treatment system options, **Chapter 6** provided basic BioWin modeling results for the CFR-DAS process. This modeling was completed at the 2050 maximum month condition for comparing potential secondary treatment alternatives, as well as to approximate the capacity afforded by 2.75 MG of aeration basin concrete tankage. BioWin modeling is completed in this Chapter using the 2040 maximum month to approximate sizing and performance of equipment, which will have a shorter design life than the concrete tankage and will likely require replacement prior to 2050. These analyses are used to establish the basic design criteria for the proposed secondary treatment system.

To allow for nitrogen reduction to meet the potential future TIN requirements, the solids retention time (SRT) must be sufficiently long to provide reliable nitrification and denitrification. As the SRT increases, the mixed liquor suspended solids (MLSS) concentration increases with the growth of the biomass. The increase in MLSS corresponds to an increase in secondary clarifier solids loading rate (SLR). As noted in **Chapter 6**, the secondary clarifier SLR will limit the capacity of the WWTP and densification strategies must be employed to allow an increased SLR. A schematic of the BioWin model used to predict SLR and other parameters is shown in **Figure 8-4**.

Figure 8-4 – Schematic of Proposed Secondary Treatment System Layout in BioWin



The model has a feature that allows the user to select a specific SRT for a simulation. For a given SRT and mixed liquor temperature, the model will calculate the corresponding effluent nitrogen species, aeration demand, MLSS concentration, clarifier SLR, and the amount of waste activated sludge (WAS) produced.

Similar to **Chapter 6**, the BioWin model was run at various SRTs for each loading condition using steady-state simulation. The predicted SRT necessary for TIN reduction was increased to the design SRT by using a conservative factor of 1.5 to account for normal diurnal flow and loading variations. This factor was established in the diurnal flow analysis in **Chapter 4**. At the design SRT, the predicted effluent TIN, aeration demand, MLSS concentration, clarifier SLR, and WAS generation are tabulated.

Loading Conditions

The Puget Sound Nutrient General Permit (PSNGP) proposes a seasonal TIN limit of 3 milligrams per liter (mg/L) from April through October. Ecology is currently completing additional modeling and analyses that may provide a TIN limit structure that varies throughout the year, such as with a low TIN limit (i.e. 3 mg/L) during the hottest months of the year and a higher limit (i.e. 5 to 10 mg/L or higher) during the colder months. This sort of structure would allow for purveyors to have more a readily achievable limit when influent flows are high due to wet weather and temperatures are colder, which slows the growth of nitrifying organisms in WWTPs. Seasonal or monthly limits may be considered as well; longer periods over which effluent results can be averaged would benefit the purveyors.

Chart 4-2 from **Chapter 4** is reproduced in **Chart 8-1** to show the historical individual daily WWTP flow values on a year over year basis for comparison to the proposed seasonal TIN limit period, while **Chart 8-2** similarly shows the historical WWTP effluent temperature.

Chart 8-1 – WWTP Daily Flow Values (2015-2020)

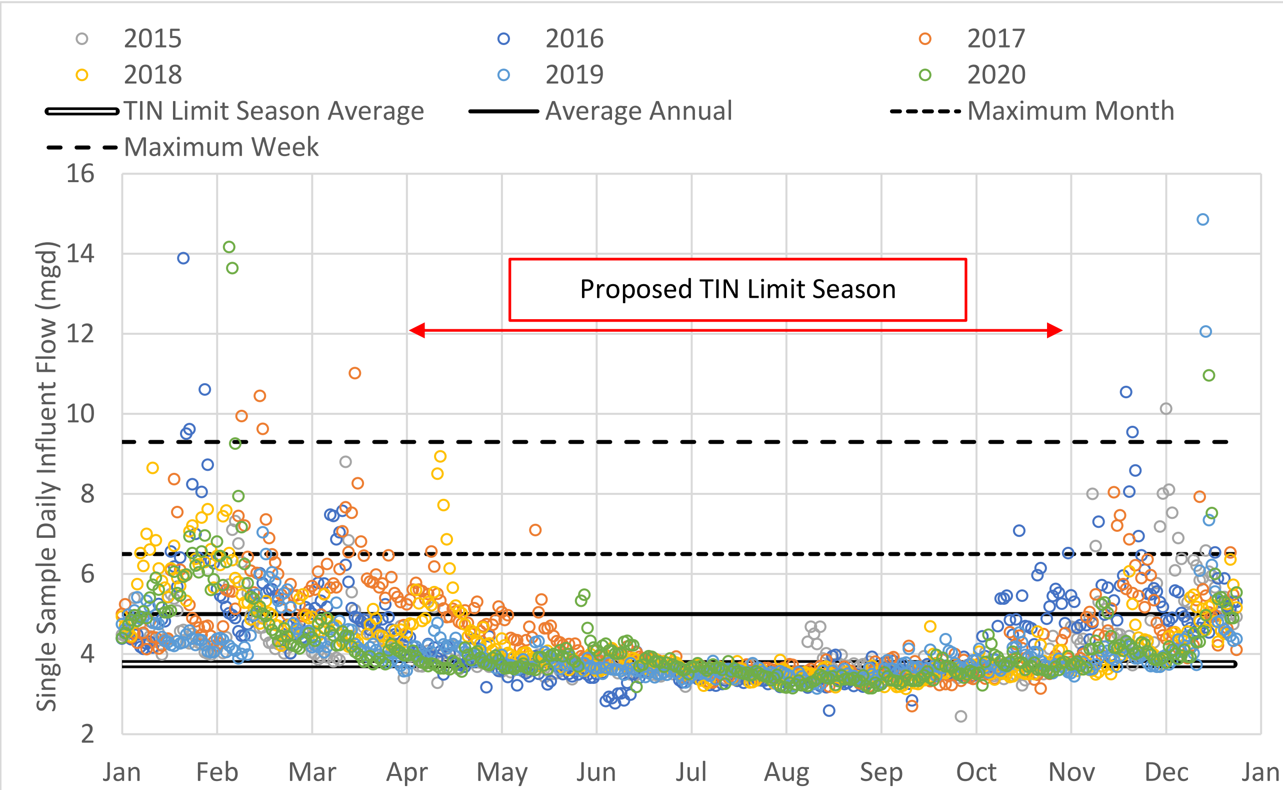


Chart 8-2 – WWTP Daily Effluent Temperature Values (2015-2020)

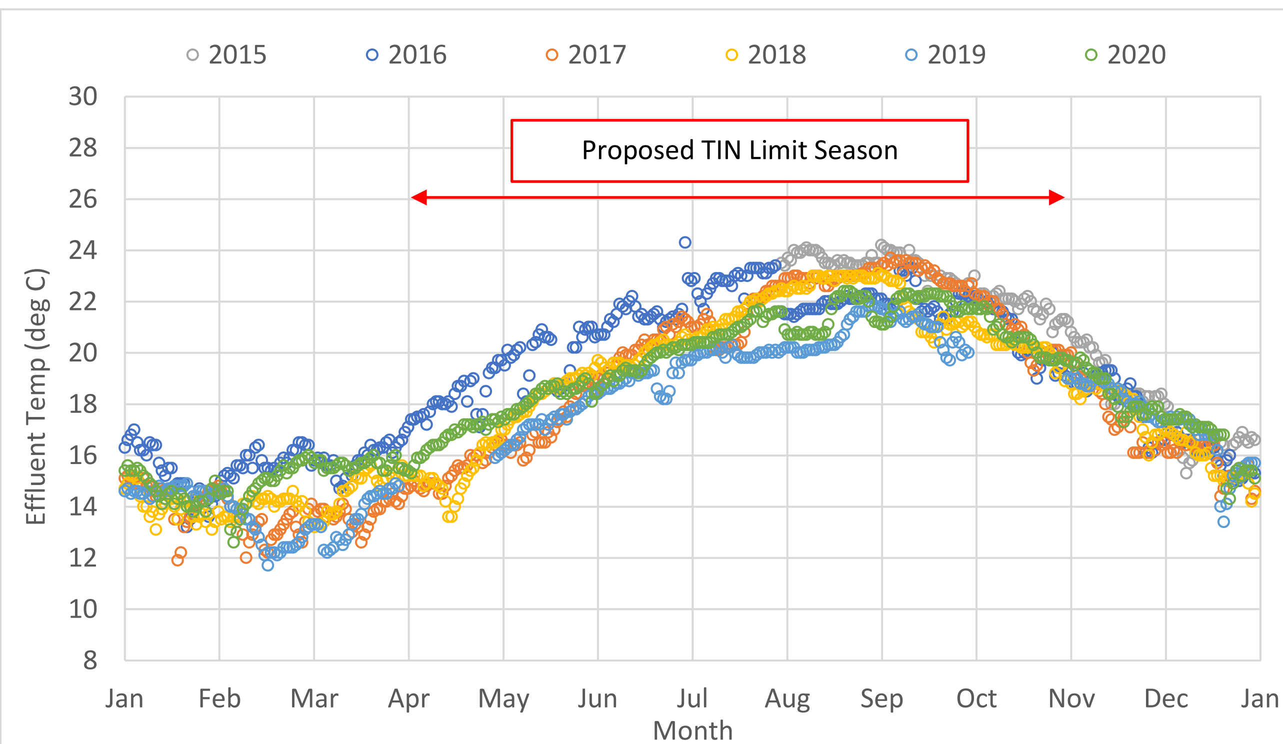


Chart 8-1 graphically displays daily flows and average flows for the following conditions based on historical daily flows from 2015 through 2020:

- TIN limit season (April through October).
- Annual average day.
- Maximum month average day (occurs in the November through March period).
- Maximum week average day (occurs in the November through March period).

Chart 8-2 shows that effluent temperatures (which correlate closely to mixed liquor temperatures), range from 14 to 18 degrees Celsius at the beginning of the potential TIN limit season. Temperatures generally average 20 degrees Celsius or above for the bulk of that season. During the coldest months, the temperature can get close to 12 degrees Celsius.

Based on these conditions, three baseline BioWin model scenarios were established that vary in influent flow, organic, solids, and nitrogen loading, as well as mixed liquor temperature. Mixed liquor temperature significantly affects microbial growth rates and is a key parameter for modeling secondary treatment systems. At higher temperatures, secondary treatment systems can achieve higher nutrient removal rates at lower SRTs. Therefore, a conservatively low temperature was selected for each model case based on the WWTP's historic data, as described in the following sections.

2040 Annual Average Day Condition

This condition models the project 2040 average annual influent flow and loading. This condition presents higher average flow and load than the potential TIN limit seasonal average, but it is used as a conservative approximation of secondary treatment for this condition. The mixed liquor temperature is modeled at 20 degrees Celsius. The model parameters for this condition are included in **Table 8-7**.

Table 8-7. 2040 Annual Average Loading Projections Used for Modeling

Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)	TKN (lb/day)	Mixed Liquor Temperature (°C)
6.34	13,700	11,700	2,300	20

2040 Maximum Month Average Day Condition Model Inputs

The wet weather flow period, which has historically produced the maximum month average day conditions for the WWTP, is generally outside of the potential TIN limit season of April through October. Some shorter wet weather events have historically occurred in early April and late October. Although conservative, the maximum month average day condition is modeled to analyze the secondary treatment system during wet weather events near either end of the potential TIN limit season. The mixed liquor temperature is modeled at 15 degrees Celsius, which is a conservative average temperature for either end of the TIN limit season based on historic data at the WWTP. This condition is modeled to verify the difficulty of meeting 3 mg/L TIN at the maximum month average day condition. The model parameters for this condition are included in **Table 8-8**.

Table 8-8. 2040 Maximum Month Loading Projections Used for Modeling

Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)	TKN (lb/day)	Mixed Liquor Temperature (°C)
8.12	14,800	12,600	2,500	15

2040 Maximum Week Flow/Maximum Month Loading Condition Model Inputs

This condition models the maximum week average day flow coupled with the maximum month average day organic, solids, and nutrient loading. As discussed in **Chapter 4**, there is not a predictable seasonal variation in biochemical oxygen demand (BOD) loading that can be correlated to the seasonal flow pattern. This is expected for a collection system serving largely residential customers with recurring periods of I/I, as high flows occur due to wet weather events that do not contribute additional BOD loading. Therefore, the maximum week organic, solids, and nutrient loading is considered unlikely to coincide with the maximum week flow caused by a wet weather event. The mixed liquor temperature is modeled at 12 degrees Celsius, conservatively the lowest temperature experienced outside of the TIN limit season based on historic data at the WWTP. This condition is modeled to estimate requirements for wet weather flow management and the predicted potential TIN results during these conditions. The model parameters for this condition are included in **Table 8-9**.

Table 8-9. 2040 Maximum Week Flow/Maximum Month Loading Projections Used for Modeling

Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)	TKN (lb/day)	Mixed Liquor Temperature (°C)
10.75	14,800	12,600	2,500	12

Other Considerations

High flow periods that are a short duration and higher magnitude than the maximum week flow are expected to require management strategies as discussed later in this chapter, but are not included in the modeling of the secondary treatment system as they are not considered primary design conditions for nutrient removal.

The City has limited influent nitrogen data, but influent nitrogen is expected to be generally proportional to BOD for this system. Influent nitrogen is projected based on a BOD to Total Kjeldahl Nitrogen (TKN) ratio of 6 to 1 as established in **Chapter 4**, which conservatively estimates influent nitrogen for moderate strength wastewater per Metcalf & Eddy *Wastewater Engineering Treatment and Resource Recovery, 5th Edition*, Table 8-1.

Modeling Results for Design SRT Determination

2040 Annual Average Condition – Two Trains and Four Clarifiers Online

This condition models the 2040 annual average flow, BOD, total suspended solids (TSS), and TKN loading from **Table 8-7**. The model used a RAS rate of 50 percent of influent and an internal recycle (IR) rate of 500 percent of influent. Swing 1 was operated under anoxic conditions and Oxic 4 operated as a post anoxic (PAx) zone with 300 gallons per day (gpd) methanol added as necessary for denitrification to TIN below 3 mg/L. Mixed liquor temperature is 20 degrees Celsius. **Table 8-10** provides the model results for this condition.

Table 8-10. 2040 Annual Average BioWin Model Results

SRT	NH3	Nitrate	Nitrite	TIN	MLSS	SLR
(days)	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(lb/ft²/d)*
3.0	1.12	0.09	2.37	3.58	-	-
4.0	0.45	1.94	0.48	2.87	3,700	25
5.0	0.26	2.19	0.07	2.52	4,400	30
6.0	0.19	2.20	0.04	2.43	5,100	35
7.0	0.15	2.22	0.03	2.40	5,700	39
8.0	0.14	2.23	0.03	2.40	6,200	43
9.0	0.13	2.23	0.02	2.38	6,800	47

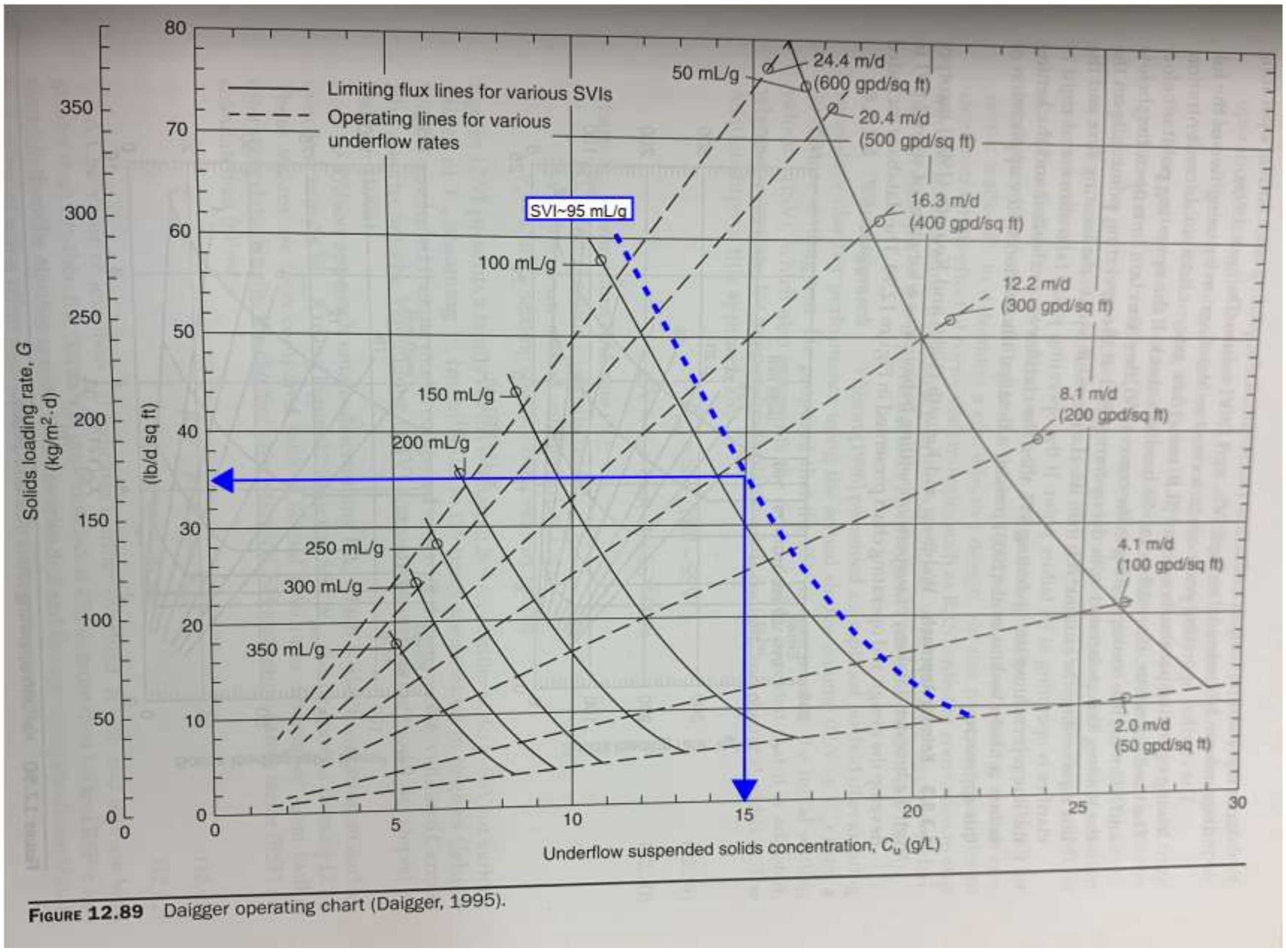
Table Notes:

1. ML temp 20° C; IR – 500% of Influent; RAS – 50% of Influent; Swing 1 – Anoxic; Ox4 – Post Anoxic (PAx); Methanol addition - 300 gpd.
2. Effluent BOD and TSS predicted to be below 15 mg/L for all conditions.

The model results estimate approximately a 4-day SRT is needed at steady-state conditions for reliable nitrification and denitrification, as evidenced by effluent ammonia (NH_3) and TIN values below 0.5 mg/L and 3.0 mg/L, respectively. The MLSS and SLR necessary to support peak diurnal loading conditions are estimated by applying a 1.5 factor to the 4-day SRT, which results in a design SRT of 6 days. At a 6-day design SRT, MLSS is estimated at 5,100 mg/L and the average SLR at 35 pounds per square foot per day (lb/ft^2/day), coupled with the TIN results estimated for the 4-day SRT condition.

As previously noted, the allowable average SLR will be a function of the achievable mixed liquor sludge volume index (SVI). As discussed in **Chapter 6**, the Daigger-Roper Operating Chart is used to estimate the SVI necessary to support an SLR. The Daigger-Roper Operation Chart can be used to conservatively approximate the SVI necessary for CFR-DAS systems. **Figure 8-5** of the Daigger-Roper Operating Chart, adapted from Figure 12.89 in Water Environment Federation Manual of Practice 8, estimates that at an average SLR of 35 lb/ft^2/day, with an assumed RAS concentration of 15,000 mg/L, an average SVI of under 100 would likely be necessary. As previously noted, SVIs of 50 or less have been routinely demonstrated at the Cashmere, Washington WWTP, and it is likely that with the correct process configuration and controls, an SVI of 100 would be achievable.

Figure 8-5 – Daigger-Roper Operation Chart for Secondary Clarifiers (SLR of 35)



2040 Maximum Month Condition – Two Trains and Four Clarifiers Online

This condition models the 2040 maximum month flow, BOD, TSS, and TKN loading from **Table 8-8**. The model used a RAS rate of 50 percent of influent and an IR rate of 300 percent of influent. Swing 1 was operated as anoxic and Oxic 4 was operated as a post anoxic (PAx) zone with 400 gpd methanol added as necessary for denitrification to TIN below 3 mg/L. Mixed liquor temperature is 15 degrees Celsius. **Table 8-11** provides the model results for this condition.

Table 8-11. 2040 Maximum Month BioWin Model Results

SRT	NH3	Nitrate	Nitrite	TIN	MLSS	SLR
(days)	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(lb/ft²/d)*
4.0	2.99	0.02	2.63	5.64	-	-
5.0	1.19	0.37	2.46	4.02	-	-
6.0	0.61	1.68	0.63	2.92	5,700	50
7.0	0.39	2.07	0.10	2.56	6,500	57
8.0	0.29	2.15	0.04	2.48	7,100	62
9.0	0.23	2.16	0.03	2.42	7,700	68
10.0	0.20	2.15	0.03	2.38	8,300	73
11.0	0.18	2.13	0.02	2.33	8,900	78

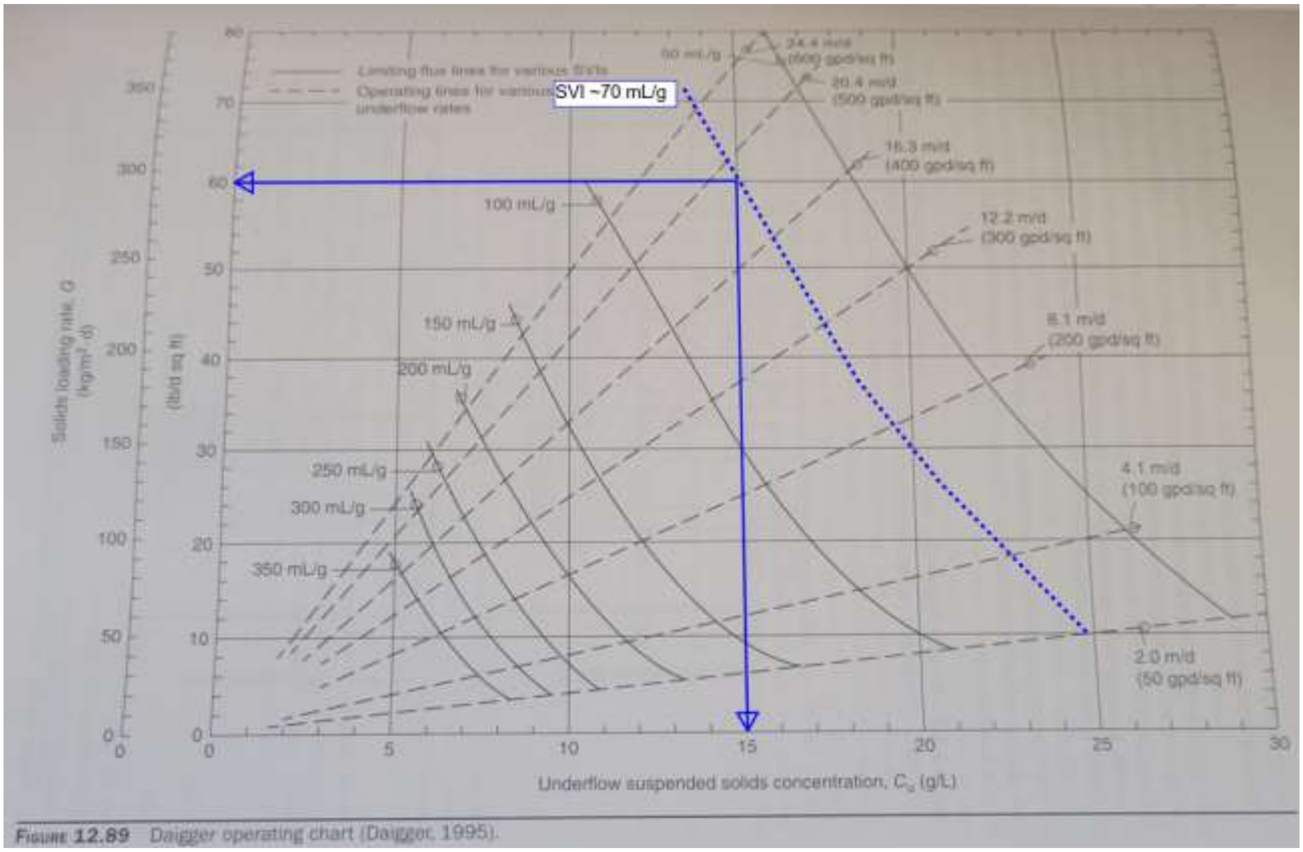
Table Notes:

1. ML temp 15° C; IR – 300% of Influent; RAS – 50% of Influent; Swing 1 – Anoxic; Ox4 – Post Anoxic (PAx); Methanol addition - 400 gpd.
2. Effluent BOD and TSS predicted to be below 15 mg/L for all conditions.

The model results estimate that starting between an approximately 7-day SRT in steady-state conditions, reliable nitrification and denitrification occurs as evidenced by the ammonia value of under 0.5 mg/L. Applying a 1.5 factor to this SRT, a design SRT between 10 and 11 days would likely be necessary to support the peak diurnal loading conditions. At a 10.5-day SRT, the MLSS is estimated at approximately 8,600 mg/L, and the average SLR is approximately 75 lb/ft^2/day. Referring to the Daigger-Roper Operating Chart in **Figure 8-5**, the SLR of 75 lb/ft^2/day is near the upper end of the chart. Other WWTPs with CFR-DAS have consistently demonstrated lower SVIs, but there is not sufficient design guidance to assume that SVI and SLR can be directly correlated using the Daigger-Roper Operating Chart for CFR-DAS systems at high SLRs. As such, it is recommended that an SLR of 60 lb/ft^2/day be conservatively assumed as the maximum that can be reliably achieved during this stage of planning.

Assuming an SLR of 60 lb/ft^2/day at an assumed RAS concentration of 15,000 mg/L, **Figure 8-6** estimates that an SVI of 75 may be necessary.

Figure 8-6 – Daigger-Roper Operation Chart for Secondary Clarifiers (SLR of 60)



A SLR of under 60 lb/ft^2/day would correlate to approximately a 7-day SRT per **Table 8-11**, with an MLSS concentration of 6,500 mg/L. The corresponding effluent TIN levels (at 4 days to derate for diurnal loading) are not expected to be below 3 mg/L. Further, ammonia is predicted to be above 2 mg/L, which indicates incomplete nitrification. This condition will be challenging for TIN reduction due to the combination of high flow and loading and colder mixed liquor temperature. Shortening the SRT reduces the MLSS concentration and SLR to decrease the likelihood of solids washout from the clarifiers. The decreased SRT will reduce TIN removal. If this condition occurs during the proposed TIN limit season, the WWTP would not be expected to meet a TIN of 3 mg/L consistently. The maximum month average day condition is more likely to occur outside of the potential TIN limit season, for which Ecology has yet to define a TIN limit. Mixed liquor temperature may be colder than the 15 degrees Celsius as used for this analysis, which would further limit TIN reduction. Based on this preliminary analysis, it would likely be difficult for the WWTP to meet a low TIN limit at this condition.

Should the CFR-DAS process produce mixed liquor characteristics similar to the Cashmere, Washington WWTP, an SVI of 50 or less could be achievable. In this case, an SLR of greater than 60 lb/ft^2/day would be expected to be achievable, allowing for an increased SRT and TIN levels lower than those shown here. However, this technology is emerging and should be conservatively estimated, especially for the City's challenging maximum month condition, and as such, low TIN limits cannot be guaranteed for this condition.

2040 Maximum Week Flow/Maximum Month Loading Condition – Two Trains and Four Clarifiers Online

This condition models the 2040 maximum week flow coupled with the maximum month BOD, TSS, and TKN loading from **Table 8-9**. The model used a RAS rate of 50 percent of influent and an IR rate of 300 percent of influent. Swing 1 is operated as aerobic at this condition, as is Oxic 4 to provide the maximum aerobic SRT. This condition is expected to represent peak wet weather events during the winter months, where hydraulically managing influent flow to meet conventional secondary effluent standards (BOD and TSS) and disinfection requirements are considered to be the main process objective. Methanol addition is suspended. Mixed liquor temperature is 12 degrees Celsius. **Table 8-12** provides the model results for this condition.

Table 8-12. 2040 Maximum Week Flow/Maximum Month Load BioWin Model Results

SRT	NH3	MLSS	SLR
(days)	*(mg/L)*	*(mg/L)*	*(lb/ft^2/d)*
6.0	0.76	-	45
7.0	0.46	4,300	50
8.0	0.32	4,700	55
9.0	0.24	5,100	60
10.0	0.20	5,500	64

Table Notes:

1. ML temp 12° C; IR – 300% of Influent; RAS – 50% of Influent; Swing 1 – Aerobic; Ox4 – Aerobic; No methanol addition.
2. Effluent BOD and TSS predicted to be below 15 mg/L for all conditions.

During these conditions, maintaining the SLR low enough to avoid solids washout will be critical. The achievable SLR will be a function of the mixed liquor characteristics that can be achieved with the future CFR-DAS process. For conservative planning, an average SLR of 60 lb/ft^2/d or less is recommended similar to the maximum month condition. As shown in the table, this is reached at approximately a 9-day design SRT and MLSS concentration of 5,100 mg/L. The corresponding effluent ammonia concentration (at a 6-day SRT to derate for diurnal loading) is predicted at greater than 0.5 mg/L, which indicates incomplete nitrification. However, at this condition, effluent TIN reduction will not be the primary treatment objective and nitrification is difficult to predict. An effluent TIN concentration cannot be reasonably quantified or guaranteed during the challenging combination of high wet weather flow and low temperature.

Analysis of Support Systems

Aeration System Analysis

For all model runs, BioWin predicted the air flow required to maintain 2 parts per million dissolved oxygen content within each aerobic zone. **Table 8-13** provides the estimated air flow necessary for each zone, as well as the total required air flow for two trains during the conditions model.

Table 8-13. 2040 Estimated Average Aeration Requirements

Condition	MLSS	Design SRT	Single Train Air Flow						Total 2 Trains
			Sw1	Ox1	Ox2	Ox3	Ox4 (Pax)	Total 1 Train	
	mg/L	*days*	*SCFM*	*SCFM*	*SCFM*	*SCFM*	*SCFM*	*SCFM*	*SCFM*
Annual Average	5,100	6	0	1,500	450	350	0	2,300	4,600
Maximum Month	6,500	7	0	1,550	500	400	0	2,450	4,900
MW (Flow) MM (Load)	5,100	9	600	1,000	350	300	250	2,500	5,000

MW = maximum week
MM = maximum month

All scenarios are predicted to require totalized airflow at or below 5,000 standard cubic feet per minute (SCFM) at steady-state conditions. A planning-level estimate of peak aeration demand can be achieved by using the 1.5 loading factor established in **Chapter 4**. This would result in a peak airflow requirement of 7,500 SCFM. Actual peak demands would be expected to be in excess of this value; for the purposes of planning, a future nominal aeration capacity of 10,000 SCFM is considered. The current aeration equipment provides a capacity of 5,000 SCFM. This equipment is being replaced during the drafting of this Plan and the capacity will be nominally increased. However, it is expected that future air demands will necessitate additional blowers located near the headworks to serve the high demand zones of Swing 1 and Oxic 1. This Plan assumes that the first stage basin blowers also should provide approximately 5,000 SCFM of capacity, and the first stage and second stage basin aeration systems could potentially be interconnected. For planning, three blowers (one for redundancy) are assumed to serve the first stage basins and each would be rated for approximately 2,500 SCFM.

WAS Production

Table 8-14 provides the estimated sludge production from the secondary treatment system at the conditions modeled.

Table 8-14. 2040 Estimated Sludge Production

Condition	BOD_5	Design SRT	WAS	Monthly WAS
	(lb/day)	*(days)*	*(lb/day)*	*(lb/month)*
Annual Average	13,700	6.0	14,400	440,000
Maximum Month	14,800	7.0	15,600	470,000
MW (Flow) MM (Load)	14,800	9.0	15,600	470,000

Table Notes:
1. WAS yield estimated by 1.05 multiplied by influent BOD_5.
2. Monthly WAS estimated as 30.5 days multiplied by estimated daily WAS load.
3. Daily values are rounded to the nearest 1,000 lb/d.
4. Monthly values are rounded to the nearest 10,000 lb/d.

As will be discussed in the **Wasting System** section, sludge is expected to be wasted from both the surface of the basins and from the clarifier underflow. However, the total wasting loading in pounds is estimated based on a WAS to influent BOD yield ratio of 1.05. The 2040 solids production values shown are used for solids handling equipment sizing in **8.6 Solids Handling System Improvements**.

Analysis of Maintenance Conditions

The secondary treatment system will require periodic maintenance of the submerged aeration basin and secondary clarifier equipment. In general, the secondary treatment system will allow for isolation to the following portions of the tankage at a time:

- Removal of one train of the first stage basins.
- Removal of one train of the second stage basins.
- Removal of one secondary clarifier.

Such work should be planned for summer months to allow for the lowest influent flow. The seasonal TIN limit must be met during this period. The 2040 annual average flow, loading, and operating conditions are used to model the maintenance conditions during the potential TIN limit season. Like the previous analyses, the SLR of 60 lb/ft^2/day is considered the maximal average SLR that will be acceptable during these conditions.

Basin Maintenance Conditions

Table 8-15 provides model results approximating the first maintenance condition, in which the first stage basins of one treatment train (An1, An2, An3, Ax1, Ax2, Sw1, and Ox1) are taken offline. Other model inputs remain the same as in the 2040 annual average non-maintenance condition.

Table 8-15. Maintenance in First Stage Basins BioWin Model Results

SRT	NH3	Nitrate	Nitrite	TIN	Total Air Flow	MLSS	SLR
(days)	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(scfm)*	*(mg/L)*	*(lb/ft^2/d)*
3.0	1.10	0.05	2.04	3.19	-	-	-
4.0	0.44	1.45	0.27	2.16	4,250	5,200	35
5.0	0.27	1.59	0.05	1.91	4,450	6,100	42
6.0	0.20	1.58	0.03	1.81	4,550	7,000	48
7.0	0.17	1.58	0.03	1.78	4,700	7,800	54
8.0	0.16	1.59	0.03	1.78	4,800	8,600	59

Table Notes:
1. One treatment train of first stage basins (An1, An2, An3, Ax1, Ax2, Swing 1, and Ox1) taken offline.
2. ML temp 20° C; IR – 500% of Influent; RAS – 50% of Influent; Swing 1 – Anoxic; Ox4 – Post Anoxic (PAx); Methanol addition - 300 gpd.
3. Effluent BOD and TSS predicted to be below 15 mg/L for all conditions.

With one train of first stage basins offline, the biomass within the remaining basins must be increased to support nitrification and denitrification. At a 8-day design SRT, an MLSS of 8,600 mg/L is predicted to produce an SLR of approximately 59 lb/ft^2/day, which is below the recommended maximum of 60 lb/ft^2/day established for planning. For this condition, average effluent TIN is expected to align with the TIN predicted for a 5-day SRT at less than 3 mg/L, with reliable nitrification predicted by the effluent ammonia of 0.27 mg/L.

Table 8-16 provides model results approximating the second maintenance condition, in which the second stage basins of one treatment train (Ox2, Ox3, and Ox4) are taken offline. Other model inputs remain the same as in the 2040 annual average non-maintenance condition.

Table 8-16. Maintenance in Second Stage Basins BioWin Model Results

SRT	NH3	Nitrate	Nitrite	TIN	Total Air Flow	MLSS	SLR
(days)	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(scfm)*	*(mg/L)*	*(lb/ft^2/d)*
5.0	0.33	2.53	0.19	3.05	4,550	5,510	38
6.0	0.23	2.62	0.06	2.91	4,650	6,350	44
7.0	0.17	2.60	0.04	2.81	4,700	7,130	49
8.0	0.14	2.56	0.03	2.73	4,750	7,860	54
9.0	0.11	2.52	0.03	2.66	4,850	8,540	59

Table Notes:

1. One treatment train of second stage basins (Ox2, Ox3, and Ox4) taken offline.
2. ML temp 20° C; IR – 500% of Influent; RAS – 50% of Influent; Swing 1 – Anoxic; Ox4 – Post Anoxic (PAx); Methanol addition - 400 gpd.
3. Effluent BOD and TSS predicted to be below 15 mg/L for all conditions.

Like in the previous maintenance condition analysis, removal of one train of second stage basins from service will require a higher MLSS concentration to provide an SRT sufficient for TIN reduction. An SLR of 60 lb/ft^2/day is reached at an 9-day SRT and a corresponding MLSS concentration of 8,540 mg/L. For this condition, average effluent TIN is expected to align with the TIN predicted for a 6-day SRT at less than 3.0 mg/L, with reliable nitrification predicted by the effluent ammonia of 0.23 mg/L.

During the summer months, it appears feasible to take one train of either stage of basins offline for the purposes of maintenance. The mixed liquor concentration must be increased to maintain the effluent TIN below 3 mg/L, but this should be achievable with a CFR-DAS process producing a mixed liquor with good settling characteristics.

Secondary Clarifier Maintenance Condition

Table 8-17 approximates the difference in SLR with four secondary clarifiers online versus three clarifiers at the annual average condition, which was previously modeled and recommended a 6-day design SRT.

Table 8-17. BioWin Model Results with One Secondary Clarifier Out of Service

SRT	MLSS	SLR with 4 Clarifiers	SLR with 3 Clarifiers
(days)	*(mg/L)*	*(lb/ft^2/d)*	*(lb/ft^2/d)*
6.0	5,900	35	47

Table Notes:

1. ML temp 20° C; IR – 500% of Influent; RAS – 50% of Influent; Swing 1 – Anoxic; Ox4 – Post Anoxic (PAx); Methanol addition - 300 gpd.

SLR increases proportionally to the decrease in operating clarifier surface area, but the SLR is expected to remain under 60 lb/ft^2/d at the 6-day design SRT. With a CFR-DAS process producing a mixed liquor with good settling characteristics, it should be feasible to take one secondary clarifier offline at a time for the purposes of maintenance during the summer months while producing an effluent TIN below 3.0 mg/L.

Recommended Effluent Limits

A future detailed analysis of the proposed secondary treatment system, either through a preliminary design effort or project-specific engineering report, should seek to further develop the initial analyses provided in this Plan such that more detailed design criteria can be established. For the purposes of this Plan, the proposed secondary treatment system is expected to provide capacity for secondary treatment to conventional standards (BOD and TSS) for the projected 2040 conditions and beyond. Depending on the level of reliably achievable densification that can be provided with the CFR-DAS process, it appears feasible to meet the TIN limits on a monthly or seasonal average for the following 2040 conditions:

- April through October – Effluent TIN of 3 mg/L appears feasible for flow and loading at or below the projected average annual condition.
- Maximum month condition – Effluent TIN of 10 mg/L may be feasible at the maximum month flow and loading condition, assuming this occurs during a period in which mixed liquor temperatures can be maintained at 15 degrees Celsius or higher.
- Peak wet weather conditions – No effluent TIN limit can currently be guaranteed during the peak wet weather conditions that occur during the coldest period of the year

Beyond 2040, the proposed secondary treatment system will provide capacity for conventional secondary treatment, but TIN reduction will be a function of the reliably achievable mixed liquor characteristics. Technological advancement in process control for densified secondary treatment systems should allow for new and improved techniques to further reduce TIN. This could aid in meeting the proposed TIN limits at loadings beyond 2040.

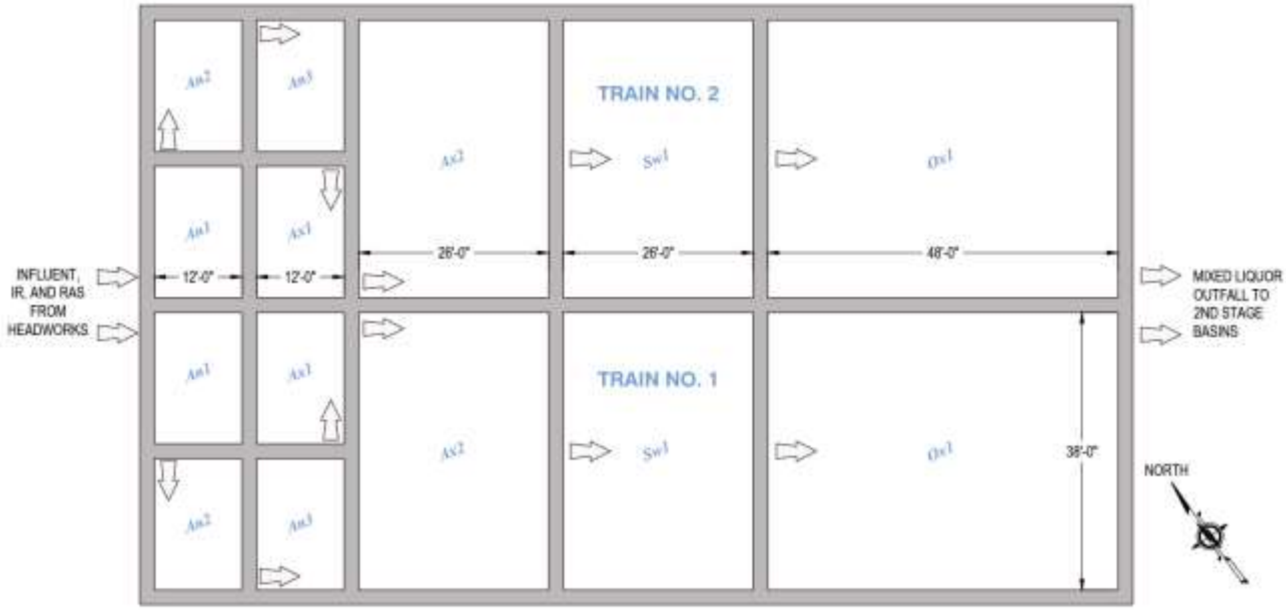
PROPOSED SECONDARY TREATMENT PROCESS CONFIGURATION

The process schematic for the future reconfigured WWTP, including the proposed secondary treatment system, is shown in **Exhibit C-10 Future Liquid Stream Process Schematic** in **Appendix C**. The proposed upper and lower site hydraulic profiles are shown in **Exhibit C-11 Proposed Hydraulic Profile – Upper Site** and **Exhibit C-12 Proposed Hydraulic Profile – Lower Site**.

First Stage Basins

Figure 8-7 shows the conceptual physical configuration of the first stage basins into two trains.

Figure 8-7 – Conceptual Configuration of First Stage Basins



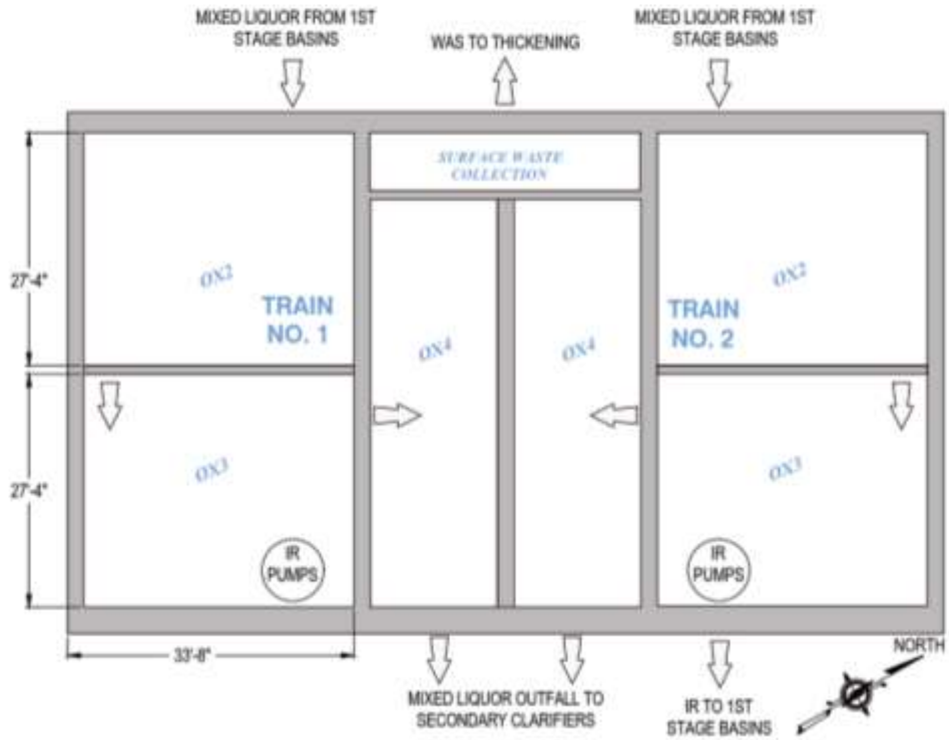
Screened influent, IR, and RAS will enter the first stage basins from the headworks. The design should allow partial combination or splitting of these flows between the initial zones of the basins. Forward flow through the basins will be over-wall between the zones and will generally follow the flow arrows shown. Mixed liquor will outfall from Ox1 to piping routed to Ox2 in the second stage basins.

Access to the basins will likely be from the headworks, for which the finished floor elevation should approximately match the top of the basin walls. Access platform(s) will run the length of the basins to access mixers, and aeration and monitoring equipment. These platforms likely will be routed along the top of the proposed walls.

Second Stage Basins

The second stage aeration basins will be constructed to provide two trains with three zones (Ox2, Ox3 and Ox4) as shown in **Figure 8-8**.

Figure 8-8 – Conceptual Configuration of Second Stage Basins



Mixed liquor from the first stage basins will enter Ox2. Forward flow through the basins will be over-wall between the zones and will generally follow the flow paths shown. Mixed liquor will outfall from Ox4 to the existing secondary clarifiers. Internal recycle pumping equipment will be installed in the latter zones of the second stage basins and will pump to the headworks for distribution into the upper basins.

Surface wasting will likely occur from Ox4. An automated gate or similar device will be used to generate surface waste flow over a weir from the basins and into a collection box for conveyance to the thickening system. Wasting is discussed further in the **Wasting System** section.

Existing Secondary Clarifiers and RAS System

The existing secondary clarifiers will remain unchanged in size and general configuration. Once the new secondary treatment system is in operation and producing densified activated sludge, it is recommended that the performance of the existing secondary clarifiers be evaluated through on-site stress testing. The goals of this evaluation would be to determine an acceptable solids loading rate to the clarifiers with densified mixed liquor and to identify enhancements that could be made to the clarifiers, such as baffling or other improvements. The project will remove the existing odor control system that treats air from the headspace beneath the secondary clarifier covers. As such, air from this location will be discharged to a new odor control system, likely in conjunction with the proposed headworks odor control system.

A new RAS system will be necessary to support the proposed secondary treatment system. The RAS system is planned to include a dedicated RAS pump per clarifier, as well as at least two online, redundant RAS pumps. Preliminary modeling suggests that these pumps and the associated piping could be installed in the pipe gallery between the existing basins and clarifiers. **Exhibit C-13 Final Site Plan** in **Appendix C** shows the extension of this pipe gallery to the proposed headworks. The RAS pipes, along with the internal recycle and mixed liquor system piping, would be routed through this gallery.

In addition to surface wasting, sludge will be able to be wasted from the clarifier underflow by splitting a small portion of the flow from the RAS discharge to the thickening system. Wasting is discussed further in the following section.

Wasting System

Wasting of sludge from the secondary treatment system will occur from two locations: the secondary clarifier underflow and directly from the latter zone of the aeration basin via surface wasting of the mixed liquor. Wasting from the secondary clarifier underflow is the common approach to wasting as it allows for lower wasting volumes due to concentration of the sludge by the secondary clarifier. However, properly configured surface wasting can assist in wasting organisms with poor settling characteristics to facilitate better mixed liquor settling characteristics.

Both wasting streams are expected to be routed through gravity thickening systems to increase the concentration to at least 2 percent prior to discharge to the solids handling system. A CFR-DAS system producing dense mixed liquor will facilitate gravity settling to 2 percent with much smaller thickeners than conventional activated sludge. The future design of the secondary treatment system will refine the gravity thickening system concept. For the purposes of planning, the system likely will consist of either two in-ground or above-grade tanks located between the existing aeration basins and the proposed solids handling system.

Wasting from the clarifier underflow is intended to be completed by splitting a small portion of the pump RAS discharge to the gravity thickening system. Surface wasting will occur by modulation of weir gates in the latter zone of each activated sludge train to allow mixed liquor to overflow the weir into a collection box and be pumped to the gravity thickener.

Underflow from the gravity thickener system will be pumped to the solids handling system as discussed in **8.6 Solids Handling Improvements.**

Process Control Considerations

In addition to the general configuration of the secondary treatment system shown, specific process control elements should be enabled by the future design as discussed in the sections that follow.

Fermentation

As discussed in **Chapter 6**, the CFR-DAS process will be constructed using an enhanced biological phosphorus removal (EBPR) process configuration for the purposes of promoting the growth of dense, self-assembled microbial communities with excellent settling and nitrogen removal characteristics. Fermentation historically has been shown to improve the reliability and performance of EBPR systems through various configurations of RAS or mixed liquor fermentation. Fermentation requires a deeply anaerobic zone or period defined by an oxidation-reduction potential (ORP) below about -300 millivolts. The design of the secondary treatment system must allow for this to occur. Options for either or both side-stream RAS and in-line mixed liquor fermentation should be included in the design to provide flexibility for process control changes as the role of fermentation in activated sludge systems becomes better understood. Mixed liquor fermentation is an important component of both the Cashmere, Washington and Peshastin, Washington WWTP processes that has likely contributed to the formation of aerobic granules and exceptional nutrient removal at these facilities.

One of the key aspects of fermentation is that it appears to promote greater diversity and resilience in the microbial population and the growth of organisms like Tetrasphaera. Tetrasphaera can ferment higher carbon forms, take up phosphorus, produce volatile fatty acids, and take up phosphorus under anoxic conditions. The ability of Tetrasphaera to ferment higher carbon forms is particularly important for removal of phosphorus and nitrogen from wastewaters that do not contain sufficient influent BOD. With Tetrasphaera, significantly more of the available carbon can be used for nitrogen and phosphorus removal rather than for growth of other heterotrophic organisms. This could allow for decreased reliance on external carbon to drive denitrification of the proposed low effluent TIN limit at the City. As such, fermentation is a key process element that must be included in the future secondary treatment system design.

Flexible Configuration of Basin Zones

The future design of the aeration basins should include flexibility for allowing various zones to have multiple operating modes so the process can be adapted for varying conditions. Some of the initial selector zones could be either anaerobic or anoxic by having multiple locations where RAS and IR can be discharged as facilitated by the valve manifolds in the lower level of the new headworks. Multiple swing zones, which include both aeration and mechanical mixing for aerobic or anoxic operation, should be considered for inclusion. At least one swing zone is assumed as shown on **Figure 8-3**. Similarly, the final aerobic zone (Ox4) should be able to be operated as a post anoxic zone with supplemental carbon addition.

Storm Bypass

During peak storm events, the primary objective of the WWTP will be to meet conventional secondary treatment standards (BOD and TSS). In these events, the most significant concern likely will be maintaining a secondary clarifier SLR low enough to avoid solids washout and TSS violations in the effluent. The future design should consider the inclusion of multiple process elements to provide operational flexibility during these conditions.

A standard practice in these events is to bypass some influent to the latter oxic zones. The objective of this approach is to provide BOD reduction while reducing the clarifier solids rate. The future design should consider automated valving to allow for a portion of the influent to bypass the first stage aeration basins and be discharged directly to the second stage basins.

During these events, it may be possible to reduce the RAS rate, which reduces SLR. With a CFR-DAS system producing good settling sludge, the intent would be to allow as much compaction of the RAS blanket to occur as possible, allowing for a reduced RAS flow rate. Automated control of the RAS system should allow for this to occur.

Reliability and Redundancy

The current National Pollutant Discharge Elimination System permit requires that the secondary treatment system meet the requirements for Reliability Class II (EPA 430-99-74-001), which includes the following:

- There must be at least two equally sized basins. *This requirement is met at all conditions as the existing four basins are equally sized and each can be isolated while the other basins remain operational.*
- The air diffuser grids shall be designed such that the largest section of diffusers can be isolated without measurably impairing oxygen transfer capability. *This requirement will be met by having individual aeration grids in each oxic zone, which can be isolated from the rest of the aeration system should the aeration grid in the zone be impaired. In this condition, the impaired zone could be operated as anoxic with permanently installed or temporary mixing. The treatment configuration will include multiple swing zones, which could allow an anoxic zone to be turned aerobic if desired.*
- There must be sufficient aeration capacity that the required oxygen transfer can be maintained with the largest unit out of service. *This requirement will be met with the multiple existing blowers, as well as if any new blowers are added at the first stage basins by interconnecting aeration piping between the first stage and second stage basins.*
- There must be sufficient secondary clarifier area such that at least 50-percent capacity is provided with the largest flow capacity unit out of service. *With a future CFR-DAS system, three secondary clarifiers are anticipated to provide at least 50-percent capacity for conventional BOD and TSS reduction. During the seasonal TIN limit period, the previous analyses showed that a secondary clarifier could be taken offline while meeting the TIN limit.*
- Backup power must be provided to operate critical components and support secondary treatment to maintain biota, though not necessary to support a full level of treatment. *This condition will be met with future backup power sources described in **8.7 Electrical and Control System Improvements**.*

Expandability

As discussed in **Chapter 6**, the proposed secondary treatment improvements will use the maximal footprint that can be supported at this site. The nature of the WWTP challenges construction and the opportunity to expand secondary treatment tankage must be maximized. In the future, expansion of treatment is unlikely to include additional tankage as the site will be fully utilized. However, advancements in secondary treatment technology are likely to aid in further densifying secondary treatment within the existing tankage. As such, the current approach will allow for such technological improvements to be implemented for the purposes of secondary treatment expansion as additional tankage will not be feasible.

8.4.3 Environmental Impacts and Public Acceptability Review

The conversion and expansion of the existing WWTP to a secondary treatment system using CFR-DAS will have significant positive impacts on the environment and the community; most notably the increase in WWTP capacity to support future growth and the expected improved effluent water quality and nutrient removal. The analyses in **Chapter 6** demonstrated that CFR-DAS should have the lowest carbon footprint and lowest life-cycle cost compared to the other applicable secondary treatment options. CFR-DAS is considered to have the least environmental impact and highest acceptability to the public of the available options.

While CFR-DAS is favorable in terms of the overall environmental impact and should be considered highly acceptable by the public, the construction of the CFR-DAS system will have short-term impacts to both the environment and the public (most specifically the neighboring properties). The major items include:

- Erosion and sediment transport;
- Vegetation removal;
- In-stream work for the Outfall Creek realignment;
- Construction traffic through local streets and neighborhoods; and
- Construction noise and lighting impacts to neighboring properties.

Further, the ongoing operation of the CFR-DAS system will have longer term impacts, including the major items that follow:

- Visual impacts such as lighting.
- Noise impacts.
- Odorous emissions.
- Traffic impacts (staff, deliveries, sludge hauling, etc.).
- Energy usage.
- Chemical usage.

The CFR-DAS process is the least impactful alternative for secondary treatment improvements at the existing WWTP. However, any significant temporary and permanent environmental and public impacts created by these improvements should still be considered and mitigated as feasible during the future permitting and design work.

8.4.4 Design Criteria

The future secondary treatment system design criteria are summarized in **Table 8-18**.

Table 8-18. Secondary Treatment System Design Criteria

Parameter	Value	Units
Loading Criteria		
Design MM Flow	8.12	*MGD*
Design MM BOD	14,800	*lb/d*
Design MM TSS	12,600	*lb/d*
Design MM TKN	2,500	*lb/d*
Basic Information		
Mixed Liquor Temp.	15	*deg C*
SRT	6	*days*
MLSS Concentration	6,800	*mg/L*
Target SVI	70	*mL/g*
Train Dimensions		
Quantity of Trains	2	
Volume Each	1.38	*MG*
An1		
Dimensions	19x12x24	*ft (LxWxSWD)*
Volume	0.04	*MG*
Aeration and Mixing	Mixing Only	
An2		
Dimensions	19x12x24	*ft (LxWxSWD)*
Volume	0.04	*MG*
Aeration and Mixing	Mixing Only	
An3		
Dimensions	19x12x24	*ft (LxWxSWD)*
Volume	0.04	*MG*
Aeration and Mixing	Mixing Only	
Ax1		
Dimensions	19x12x24	*ft (LxWxSWD)*
Volume	0.04	*MG*
Aeration and Mixing	Mixing Only	
Ax2		
Dimensions	26x39x24	*ft (LxWxSWD)*
Volume	0.18	*MG*
Aeration and Mixing	Mixing Only	
Sw1		
Dimensions	26x39x24	*ft (LxWxSWD)*
Volume	0.18	*MG*
Aeration and Mixing	Mixing and Aeration	
Ox1		
Dimensions	60x39x24	*ft (LxWxSWD)*
Volume	0.42	*MG*
Aeration and Mixing	Aeration Only	
Ox2		
Dimensions	26x32x24	*ft (LxWxSWD)*
Volume	0.15	*MG*
Aeration and Mixing	Aeration Only	
Ox3		
Dimensions	26x32x24	*ft (LxWxSWD)*
Volume	0.15	*MG*
Aeration and Mixing	Aeration Only	
Ox4 (Pax)		
Dimensions	48x15x24	*ft (LxWxSWD)*
Volume	0.13	*MG*
Aeration and Mixing	Mixing and Aeration	
Aeration System		
Target D.O. Concentration	2.00	*mg/L*
1st Stage Blower Qty.	3 (turbos)	
2nd Stage Blower Qty.	4 (2 turbos and 2 screw)*	
1st Stage Blower Types	Turbo – 200 hp each	
2nd Stage Blower Types	Turbo – 150 hp, Screw – 125 hp	
Diffuser Type	Fine bubble	
Total Airflow Capacity	10,000	*SCFM*
Internal Recycle		
Pump Type	Submersible axial flow or similar	
Pump Quantity	4 (2 per train) and 2 shelf spares	
Rate	100-300	*% influent*
Single Pump Capacity	1.0 – 5.8	*MGD*
Total Capacity	24	*MGD*
Wasting System		
Configuration	Surface and RAS wasting	
Secondary Clarifiers		
Configuration	Rectangular	
Quantity	4	
Length	120	*ft*
Width	24	*ft*
Sidewater Depth	14	*ft*
Volume	0.30	*MG*
Nominal Area Each	2,880	
Nominal Total Area	11,520	*SF*
MM Average SLR	60	*lb/d/SF*
MM Average SOR	705	*gpd/SF*
RAS Pumps		
Pump Type	Drypit Screw Centrifugal or similar	
Pump Quantity	6 (4 duty, 2 redundant)	
Rate	25-100	*% influent*
Single Pump Capacity	1.0 – 3.6	*MGD*
Total Capacity	15	*MGD*

D.O. = Dissolved oxygen

The secondary treatment tankage and piping is sized for the 2050 condition. The pumping, mixing, and aeration equipment is sized for the 2040 condition as shown in **Table 8-18**. Refer to **Exhibit C-10 Future Liquid Stream Process Schematic** in **Appendix C** for additional information.

8.4.5 Life-Cycle Cost

DESIGN LIFE

The expected design life of most of the electrical and mechanical components of this system is 20 years, with some high wear items necessitating refurbishment or replacement on a shorter interval. The structural components of the system (tankage and buildings) and major piping systems are intended to last significantly longer, potentially 50 years or more, and with proper maintenance could have an indefinite span.

O&M

A discussion of the expected ongoing O&M costs is provided by category as follows.

Labor

Secondary treatment O&M, with consideration given to the proposed aeration basins with nitrification/denitrification and carbon addition, rectangular clarifiers, gravity thickening of WAS, and the usage of emerging or developmental technologies, is expected to necessitate an average staffing level of 4 FTEs.

Energy

The major categories of electrical costs for the secondary treatment system were estimated based on the following assumptions:

- Aeration energy – The projected annual average aeration demand was used to estimate total connected blower horsepower.
- Major pumps – The electrical draw for the IR, RAS, and WAS pumps was estimated based on the projected annual average aeration flow rates for each pump, the approximated discharge pressure, and the estimated pump and motor efficiencies.
- Major motors – Mixer and clarifier drive electrical draw was based on the full speed draw for each of these motors
- Miscellaneous systems – Electrical draw for minor systems associated with secondary treatment were estimated at 5 percent of the total electrical draw for the other items calculated.

Chemicals

Chemical use consists primarily of methanol or a similar supplemental carbon source for denitrification. Methanol is assumed to cost $1.25 per gallon.

Normal Maintenance Materials

Annual material expenses for normal maintenance procedures were calculated at 2 percent of the construction cost for the major mechanical and electrical systems necessary to support secondary treatment.

The estimated annualized O&M costs for the future secondary treatment system are summarized in **Table 8-19**.

Table 8-19. Secondary Treatment Estimated Annual O&M Costs

Description	Total Amount
Labor for Operations and Maintenance	$416,000
Energy	$226,000
Chemical	$137,000
Normal Maintenance Materials	$380,000
Total O&M *(Rounded up to nearest $10,000)*	**$1,160,000**

The total future secondary treatment system annual O&M cost is expected to be approximately $1.2 million in 2021 US dollars.

CAPITAL COST

The planning-level cost estimate for the planning, design, permitting, and construction of the future secondary treatment system is provided in **Table 8-20**.

Table 8-20. Secondary Treatment Estimated Capital Cost

Item No.	Description	Total Amount
1	Mobilization	$4,531,000
2	First Stage Aeration Basins	$16,150,000
	Tankage Structural	*$10,170,000*
	Mechanical	*$5,980,000*
3	Second Stage Aeration Basins	$7,980,000
	Tankage Structural	*$3,240,000*
	Mechanical	*$4,740,000*
4	Pipe Gallery	$2,700,000
	Structural	*$1,200,000*
	Mechanical	*$1,500,000*
5	Secondary Clarifiers and RAS System	$1,930,000
	Mechanical	*$1,930,000*
6	Ancillary Secondary Treatment Systems and WAS Thickening	$2,350,000
	Civil	*$270,000*
	Structural	*$840,000*
	Mechanical	*$1,250,000*
7	Plant Drain Lift Station	$1,050,000
	Structural	*$300,000*
	Mechanical	*$750,000*
8	Demolition of Existing Headworks and Main Plant Pump Station	$730,000
9	Electrical and Automatic Control	$12,420,000
	Subtotal	**$49,850,000**
	Sales Tax (10.4%)	$5,190,000
	Construction Total	**$55,040,000**
	Indirect Costs (30%)	$16,520,000
	Planning-Level Contingency (30%)	$16,520,000
	Project Total	**$88,080,000**

The total planning-level cost is estimated to be $88.1 million, including sales tax, indirect costs, and contingency. The values in **Table 8-20** may differ from the capital costs provided in **Chapter 7** as the **Chapter 7** costs were cost differential items that were provided for the comparison of alternatives only. A description of each major cost item is provided as follows.

1. **Mobilization:** Mobilization, contractor's temporary utilities and facilities, temporary bypass, and demobilization. The mobilization value is 10 percent of the total of items 2 through 9.
2. **First Stage Aeration Basins:** Cast-in-place concrete aeration basin tankage, access platforms, and steel roof structure for visual mitigation; secondary treatment system equipment, including mixers, aeration blowers, and diffuser equipment, and monitoring and

control devices; piping systems for aeration; and mixed liquor conveyance to the second stage basins.

3. **Second Stage Aeration Basins:** Demolition and reconfiguration of existing tankage walls to partition existing basins into two trains; access platforms and steel roof structure for visual mitigation; secondary treatment system equipment, including mixers, aeration diffuser equipment, and monitoring and control devices; internal recycle pumps and piping; aeration piping; and surface wasting equipment.
4. **Pipe Gallery**: Enclosed, partially buried pipe gallery, including pipes for screened influent (storm flow bypass to second stage basins), mixed liquor, internal recycle, RAS, and aeration.
5. **Retrofit Existing Clarifiers and RAS System:** RAS pumps and piping system; and improvements to enhance clarifier performance such as baffling.
6. **Ancillary Secondary Treatment Systems and WAS Thickening:** WAS pumps and piping from both RAS and surface wasting locations; dual gravity thickeners; and thickened sludge pumping equipment to solids handling system.
7. **Plant Drain Lift Station:** Concrete wet well and pumping equipment to collect in-plant drainage and recycle flows and lift City of Edmonds discharges to the proposed new headworks.
8. **Demolition of Existing Headworks and Main Plant Pump Station:** Demolition, removal, and off-site haul/disposal allowance for the existing headworks and Main Plant Pump Station structures to allow for expansion of the secondary treatment system and ancillary systems.
9. **Electrical and Automatic Control:** Replacement of electrical motor control equipment and control panels located in Building No. 6; replacement of the generator in Building No. 7; electrical motor control equipment and control panels located at the new headworks facility; and all raceways and instrumentation for the first stage and second stage basins and associated systems.

8.5 EFFLUENT DISINFECTION IMPROVEMENTS

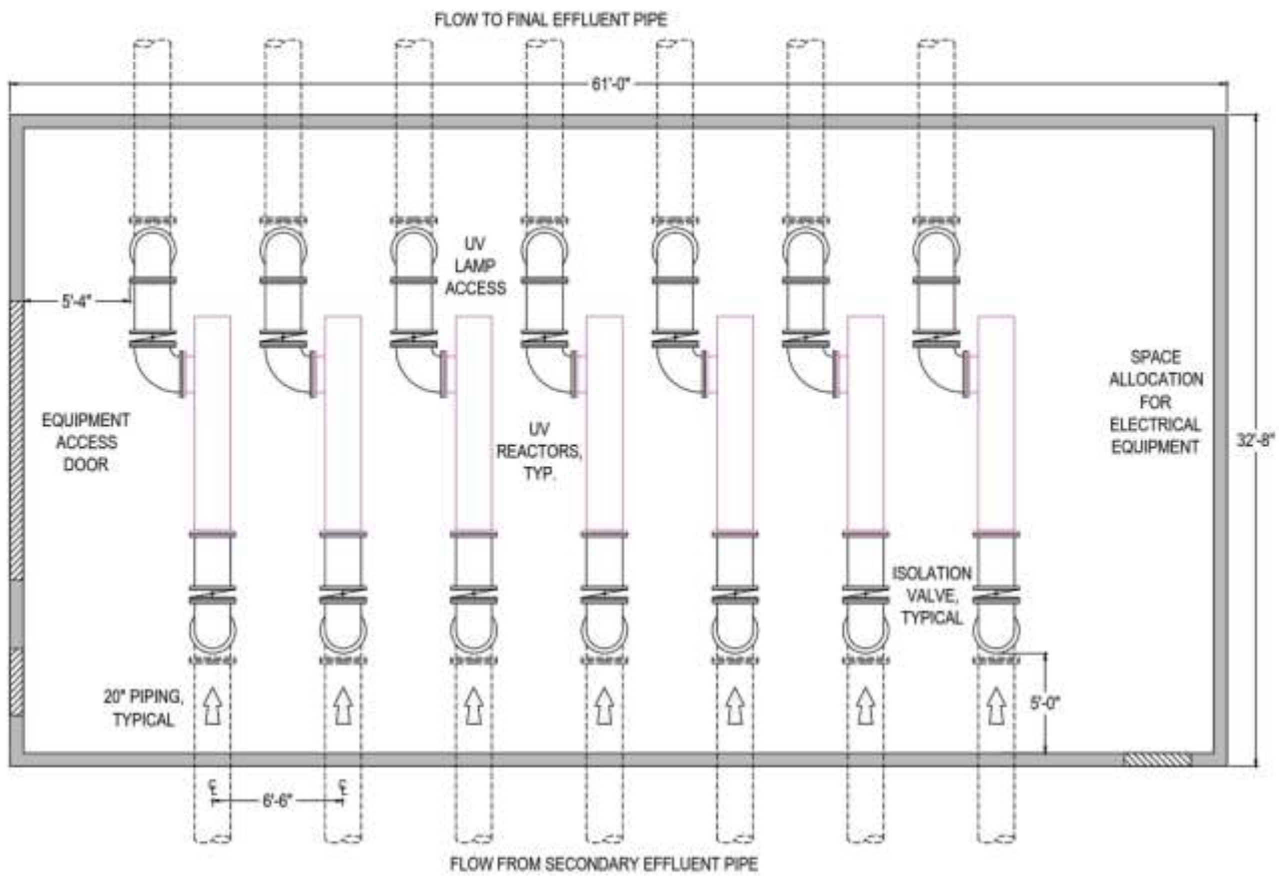
8.5.1 Introduction

As described in **Chapter 5**, the existing effluent disinfection system consists of chlorination using a chlorine gas system and a liquid sodium bisulfate dechlorination system, both housed in Building No. 2. The chlorine contact chamber is located below the Control Building (Building No. 4). The system is aging and undersized for future peak flow conditions. Further, the use of chlorine gas bears high O&M costs and risks associated with the transport, storage, and handling of a hazardous material. UV disinfection is the recommended future method of disinfection, and an alternatives analysis in **Chapter 6** compared open-channel to enclosed vessel UV disinfection. Based on this analysis, it was determined that an enclosed vessel UV system is likely to have a higher capital cost than an in-channel system. However, an enclosed system will provide some benefits in the flexibility of the installation location and allow for the complete enclosure of the outfall system. A future design should weigh these benefits further relative to the additional capital cost, but for the purposes of conservative planning-level budgeting, it is recommended that the City budget for the enclosed vessel UV system.

8.5.2 Description of Improvements

The enclosed UV disinfection system will be installed in either a new building or within a portion of another building, such as the proposed solids handling facility. For budgeting, a new standalone building is assumed. Effluent from the secondary clarifiers can be split among parallel UV reactors (minimum one redundant reactor at all flow conditions). The reactors will be located above grade. The parallel setup of the reactors will allow for isolation and maintenance of each reactor. A flow meter will be installed downstream of the combined effluent of all reactors, likely consisting of an electromagnetic flow meter outside of the disinfection building in a below-grade vault. Hydraulic control will be necessary downstream of the meter and reactors to ensure that full pipe flow is maintained through the system. **Figure 8-9** provides a conceptual layout of the enclosed UV disinfection system.

Figure 8-9 – Conceptual Layout of Enclosed UV Disinfection System



LOADING CRITERIA

The UV disinfection system was sized to treat the projected 2050 peak hour flow of 30 MGD. The design would include a redundant reactor at this peak condition. A minimum design dose of

30 millijoules per square centimeter (mJ/cm^2) at 55-percent UV transmittance was used to approximate equipment sizing.

CONFIGURATION

Figure 8-9 provides a conceptual layout and approximate size of the proposed UV Disinfection Building. To minimize the building footprint, it is likely that lateral piping will split from the secondary and final effluent pipes below grade and outside of the building footprint. The above-grade piping in the building will be configured with inlet and outlet isolation valves for each reactor. Automated or manual valving should be considered during final design. The reactors will be configured to allow sufficient space for access and maintenance. The building will be a dry, unclassified space and necessary electrical equipment can be installed in the same room as the UV equipment if desired. A monorail or similar system likely will be necessary to allow removal of reactors or piping components and should be oriented in a manner to efficiently convey items to an equipment access door. The building should be climate controlled as recommended by the UV equipment manufacturer.

OTHER CONSIDERATIONS

The WWTP must have the capacity to continuously disinfect secondary effluent. Therefore, the installation of the UV disinfection system must be phased such that the new disinfection system is constructed and tested before decommissioning of the existing chlorine contact basins and chemical feed system.

RELIABILITY AND REDUNDANCY

The UV disinfection system will be sized to accommodate the 2050 peak hour flow condition of 30 MGD with one redundant reactor at buildout (7 total reactors). This will provide sufficient redundancy. Each reactor will be able to be isolated from the system to allow efficient maintenance or replacement if needed.

EXPANDABILITY

As noted in **8.3 Preliminary Treatment Improvements**, peak hour flow events are driven by wet weather conditions with significant I/I. It is possible that I/I will be reduced in the future with redevelopment of the collection system, and as such, the 30 MGD projection is likely very conservative and will provide capacity beyond 2050. However, planning for additional UV reactors could be considered in the future design of the structural, mechanical, and electrical systems for UV disinfection.

8.5.3 Environmental Impacts and Public Acceptability Review

The major environmental impact of the transition to UV disinfection will be that the facility will no longer discharge chlorine or disinfection byproducts into Puget Sound, which is beneficial to water quality. However, the UV system will require greater electrical energy than the existing chlorine disinfection system, although this energy usage is mitigated by the fact that the UV system will not be reliant of the continual transport of 1-ton chlorine gas containers to the facility. Suspending the transport of hazardous chlorine gas is beneficial from an environmental standpoint and is beneficial to the public, as it removes the risk associated with regularly transporting these containers through the surrounding community.

8.5.4 Design Criteria

Table 8-21 provides a summary of the design criteria for sizing the UV disinfection system.

Table 8-21. UV Disinfection System Design Criteria

Parameter	Value	Units
Loading Criteria		
Average Daily Flow	5.0 MGD	
Peak Hour Flow (2050)	30.0 MGD	
Design UV Transmittance	55% (assumed for planning)	
TSS	10 mg/L	
Influent Fecal Coliform	<50,000 CFU/100 mL	
Effluent Disinfection System		
Configuration	Enclosed pipe UV with self-cleaning system	
Reactor Quantity	7 (6 duty, 1 redundant)	
Reactor Inlet Size	20-inch	
Reactor Capacity (each)	5.0 MGD	
Lamp Type	Low Pressure, High output	
Lamps per Reactor	30	
Lamp Power	800 Watts	
Effluent Fecal Coliform	<200 fc/100 mL (7-day geometric mean)	
	<100 fc/100 mL (30-day geometric mean)	
Dose	30 mJ/cm^2	
End of Lamp Life Factor	0.85	

CFU/100 mL = colony forming units per 100 milliliters

The effluent disinfection reactors and piping is sized to provide a redundant reactor at the 2050 peak hour flow condition.

8.5.5 Life-Cycle Cost

DESIGN LIFE

The estimated design life of the equipment is 20 years, which is a typical expected value for the lifetime of electrical and mechanical equipment. Lamps will be periodically replaced over the course of the design life to ensure a consistent dose. The structure and piping supporting this system is expected to have a 40 year or greater useful life.

O&M

A discussion of the expected ongoing O&M costs is provided by category as follows.

Labor

The UV system is largely automated and will primarily require basic monitoring and periodic maintenance to service the automated cleaning system and replace lamps. The system is expected to necessitate an average staffing level of 0.5 FTEs.

Energy

Each UV reactor is expected to use approximately 25 kilowatts. At the average annual condition, one to two reactors will be needed in service. This electrical draw was used to calculate the average annual electrical costs.

Chemicals

No significant chemical usage is expected for the UV system. Minor chemical usage with cleaning is expected to be part of the **Normal Maintenance Materials** category.

Normal Maintenance Materials

Annual replacement of lamps and other short-lived items for this system is conservatively estimated at 2 percent of the construction cost for the UV system equipment.

Table 8-22 provides a summary of the O&M costs for the UV disinfection system.

Table 8-22. UV Disinfection Estimated Annual O&M Costs

Item	Cost
Labor for Operations and Maintenance	$52,000
Energy	$37,000
Chemical	$0
Normal Maintenance Materials	$24,000
Total O&M *(Rounded up to nearest $10,000)*	**$120,000**

CAPITAL COST

The planning-level cost estimate for the planning, design, permitting, and construction of the future effluent disinfection system is provided in **Table 8-23**.

Table 8-23. Effluent Disinfection System Capital Costs

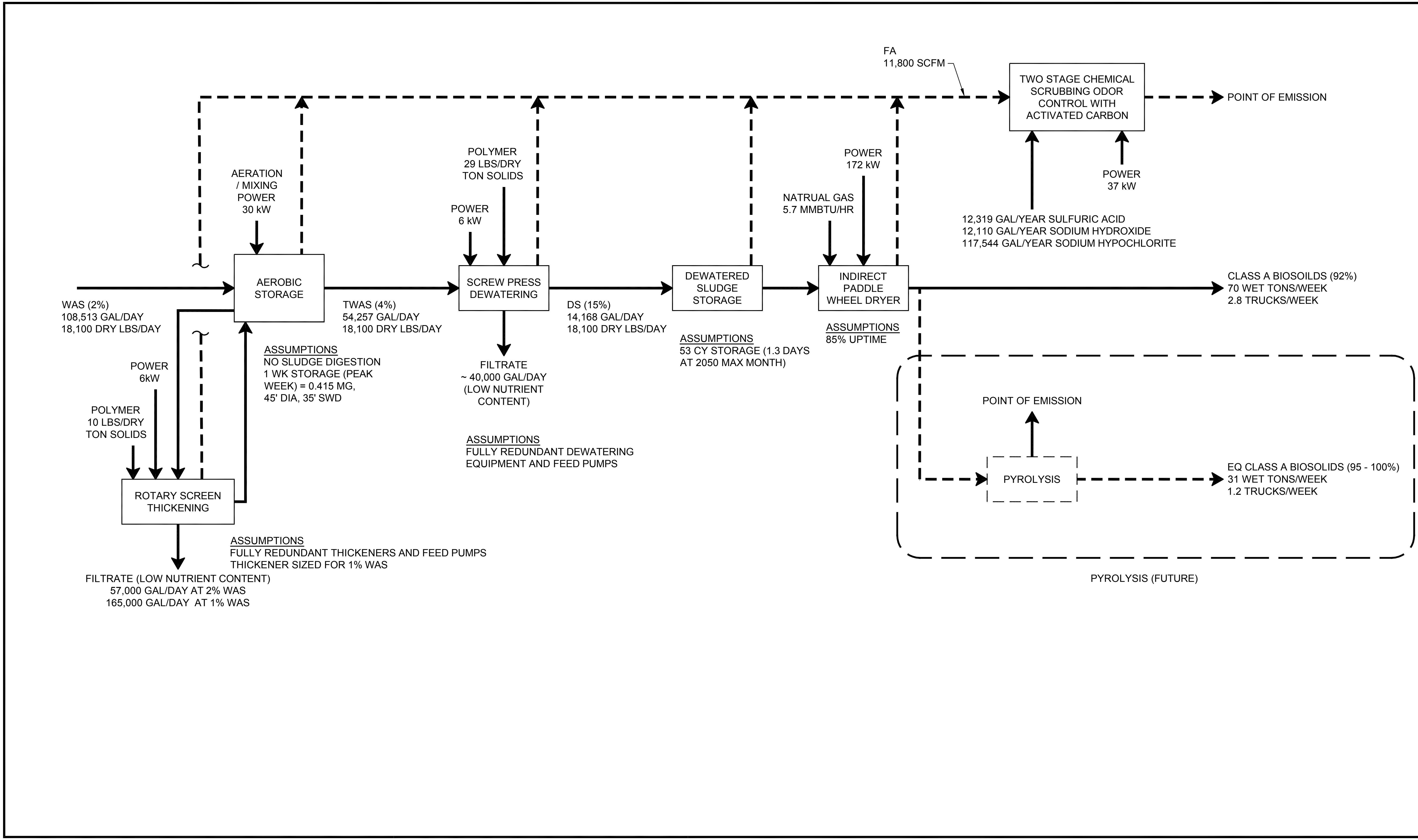
Item No.	Description	Total Amount
1	Mobilization	$538,000
2	Effluent Disinfection System	$5,380,000
	Civil	*$1,000,000*
	Structural	*$1,200,000*
	Mechanical	*$3,171,000*
	Subtotal	**$5,918,000**
	Sales Tax (10.4%)	$620,000
	Construction Total	**$6,538,000**
	Indirect Costs (30%)	$1,970,000
	Planning-Level Contingency (30%)	$1,970,000
	Project Total	**$10,478,000**

1. **Mobilization:** Mobilization, contractor's temporary utilities and facilities, temporary bypass, and demobilization. The mobilization value is 10 percent of the total of item 2.
2. **Effluent Disinfection System:** Above-grade enclosed pipe UV disinfection equipment and associated piping installed on a concrete slab-on-grade within a steel building (or within a portion of another building such as the proposed solids handling facility).

8.6 SOLIDS HANDLING IMPROVEMENTS

8.6.1 Introduction

As described in **Chapter 7**, the existing solids handling process includes mechanical dewatering of primary sludge and WAS using a single screw press. The dewatered sludge at 22 to 24 percent is fed to the sewage sludge incinerator (SSI) where it is incinerated. Ash from the incineration process is dewatered and disposed of offsite. The SSI is aging and is struggling to meet capacity requirements. The SSI, due to ongoing maintenance and performance issues, also presents the City with unpredictable and elevated maintenance and part replacement costs. **Appendix A** to **Chapter 7** also includes a capacity evaluation of the SSI. Further, the future regulatory landscape for SSIs is uncertain and is trending towards more stringent emissions standards, which poses significant risk in relying on sludge incineration for solids handling going forward. Given the SSI challenges described in **Chapter 7**, multiple solids handling process upgrade options were evaluated as part of a two-stage evaluation. The evaluation process encompassed the entire solids handling process from WAS storage to off-site disposal with the core technology recommended being the indirect paddle wheel dryer. The solids handling process schematic is shown in **Figure 8-10**.



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Indirect Paddle Wheel Dryer Process Schematic

Lynnwood Facility Plan

June 2022

Figure

8-10

The solids handling process in **Figure 8-10** accomplishes the City's goals of fitting the new process onsite while meeting 2050 maximum month solids production assuming the liquid stream upgrades described in this chapter. The selected process also will allow the City to minimize biosolids hauling truck traffic to 2 to 3 trucks per week by reliably producing, with an 85 percent minimum process uptime, 90-percent Class A biosolids.

8.6.2 Description of Improvements

The solids handling process outlined in **Figure 8-10** includes the following process elements and projected sizing:

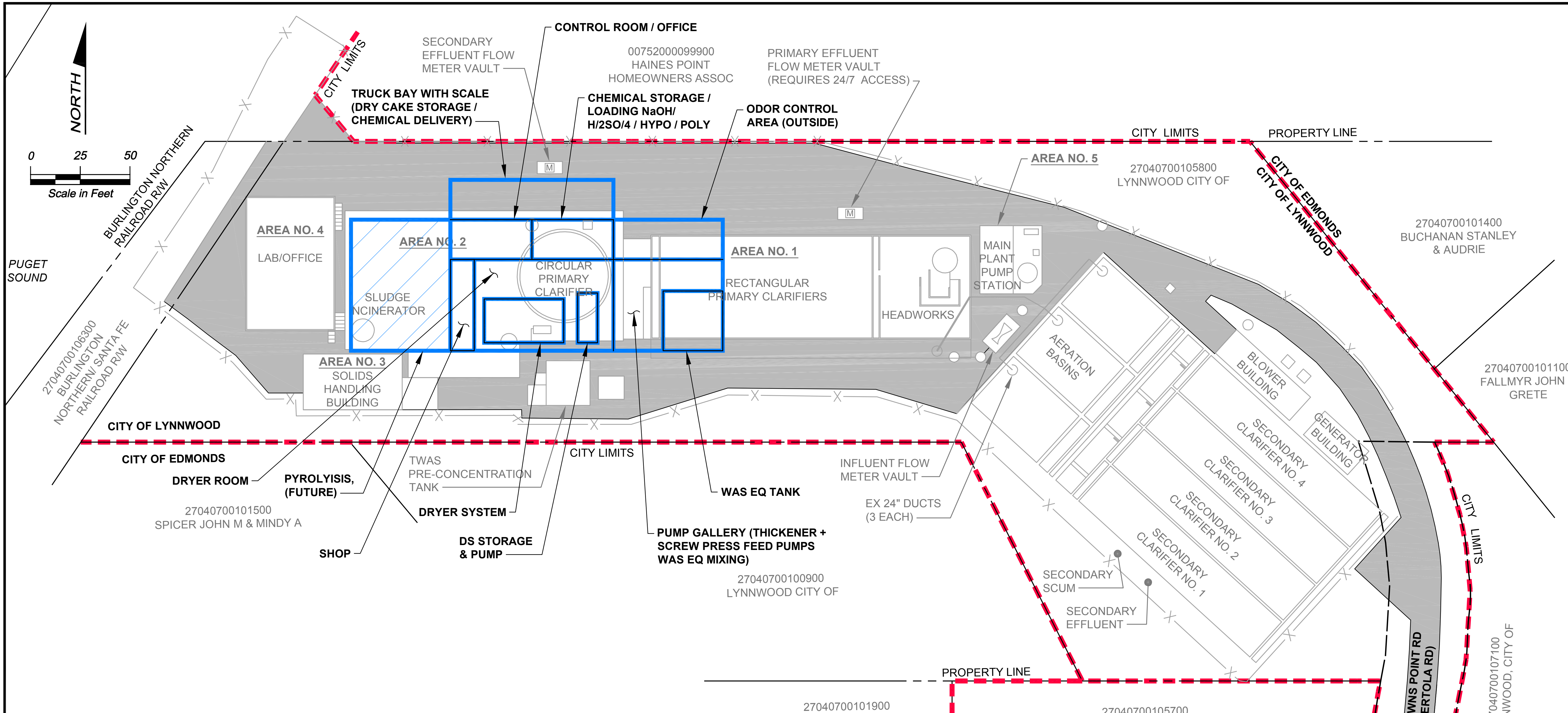
- One continuously mixed aerobic storage tank that will provide approximately 1 day of storage at 2050 maximum month flows. The tank will be cast-in-place concrete and integral to the Solids Handling Building foundation/walls. The tank will be mixed and aerated using mechanical mixing provided by a pair of fully redundant externally mounted centrifugal pumps equipped with venturi injection nozzles that entrain air in the hydraulically mixed contents of the tank. The tank will be enclosed with foul air removed to the odor control system described as follows.
- WAS will be thickened to 4 percent using recuperative thickening via a rotary screen thickener. Two fully redundant thickeners, each with dedicated feed pumps and a shared polymer system, will be installed above/adjacent to the aerobic storage tank. Each thickener will discharge approximately 57,000 gpd at 2 percent (165,000 gpd at 1 percent) of filtrate to a floor drain system for conveyance back to the liquid process. The thickeners will be fully enclosed with foul air removed to the odor control system described later in this section.
- Four (4) percent WAS from the aerobic storage tank will be fed to two fully redundant screw presses to dewater the biosolids to 16 to 20 percent. Each screw press will be capable of processing 18,100 dry pounds per day and will require an estimated 30 pounds of polymer per dry ton of solids. The screw presses will each be equipped with a dedicated feed pump and discharge by gravity into a dewatered storage hopper. The screw presses will have a shared polymer system. Each screw press will discharge an estimated 40,000 gpd of filtrate to a floor drain system for conveyance back to the liquid process. The screw presses will be fully enclosed with foul air removed to the odor control system described later in this section.
- Dewatered sludge will discharge by gravity into a conveyor system that will discharge solids to a live-bottom dewatered sludge hopper sized to store approximately 1 day at the 2050 maximum month solids load. The sludge hopper system and associated dryer feed piston pump are intended to be a packaged system by a single manufacturer. The dewatered sludge hopper system will be fully enclosed with foul air removed to the odor control system described later in this section.
- The dewatered sludge will be pumped directly to the dryer using a piston pump with the paddle wheel dyer system operating based on a level setpoint within its system. The dryer will discharge 90-percent Class A biosolids to a series of conveyors that will convey the product to a dried biosolids storage hopper. The dryer heating loop and boiler will be

housed in a separate room adjacent to the Dryer Room. The anticipated boiler size is expected to be less than 10 Metric Million British Thermal Units (MMBtu) and thus be exempt from rigorous PSCAA air permitting requirements. The dryer heat loop system will be sized and designed to accommodate the potential future addition of a pyrolysis process and associated hydronic loop. The pyrolysis process can use waste heat from the dryer to reduce its energy consumption, while converting the dried biosolids into biochar, further reducing off-site traffic by 50 percent. The pyrolysis process, as it requires a biosolids feed that is 75 percent and not 90 percent, also will extend the dryer capacity beyond the projected 2050 maximum month capacity requirement. The future pyrolysis process is assumed to be installed to the west of the Solids Handling Building shown in **Figure 8-11**.

- The dried biosolids storage hopper (sized for 40 cubic yards (CY), or approximately 1 day of storage at 2050 maximum month solids production) will be located above/near the truck bay where biosolids can be loaded to trucks and trailers for weighing prior to off-site disposal. The conveyance and storage of dried biosolids will be equipped with dust abatement and control equipment, the air discharge of which will be conveyed to the odor control system described as follows. Dust from the dust collection system will be discharged into the dried biosolids storage hopper. Dried solids will be discharge by gravity from the storage hoppers to a shared distribution conveyor that will distribute biosolids to the truck and trailer parked below. The truck and trailer will be parked on an integrated truck scale flush with grade.
- Per **Figure 8-10**, multiple solids process foul air sources, for a total of approximately 12,000 SCFM, will be conveyed to a single shared odor control system. The odor control system identified as the most conservative is a dual stage chemical scrubber with an activated carbon polishing step. This system will require dedicated sulfuric acid, sodium hydroxide, and sodium hypochlorite storage and chemical delivery systems. The odor control system is intended to be housed within an exterior secondary containment area connected to the Solids Handling Building drain/sump pump system. The odor control point of emission will require an air permit with PSCAA.

CONFIGURATION

The solids handling process will include the construction of a new Solids Handling Building onsite to house the process outlined in **Figure 8-10**. As of the writing of this Plan, it is assumed that the SSI will be taken out of service by the time the solids handling improvements described herein will be constructed with dewatered biosolids being trucked offsite using a temporary bypass and conveyance system. The new Solids Handling Building will straddle a portion of Area No. 1 – Primary Clarifiers and Area No. 2 – Incinerator Building. The approximate location of the proposed Solids Handling Building is shown in **Figure 8-11**.



LEGEND

SITE BOUNDARY
PROPOSED FOOTPRINT
PROPOSED SOLIDS HANDLING PROCESS ELEMENTS

Map Source:

This drawing was created from a variety of record drawing and site visit information.

Path: S:\Cad\Lynnwood\20-10700 Facility Plan\Alt Dev Report\dwgs_2 Filename: P20-10700_Fig 8-11 Plot date: Jun 22, 2022-09:15:00am CAD User: solsoe.
Xref Filename: | X20-10700_wwtp-xc3d-eg |

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Solids Handling Building Concept Site Plan
Lynnwood Facility Plan
June 2022

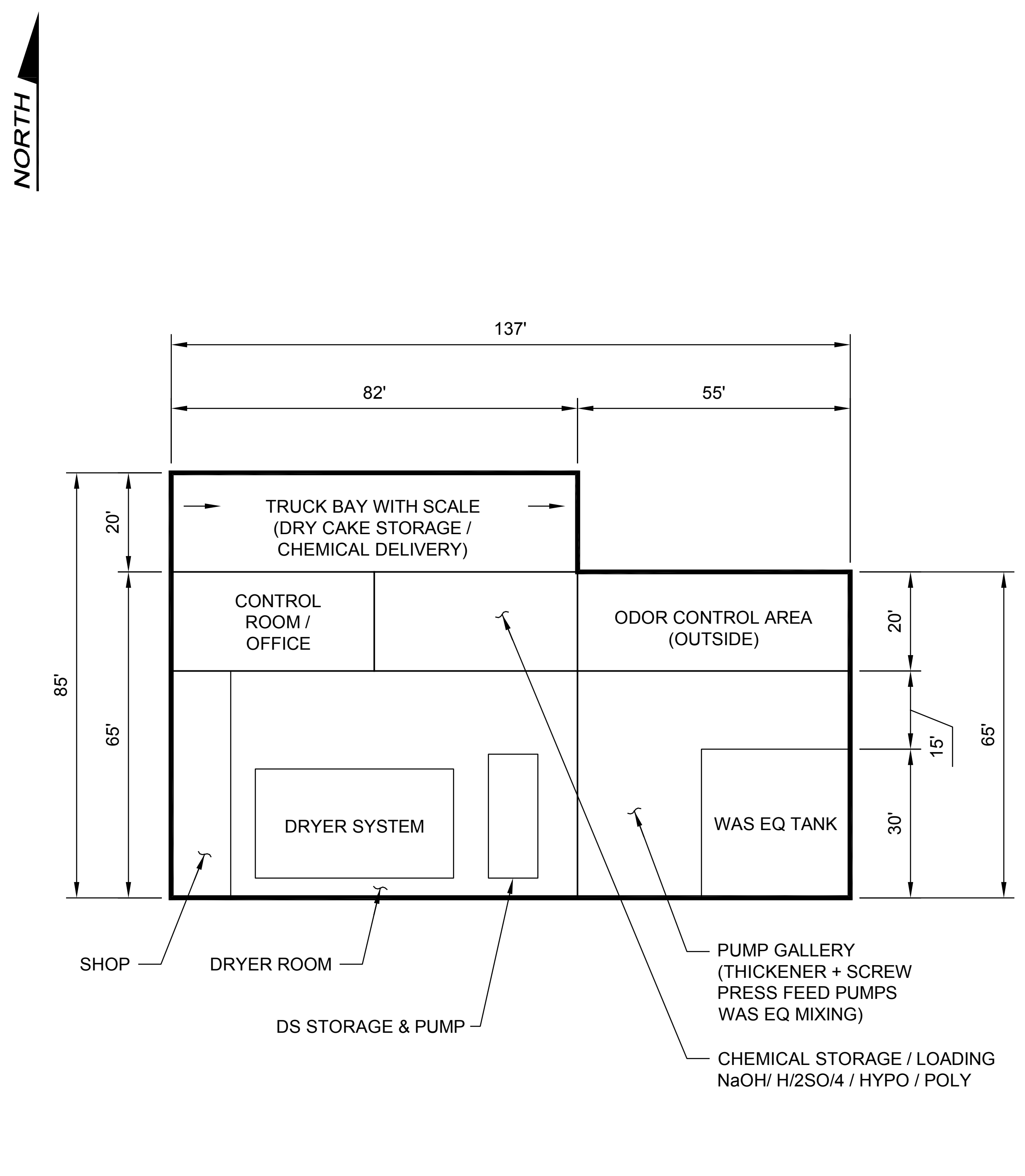
Figure **8-11**

The Solids Handling Building is intended to be slab-on-grade with a metal frame and siding construction on two stories. The building's location will require the demolition of the existing structures, including the existing concrete foundations. Existing structures will be removed to the require subgrade depth and the new structure is assumed to not require pile construction. In the footprint of Area No. 1, the primary clarifier concrete structure will be removed to the required depth and then backfilled with geofoam with the new building slab constructed on grade. Existing utilities and large storm drain piping between the existing Area No. 1 and Area No.2 structures will be maintained and protected in place. Design of the new Solids Handling Building will include provisions to allow access to these facilities where they are located below the building structure. The existing thickened WAS (TWAS) pre-concentration tank and Area No. 3 Solids Handling Building (housing the existing dewatering process) will be kept in operation during construction. This will likely require temporary power and piping modifications to facilitate construction sequencing. Once the solids process is fully commissioned, the TWAS pre-concentration tank and Area No. 3 will be fully demolished.

The Solids Handling Building is positioned to allow for trucks (either for biosolids hauling offsite or chemical deliveries) to enter the site north of the proposed truck bay, turnaround at the west end of the WWTP site, and then enter the proposed truck bay from the west. Grades in proximity of the new building and truck bay will be adjusted as required to meet required grades. Associated storm drainage and utilities will be relocated and replaced as needed to accommodate new site features and the new building.

West of the Solids Handling Building will be an open area that can accommodate a future pyrolysis process. Until that addition is desired, the area identified in **Figure 8-11** will be used to access the Dryer Room for major dryer maintenance and/or equipment replacement. This general area also will offer opportunities for staff parking, storage, and/or equipment turnaround.

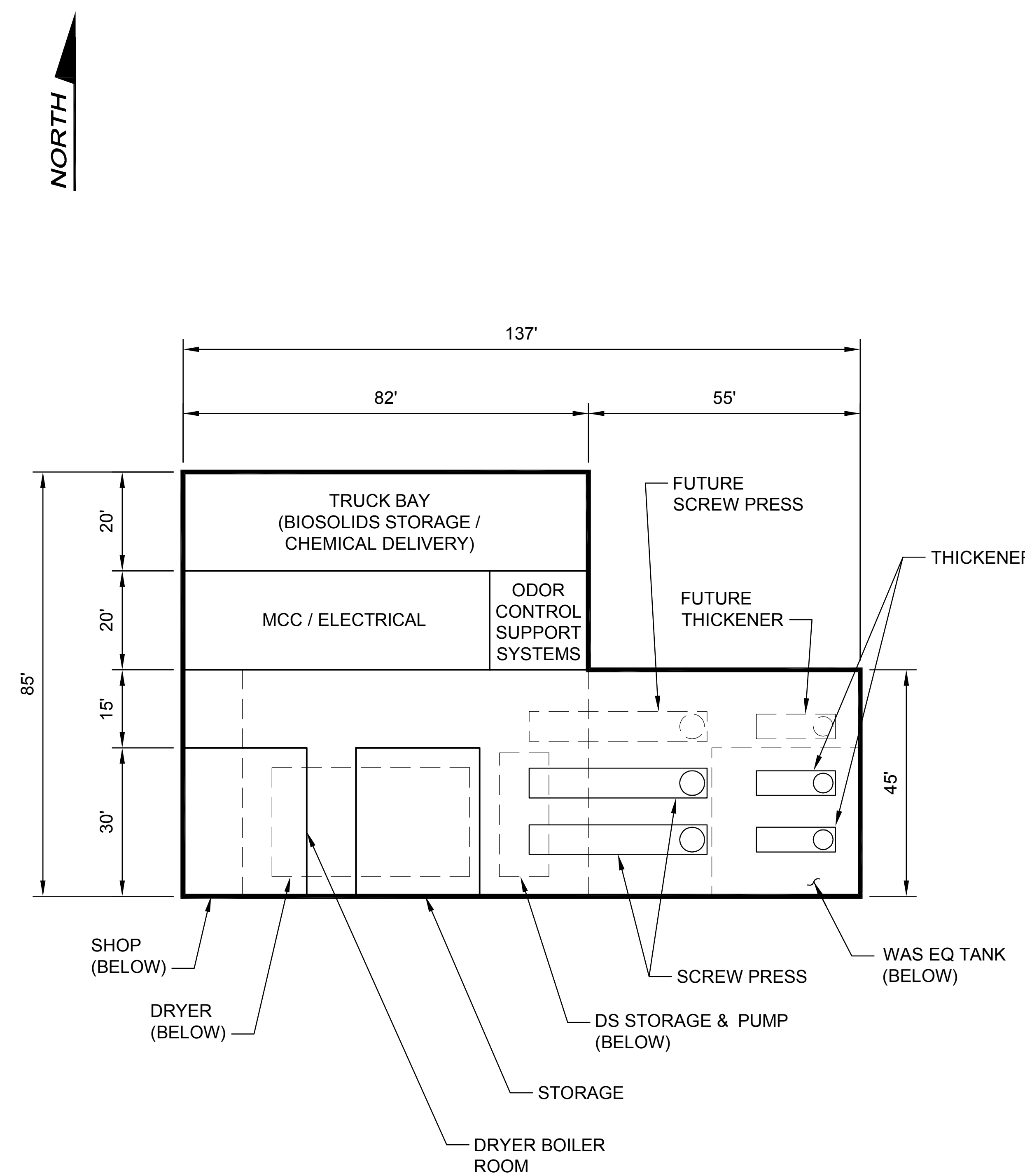
In order to size the Solids Handling Building, a preliminary planning effort was performed to lay out the process elements into a footprint-saving configuration that will still allow for ease of access and maintenance while providing for future expansion. The Solids Handling Building Concept Detail Plan showing the layout of unit processes is in **Figure 8-12**.



GROUND LEVEL
FROM EL 0' TO 20'

PLAN 1

SCALE: 1/16" = 1'-0"



TOP LEVEL
FROM EL 20' TO 40'

PLAN 2

SCALE: 1/16" = 1'-0"

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Solids Handling Building Concept Detail Plan

Lynnwood Facility Plan

June 2022

Figure 8-12

The ground level of the building will consist of the WAS tank surrounded by a pump/pipe gallery for the thickener and screw press feed pumps. This space will be separated from the larger Dryer Room that will house the dryer system. Adjacent to the Dryer Room, a shop and maintenance access on the west side of the building will allow for parts storage, maintenance of equipment, and removal of major pieces of equipment. The control room and office space is located between the truck bay and Dryer Room, allowing operators direct visuals of the two most labor-intensive processes in the facility: loading trucks and drying biosolids. The truck bay is envisioned to be a two-story bay with dried biosolids storage overhead with a distribution conveyance system that will distribute solids in a controlled manner into a parked truck below. The trucks will be positioned on a truck scale integrated into the building slab. The truck bay is assumed to be a fully enclosed spaced with roll-up doors to mitigate odor concerns. The truck bay will include the dust abatement equipment needed on the dried solids conveyance and storage systems. Removed dust will be collected and discharged to the dried biosolids storage hopper. Chemical storage and delivery systems for sodium hydroxide, sulfuric acid, polymer, and sodium hypochlorite will be located in a separate environment adjacent to the truck bay from which chemical deliveries can be made under cover and within secondary containment. Adequate chemical storage volumes, safety measures, and containment were considered in defining the footprint in **Figure 8-12**.

The second level of the facility will house the thickeners and screw presses such that the thickened sludge can be returned to the aerobic storage tank by gravity and the dewatered sludge can be discharged by gravity into the dewatered sludge hopper. The second level also will house the dryer boiler system and associated equipment, the motor control center (MCC) and Electrical Room, and the odor control support systems (including odor control fans).

RELIABILITY AND REDUNDANCY

The unit processes of the solids handling process were sized to account for 85 percent uptime while providing full redundancy for aerobic storage mixing/aeration, WAS thickening, and dewatering. Whereas there are no specific Orange Book requirements for biosolids storage, dewatered sludge storage and dried biosolids storage were each sized to store approximately 1 day (24 hours) at the 2050 maximum month. Dried biosolids storage volume can be increased to reduce off-site truck traffic, but will require storing in excess of 120 CY of dried product onsite, the cost impact of which was not included in the evaluation herein. The solids handling process odor control system is sized to operate 24 hours a day, 7 days a week with a single odor control fan. Additional redundancy can be achieved by installing a fully redundant odor control fan, the cost for which was not included in the evaluation herein. Lastly, as an additional measure of redundancy, shelf spares for critical parts and motors of the solids handling process can be stored onsite to allow for a rapid changeout should the need arise.

EXPANDABILITY

The Solids Handling Building shown in **Figures 8-11** and **8-12** includes equipment sized to meet the 2050 peak day flow condition while offering redundancy and O&M downtime. The Solids Handling Building was sized to accommodate process expansion beyond 2050 by accommodating the footprint for a third thickener and screw press with associated feed pumps and by sizing the Dryer

Room to house the largest footprint belt dryer (Huber) should the City opt to not install an indirect paddle wheel dryer. Future expansion may require additional chemical and polymer storage, which will require additional footprint not allocated in **Figure 8-12**. Lastly, the solids handling process MCC was sized based on the conservative inclusion of the third thickener and screw press. Opportunities exist to reallocate space and reduce building footprint should this requirement become obsolete during detailed design.

8.6.3 Environmental Impacts and Public Acceptability Review

The positive environmental impacts of the proposed solids handling process improvements described herein are:

- The reduction and/or elimination of air emissions and air permit violations from the aging SSI;
- Reduced emissions from reduced truck traffic from liquid sludge hauling due to either regularly scheduled or emergency repairs of the SSI and its subsystems;
- Replacement of an aging and energy inefficient building with a new inconspicuous facility designed to maximize energy efficiency and reduce footprint;
- Elimination of the SSI ash waste stream, which is a hazardous waste; and
- Elimination of odor from the solids handling process.

The public acceptability impacts of replacing the SSI with an indirect paddle wheel dryer system are:

- Reduced truck traffic to and from the WWTP site;
- Elimination/reduction of odor from the solids handling process; and
- Replacement of an aging facility with a new, aesthetically pleasing, and energy efficient Solids Handling Building.

8.6.4 Design Criteria

The solids handling process loading and design criteria are summarized in **Table 8-24**.

Table 8-24. Solids Handling System Design Criteria

Parameter	Value
2050 Max Month Solids Loading	18,100 dry lbs/day
Influent WAS Solids Content	2%
WAS Equalization Volume	120,000 gallons
WAS Equalization Tank Storage Time	26 hours
Thickener Polymer Requirement	10 lbs/dry ton
Thickened WAS Concentration	4%
Thickener Filtrate Production at 2% WAS	57,000 gpd
Screw Press Polymer Requirement	29 lbs/dry ton
Screw Press Dewatered Sludge Concentration	15%
Screw Press Filtrate Production	40,000 gpd
Dewatered Sludge Storage Volume	53 CY
Dryer Type	Indirect, Paddle wheel
Dryer Natural Gas Requirement	5.7 MMBTU/hr
Dried Biosolids Storage Volume	40 CY
Minimum Dried Biosolids Solids Content	92%
Total Biosolids Production	70 wet tons/week
Solids Handling System Total Foul Air Production	11,800 SCFM

The solids handling process is sized to process projected 2050 maximum month solids loading, with redundancy of selected individual equipment units (thickeners, screw presses, and pumps) that may be taken offline without negatively impacting the process. Dewatered sludge and dried biosolids storage systems are not sized for redundancy as they offer approximately 1 day (24 hours) of storage each to facilitate minor equipment repairs and maintenance. The process is sized to operate without the need of the dewatered sludge and dried biosolids storage volumes. Refer to **Figure 8-10** for a detailed process schematic.

8.6.5 Life Cycle Cost

DESIGN LIFE

The estimated design life of the system is 20 years, which is a typical expected value for the lifetime of electrical equipment. Motors, drives, and gear boxes likely will require either rebuild and/or replacement within the 20-year timeframe. Depending on the level of grit that bypasses the headworks, standard sacrificial storage bin and conveyor liners will require replacement approximately every 10 years.

O&M

O&M costs include five categories, costs for which were estimated based on 2050 average annual projections:

- Energy – electricity and natural gas consumption;
- Chemicals – polymer, sodium hydroxide, sodium hypochlorite, and sulfuric acid consumption;
- Staffing – number of full-time employees required;
- Maintenance – cost for replacing wear parts; and
- Disposal cost – final biosolids disposal costs.

Annual electrical costs were developed using the assumptions of an industrial cost of electricity of $0.086 per kilowatt-hour and motors running at full speed per the manufacturer's suggested uptime. Natural gas was assumed to be $1.00 per therm, with the dryer boiler operating per the manufacturer's suggested uptime. Chemical use consists of polymer for thickening and dewatering ($2.50 per pound), sulfuric acid ($8.00 per gallon), sodium hydroxide ($3.00 per gallon), and sodium hypochlorite ($0.50 per gallon) for the two-stage chemical scrubber odor control system. Staffing costs were assumed to be $104,000 per FTE. A total of 2 FTEs was estimated to be necessary to operate the entirety of the solids handling process. Maintenance costs were assumed to be 2 percent of the purchase price of the equipment. This is equivalent to the cost of a full replacement of all equipment in a 50-year time span. While the equipment is assumed to have a 20-year design life (equivalent to a 5 percent annual maintenance cost), the likelihood of all equipment requiring a complete replacement is low; therefore, 2 percent was used as a basis. Rebuild costs are expected to be significantly lower than complete replacement of equipment. Finally, a biosolids disposal cost of $85 per wet ton was assumed. It is possible that this number can be reduced by finding a geographically closer site to handle the Class A biosolids. A summary of the estimated O&M costs is provided in **Table 8-25**.

Table 8-25. Solids Handling System Estimated Annual O&M Costs

Description	Total Amount
2021 Dryer Equipment O&M Cost (rounded to $10,000)	$1,150,000
Natural Gas	$450,000
Electricity	$111,000
Staffing	$208,000
Maintenance Costs	$78,000
Biosolids Disposal	$305,000
2021 Odor Control O&M Cost (rounded to $10,000)	$170,000
Sulfuric Acid	$44,000
Sodium Hydroxide	$16,000
Sodium Hypochlorite	$59,000
Maintenance Costs	$13,000
Electricity	$35,000
2021 WAS Equalization O&M Cost (rounded to $10,000)	$20,000
Electricity	$19,000
Staffing	$1,000
Maintenance Costs	$1,000

Table 8-25. Solids Handling System Estimated Annual O&M Costs

Description	Total Amount
2021 Thickening O&M Cost (rounded to $10,000)	$100,000
Polymer	$83,000
Electricity	$5,000
Staffing	$1,000
Maintenance Costs	$8,000
2021 Dewatering O&M Cost (rounded to $10,000)	$230,000
Polymer	$207,000
Electricity	$4,000
Staffing	$3,000
Maintenance Costs	$18,000
2021 DS Storage O&M Cost (rounded to $10,000)	$20,000
Electricity	$5,000
Staffing	$3,000
Maintenance	$12,000
Total O&M	**$1,690,000**

The total solids handling system annual O&M cost at 2050 average annual loading conditions is $1.69 million in 2021 US dollars. The largest cost items were associated with operating the dryer. Across the multitude of solids handling unit processes, chemical costs, which include polymer for thickening and dewatering, and chemicals for the odor scrubber, were also high. Given the market conditions at the time of the writing of this Plan, equipment, chemical, and labor costs may vary significantly over the course of the intended 20-year planning horizon.

CAPITAL COST

The planning-level cost estimate for the planning, design, permitting, and construction of the solids handling process is provided in **Table 8-26**.

Table 8-26. Solids Handling Process Capital Costs

Item No.	Description	Total Amount
1	Mobilization	$3,073,900
2	Demolition	$1,380,000
3	Utilities	$203,000
4	Site Preparation - Civil	$530,000
5	Site Preparation - Electrical	$760,000
6	Solids Handling Building	$13,487,000
7	Solids Handling Building Electrical	$1,176,000
8	Solids Handling Building Utilities	$569,000
9	Solids Handling Equipment Electrical	$2,274,000
10	Solids Handling Equipment	$9,652,000
11	Solids Handling Process Piping	$360,000
12	Administration and Laboratory Improvements	$2,000,000
13	Site Restoration	$348,000
	Subtotal	**$35,820,000**
	Sales Tax (10.4%)	$3,730,000
	Indirect Costs (30%)	$11,870,000
	Contingency (30%)	$11,870,000
	Planning-Level Cost	**$63,290,000**

The total planning-level cost is estimated to be $63.3 million, including sales tax, indirect costs, and contingency. The values in **Table 8-26** may differ from the capital costs provided in **Chapter 7** as the **Chapter 7** costs were merely for technology comparison purposes only. Construction costs such as installation, contractor overhead and profit, etc. are included in the **Table 8-26** costs. The estimate comprises of 13 items. A description of each cost item is provided as follows.

1. **Mobilization:** Mobilization, contractor's temporary utilities and facilities, temporary bypass, and demobilization. The mobilization value is 10percent of the total of items 2 through 13.
2. **Demolition:** Demolition, removal, and off-site haul/disposal of Area No. 1 and Area No. 2 (including contents) and existing hot mix asphalt (HMA) pavement, excluding the headworks portion of Area No. 1. The estimates for structural demolition (building and slab-on-grade), civil demolition (HMA), and process equipment demolition assumes crews of a foreman, equipment operator(s), laborers, and heavy equipment and the estimated duration these crews will take to complete the demolition work. Off-site hauling costs are based on RS Means, and the disposal fee is based on disposal of construction and demolition debris at the Southwest Recycling & Transfer Station (21311 61st Place W, Mountlake Terrace, Washington 98043), which is approximately 9 miles roundtrip to the City's WWTP.
3. **Utilities:** Proposed 4-inch natural gas line, assumed to come from the gas main along 76th Avenue W. All other utilities (water, sanitary sewer, electrical, and telecommunications) are assumed to be available onsite; associated costs are included for the connection of these on-site utilities to the proposed Solids Handling Building.

4. **Site Preparation – Civil:** Excavate 2 feet below ground surface (bgs) within Area No. 1 and Area No. 2 footprints, excluding the headworks footprint, and backfill the excavation with crushed surfacing base course (CSBC). Large subsurface void areas (i.e., Area No. 1 Primary Clarifiers) are assumed to be backfilled with geofoam, in lieu of CSBC, to cut back on backfill material for the primary clarifiers. The use of geofoam is anticipated to decrease truck traffic to the site, particularly if on-site material cannot be reused for backfill (unknown at this project stage).
5. **Site Preparation – Electrical:** Electrical work required to maintain service to the existing facilities that are to remain in service during construction.
6. **Solids Handling Building:** Construction of the proposed two-story Solids Handling Building, with a plan area of 9,554 square feet. Cost includes foundation, building exterior (walls and roof), interior floors, and finish work (flooring, ceiling, doors, windows, etc.). Cost also includes the WAS equalization tank, assumed to be 30 feet by 30 feet by 25 feet tall (includes a 5-foot freeboard). Tank construction is assumed to be reinforced concrete.
7. **Solids Handling Building Electrical:** Electrical scope required to provide electrical power and telecommunications within the proposed Solids Handling Building. This cost item includes electrical lines and receptacles, power distribution throughout the proposed building, telecommunication lines and receptacles, and a fire alarm system.
8. **Solids Handling Building Utilities:** Utilities within the proposed Solids Handling Building, including HVAC, plumbing, compressed air, sanitary sewer, and fire suppression.
9. **Solids Handling Equipment Electrical:** Electrical scope required to provide electrical power and controls to process equipment covered under cost item no. 10.
10. **Solids Handling Equipment:** Solids handling equipment, including transport to site, material, equipment (for installation), labor (for installation), and startup/training (for individual equipment). Costs for the following equipment are included: thickener; screw press; WAS equalization mixing; dryer system; dryer system storage and pump; odor control equipment; truck scale; dry cake storage and conveyance; and chemical delivery.
11. **Solids Handling Process Piping:** Process piping and ductwork (material, equipment, and labor). Costs for the following process piping and ductwork are included: mixing/aeration;, thickener feed; thickener filtrate; screw press feed; screw press filtrate; dryer feed; reuse water; natural gas; chemical and polymer; odor control (ducting); and miscellaneous drain.
12. **Administration and Laboratory Improvements:** Allowance for renovation or improvements to the existing Control Building or potential consolidation of the administration and laboratory areas into the new Solids Handling Building.
13. **Site Restoration:** A 6-inch-thick layer of CSBC below a 6-inch-thick layer of HMA over an area of 37,450 square feet. Existing CSBC layer is 8 inches thick, but it is not anticipated that the full depth of the existing layer will be disturbed during construction. The new HMA layer will match the existing HMA layer (6 inches thick).

In addition to the assumptions listed in **8.1 Introduction**, the assumptions that were made as part of the **Table 8-26** costs include the following:

- Proposed Solids Handling Building is assumed to have a shallow foundation (mat foundation) and piles are not required. Excavation related to demolition of existing buildings is limited to 2 feet bgs.
- The MCC was estimated to include 60 process motors between 1 horsepower (hp) and 125 hp with light industrial controls networking primarily of communications cable in conduit or cable tray in non-hazardous areas. Electrical design is based on standard power distribution switchboard and engine generator switchboard, grouped switches, and power panel distribution.
- The Solids Handling Building will include approximately 3,000 square feet of National Electrical Code (NEC) 500 hazardous area (Class I or Class II) lighting with NEC 500 area monitoring and signaling. The building will include commercial/light industrial lighting, receptacles, and power distribution throughout the building. It is assumed the building will be equipped with a typical fire alarm system.

The costs in **Table 8-26** do not include the following:

- Costs for potential future processes (e.g., Pyrolysis).
- Costs associated with dewatering.
- New electrical service to Area No. 5.
- Programmable logic controllers, human machine interface, Operator Interface, or other control panel-based programming or configuration.
- Costs for network switches, computers, or office-type equipment.
- Electrical costs for vendor-furnished control panels are not included.
- Electrical costs vendor-furnished instrumentation or motor control equipment are not included.
- On-site power generation (i.e. generator) and automatic transfer switch are not included.
- Power utilities or communications facilities from service providers or the City are not included.

8.7 ELECTRICAL AND CONTROL SYSTEM IMPROVEMENTS

A new electrical service is planned for the construction of the proposed headworks and additional basins. New electrical service switchboard equipment with parallel service disconnects will be installed for redundancy purposes. Each service disconnect will have a dedicated automatic transfer switch. A permanent standby generator will be installed at this location for providing standby power to the proposed headworks and basins electrical loads. Additional electrical distribution switchgear and motor control centers will be required to supply power to the new electrical loads. Each of the two existing electrical services will remain in operation during the construction of these improvements.

The existing electrical service located outside Building 7 will be used to supply power to the existing clarifiers, reconfigured existing basins, ancillary process expansion, existing control building, and the solids handling improvements. The existing pad-mount transformer may need to be upsized by SNOPUD. This will be determined during design when final electrical load sizes are determined. Similarly, the existing generator at this location will need to be evaluated during design for replacement. Replacement of this existing generator is expected as the electrical loads associated with the solids handling improvements are significant. Modifications to the existing electrical service switchgear and distribution switchboards will be required to add distribution circuit breakers.

The existing electrical service and pad-mount transformer that supplies power to the existing Building No. 2 will remain operational throughout construction until the proposed headworks and basins are constructed, and the reconfiguration of the existing basins is completed. Once Building No. 2 is ready to be demolished in order to construct the solids handling improvements, the existing pad-mount transformer will be removed, and this electrical service will be abandoned.

Control system improvements will include installing new control panels and fiber optic network panels at the proposed headworks and basins, the solids handling buildings, and at the existing basins and clarifiers where necessary for integration of proposed improvements. Additionally, the existing fiber optic network will be extended to the control panels at these locations. Most of the existing fiber optic network will need to be replaced as the improvements are constructed. All control panels will be constructed to existing City standards.

8.8 SUMMARY OF CAPITAL COSTS

Table 8-27 summarizes the expected capital costs for the recommended improvements discussed in this chapter.

Table 8-27. Summary of Expected Capital Costs (in millions) for Recommended Improvements

	Upper WWTP Site Preparation	Preliminary Treatment	Secondary Treatment	Effluent Disinfection	Solids Handling	Total
Subtotal	**$11.0**	**$15.3**	**$49.9**	**$5.6**	**$35.8**	**$117.6**
Sales Tax (10.4%)	$1.1	$1.6	$5.2	$0.6	$3.7	$12.2
Construction Total	**$12.1**	**$16.9**	**$55.0**	**$6.2**	**$39.5**	**$129.8**
Indirect Costs (30%)	$3.6	$5.1	$16.5	$1.9	$11.9	$38.9
Contingency (30%)	$3.6	$5.1	$16.5	$1.9	$11.9	$38.9
Project Total	**$19.4**	**$27.1**	**$88.1**	**$9.9**	**$63.3**	**$207.7**

The total capital cost to implement all recommended improvements is approximated at $208 million in 2021 dollars.

8.9 SUMMARY OF EXPECTED O&M

Table 8-28 summarizes the expected O&M costs for the categories of recommended improvements discussed in this chapter.

Table 8-28. Summary of Expected Annual O&M Costs for Recommended Improvements

	Preliminary Treatment	Secondary Treatment	Effluent Disinfection	Solids Handling	Total
Labor	$104,000	$416,000	$52,000	$216,000	$788,000
Labor (FTE)	1.0	4.0	0.5	2.0	7.5
Electrical	$94,000	$226,000	$37,000	$179,000	$536,000
Natural Gas	$0	$0	$0	$450,000	$450,000
Chemical	$0	$137,000	$0	$409,000	$546,000
Maintenance	$200,000	$380,000	$24,000	$130,000	$734,000
Biosolids Disposal	$0	$0	$0	$305,000	$305,000
Total O&M *(Rounded up to nearest $10,000)*	**$398,000**	**$1,159,000**	**$113,000**	**$1,689,000**	**$3,359,000**

The total annual O&M project costs to implement all recommended improvements is approximated at $3.4 million in 2021 dollars. As previously noted, additional ongoing costs associated with the WWTP and collection system are not included in this estimate.

As shown in the table, 7.5 FTEs are recommended for the operations and maintenance of the recommended improvements. Additionally, it is expected that approximately 5 FTEs are necessary for other WWTP functions related to operations lead, administration, telemetry and control, laboratory work, facility and fleet maintenance, etc. At the 20-year condition, this Plan projects approximately 12.5 FTEs necessary for the WWTP. A detailed staffing analysis is recommended to further refine this estimate and to review certification levels and requirements, specific labor needs, and other criteria to provide guidance in the staffing of the facility.

8.10 SUMMARY

This chapter details the recommended improvements necessary to meet the needs identified in the preceding chapters. Implementing these large and complex improvements while maintaining WWTP operation requires thorough consideration of planning, funding, phasing, and other requirements as discussed in **Chapter 9**.

9 | IMPLEMENTATION PLAN

9.1 INTRODUCTION

The recommended improvements for the City of Lynnwood's (City) wastewater treatment plant (WWTP) are identified in **Chapter 8**. This chapter outlines other considerations and the necessary steps for the successful implementation of these improvements.

9.2 PHASING OF RECOMMENDED IMPROVEMENTS

9.2.1 Introduction

Major improvements to the WWTP must be phased in a manner that maintains the operation of the existing WWTP. The physical constraints of the existing site, as well as the complexity of the WWTP infrastructure, will challenge the implementation of significant improvements at this site. A basic phasing plan is provided herein to describe the major phases of the proposed construction and highlight the most significant phasing considerations. **Exhibit C-14 Recommended Improvements Phasing Plan** in **Appendix C** graphically displays the proposed phasing plan. To discuss phasing of improvements, the figure denotes the "Lower Site," which consists of all the existing WWTP infrastructure, and the "Upper Site," which refers to the undeveloped area uphill from the existing secondary clarifiers.

9.2.2 General Phasing Considerations

Construction can commence at the Upper Site with relatively low impact to the existing WWTP. This work would primarily impact access to the Lower Site, but should not significantly impact the existing WWTP infrastructure. Given this, construction on the Upper Site will commence ahead of the other work.

The construction of the Upper Site will allow for the commissioning of the new headworks and first stage aeration basins. The influent sewer pipe would be re-routed to the new headworks and process piping would be extended between the first stage and second stage aeration basins. Once this work is completed, the new headworks and first stage aeration basins could be commissioned to treat the influent and discharge to the secondary clarifiers while the new second stage basins are constructed.

Once the basin work is complete, the existing secondary clarifiers could be retrofitted or refurbished as needed. The existing headworks, primary clarifiers, and Main Plant Pump Station (MPPS) could then be decommissioned. Consideration for temporary pumping of plant drainage and City of Edmonds (Edmonds) influent from the existing headworks up to the new headworks is given in **9.3.3 Detailed Phasing Plan**.

Any ancillary secondary treatment improvements, such as gravity thickening, would be implemented in space made available from the removal of the existing headworks, MPPS, and primary clarifiers. A new effluent disinfection system consisting of ultraviolet (UV) disinfection would be installed to replace the existing chlorination system.

The final step of the improvements to the WWTP will be to decommission the existing solids handling system and construct the new Solids Handling Building to include thickening, dewatering, sludge drying, and truck loading facilities.

9.2.3 Detailed Phasing Plan

The following sections provide the detailed sequencing of construction of the proposed improvements. These are intended to provide the major phasing items for use in guiding the future design.

PHASE 1 – UPPER SITE PREPARATION

1. **Relocate Access Road and Influent Sewer Pipe** – The new location of the proposed road and sewer pipe is located uphill from the existing infrastructure to allow for installation while use of the existing road and pipe are maintained. Other utilities (such as gas piping) are expected to be located within the relocated access road. Once relocations are complete, the existing road and pipe can be demolished for the major site excavation and grading work.
2. **Clearing of the Site** – Remove major trees and vegetation within the limits of the proposed excavation and grading of the Upper Site. Temporary stabilization and erosion control likely will be necessary once clearing commences.
3. **Relocate Outfall Creek Pipe System** – The new pipe system will be installed and reconnected to the existing piping downstream to allow for the major excavation and shoring necessary for the Phase 2 headworks and basins.
4. **Mass Excavation** – Shoring and excavation will be completed as applicable to allow for the construction of the Phase 2 headworks, basins, piping, etc. Some excavation is expected during the Phase 2 project, although the majority of the necessary excavation and shoring is expected to be completed in Phase 1.
5. **Final Stabilization** – For areas that will not be further impacted by construction, final stabilization will be completed to control sediment transport and provide visual mitigation for the site. This work likely will consist of planting, terracing, screening at the property edge, and other measures to complete the stabilization of the site.

PHASE 2 – LIQUID STREAM IMPROVEMENTS

1. **Construct Headworks and First Stage Aeration Basins** – The new cast-in-place concrete structures and associated below-grade piping will be constructed and backfilled on the Upper Site. The upper level of the headworks will be constructed, and the architectural, mechanical, and electrical work will be completed with these structures. The new electrical service and backup generator will be installed, as well as ancillary systems like odor control. Finish grading and paving of the new surfaces around the headworks and first stage basins will be completed.
2. **Test Headworks and First Stage Aeration Basins** – Clean water testing of the new headworks and first stage basins will be completed to verify the functionality and interlocking control of the new equipment.

3. **Construct Pipe Gallery** – Construct the cast-in-place concrete pipe gallery from the lower level of the headworks to the existing pipe gallery between the second stage basins and secondary clarifiers. Extend mixed liquor, internal recycle, return activated sludge (RAS), aeration, non-potable water, and other process piping between the first stage and second stage basins through the pipe gallery.
4. **Commission Headworks and First Stage Aeration Basins** – The new headworks and first stage basins would be commissioned to allow for construction of the second stage basins and improvements to the secondary clarifiers. For this to occur, some temporary connections and systems likely will be necessary and will be further considered during design. One example of this will be a temporary force main from the MPPS to the new headworks for the purpose of temporary RAS pumping to the first stage basins during the construction of the second stage basins.
5. **Construct Second Stage Aeration Basins and Secondary Clarifier Improvements** – Influent flow will be diverted to the new headworks. The first stage basins will provide all secondary treatment and discharge to the secondary clarifiers while the second stage basins are constructed. This work would likely need to be staged to ensure the construction of second stage basins is completed during a single dry weather season.

   Following this work, necessary improvements to the secondary clarifiers and RAS system can be made sequentially. To maintain WWTP operation through this construction, the complexities of sequencing this work will be further analyzed during design to refine the phasing plan.
6. **Demolish Existing Headworks, Primary Clarifiers, and MPPS** – Remove existing infrastructure once the new headworks and aeration basins are operable. Prior to removal of the MPPS, construct a new Plant Drain Lift Station to collect all plant drainage and influent from Edmonds and convey it to the new headworks.
7. **Construct Ancillary Secondary Treatment Systems** – Within the footprint of the existing headworks, MPPS, and a portion of the primary clarifiers, construct ancillary systems such as the gravity thickening system for waste activated sludge (WAS) from the new secondary treatment process.
8. **Install UV Disinfection System** – Construct the new UV system within a portion of the footprint made available by removing the primary clarifiers. Extend and reconnect the secondary effluent piping as needed.

PHASE 3 – SOLIDS HANDLING IMPROVEMENTS

1. **Demolish Building No. 2** – Demolish remaining Primary Clarifier No. 4, gravity thickener, chlorine gas equipment, and portions of Building No. 2 as necessary to construct the new Solids Handling Building while allowing the existing electrical gear, dewatering equipment, and associated systems to remain in service during construction. Some temporary reconfiguration of the existing solids handling equipment likely will be necessary to maintain solids handling through construction.
2. **Construct Solids Handling Building** – Complete construction of the Solids Handling Building and associated systems. Test and commission the new facility. Once operable, begin

discharging gravity thickened WAS from the new secondary treatment system to the new solids handling system.

3. **Demolish Remaining Unused Infrastructure** – Remove all remaining unused infrastructure not already demolished through the course of the Solids Handling Building construction. This will include the dewatering system, sludge blending and WAS pre-concentration tankage, existing odor control, etc.

   If the administration, control, and laboratory areas are incorporated into the new Solids Handling Building, it is likely the existing Control Building and chlorine contract tank can be decommissioned at the end of Phase 3.

9.3 WWTP PERMITTING

9.3.1 NPDES and PSNGP

The current draft of the National Pollutant Discharge Elimination System (NPDES) permit for WWTP became effective on March 1, 2019. The City must apply for renewal by August 31, 2023. The proposed improvements to the WWTP will require review and approval of an engineering report in accordance with Washington Administrative Code (WAC) 173-240-060. This WWTP Facility Plan (Plan) is intended to meet those requirements. Construction documents for the proposed improvements will require review and approval by the Washington State Department of Ecology (Ecology) prior to construction in accordance with Section G5 of the NPDES permit.

The Puget Sound Nutrient General Permit (PSNGP) requires that the City prepare a Nitrogen Optimization Plan (NOP) for submittal to Ecology and comply with intermediate milestones. Optimization refers to short-term actions, such as low-cost controls and process changes focused on improving existing performance. Optimization processes do not have to include large scale capital investments. The City should complete the NOP to meet the requirements of the PSNGP.

The PSNGP also requires each treatment facility to conduct a Nutrient Reduction Evaluation (NRE) during the first permit cycle. The NRE is due by December 31, 2025. The City should plan to complete this work, which will include analysis of mainstream, side-stream, offsite, effluent management strategies, or the other options to reach 3 milligrams per liter (mg/L) Total Inorganic Nitrogen (TIN) seasonally. The analysis must be sufficiently complete that an Engineering Report may be developed for the preferred all known, available, and reasonable technologies (AKART) alternative. The NRE is anticipated to build upon the analyses provided in this Plan for mainstream treatment and can incorporate the findings of off-site alternatives from the City's General Sewer Plan (GSP). As previously noted, Ecology is continuing to perform modeling which is expected to guide the future proposed TIN limit structure and these findings should be included in the NRE. Other requirements, such as the environmental justice review, must be met as part of the NRE work.

The City must also comply with the other requirements of the PSNGP, such as the additional monitoring requirements. The additional data collected can guide the NRE and be used to refine the analyses included in this Plan.

9.3.2 Biosolids

In the future, a disposal method for the biosolids produced by the proposed solids handling system will need to be identified. The dryer will produce a Class A biosolid. At this time, it is anticipated that the biosolids will be disposed of via land application. If this approach is chosen, the City likely will be required to renew coverage under the state-wide general permit for the proposed solids handling process and validate the process through testing after startup. Once validated, the City will follow the testing and reporting requirements as derived from Chapter 173-308 WAC.

9.3.3 Air Quality

INTRODUCTION

This section summarizes applicable air quality requirements associated with proposed improvements presented in this Plan.

This overview incorporates guidance on rule interpretations provided by PSCAA staff in meetings and conversations on November 22, and December 3, 2021, and in email correspondence on January 10, 2022. Note that all guidance provided by PSCAA is informal; applicability determinations are made only when a NOC application is submitted, and decisions are based on regulations and policies in effect at the time the application is submitted.

A brief summary of the major air emissions permitting considerations include:

- Air emissions permitting is not required for wastewater treatment facilities that are newly constructed emissions units, except for those utilizing anaerobic digesters or chlorination systems. This includes both the individual emissions units and emissions controls (including odor control units) that serve newly constructed equipment.
- The air emissions permitting exemption for newly constructed wastewater treatment facilities also includes solids management facilities and associated emissions controls.
- For existing equipment that will remain in operation, replacement or alteration of existing odor control equipment cannot be completed without submitting a NOC application. This includes removal of existing odor controls.
- If a new odor control unit is installed that serves both new and existing equipment, a NOC application is required if the new odor control unit replaces an existing odor control unit.
- Air emissions permitting may be needed if the final design includes equipment that is not exempted, such as equipment for storage and handling of dry materials.

BACKGROUND

The WWTP improvements detailed in Chapter 8 simplify air emissions permitting through the following methods:

- Removal of the primary clarifiers and associated odor control equipment.

  All primary clarification equipment will be removed. After completion of the Plan improvements, the WWTP will not use primary clarification.

- Removal of the SSI and installation of new solids treatment equipment, including a belt dryer, with the dried sludge hauled to an off-site disposal location.

  A new natural gas burning boiler will be required to provide heat for sludge drying, but the boiler will be below the 10 MMBtu threshold for PSCAA permitting. The existing screw press and SSI will be removed. With elimination of the SSI, the WWTP will no longer be subject to EPA SSI Rules in 40 CFR 62 Subpart LLL. This includes requirements pertaining to operator training, annual emission testing, emission limits and standards, operating limits for air pollution control devices, and a requirement to obtain an operating permit pursuant to 40 CFR Part 70.

  The new solids handling system will be contained within a newly constructed building with odor control provided for building air.

- Removal of the chlorine gas effluent disinfection system.

  The new effluent disinfection will consist of UV disinfection, which will not necessitate air emissions permitting.

Additionally, the WWTP modifications identified in this Plan will include the following:

- Removal of the existing headworks and construction of a new headworks.

  The new headworks will be contained within a newly constructed headworks building with odor control provided for building air.

- Removal of the existing aeration basins and construction of new aeration basins.

  The new aeration basins will be configured for the densified activated sludge in a continuous flow reactor (CFR-DAS) process. The new aeration basins will be uncovered.

- The secondary clarifiers will generally remain unchanged though the existing odor control system will be removed.

  Air from beneath the existing secondary clarifier covers will remained contained and discharged to a new odor control system likely collocated with the new Headworks system.

Implementation of this Plan will be subject to PSCAA regulations, most notably the NSR provisions of Reg. 1, Article 6. General applicability of Article 6 is set forth in Section 6.03 Notice of Construction, paragraph (a):

> *(a). It shall be unlawful for any person to cause or allow the establishment of a new source, or the replacement or substantial alteration of control equipment installed on an existing source, unless a "Notice of Construction application" has been filed and an "Order of Approval" has been issued by the Agency.*

Recommendations of the Plan include both the construction of new emissions sources and the replacement or substantial alteration of control equipment installed on an existing source. These are discussed separately below.

ESTABLISHMENT OF A NEW SOURCE

"Establishment of a new source" is an encompassing term that includes:

- Creating an entirely new source; and
- Modifying or changing the operation of an existing source such that there is an increase in the amount of any air contaminant emitted or emission of any air contaminant not previously emitted.[1]

Exemptions to the PSCAA NSR requirements are contained in Reg. 1 Section 6.03(c). The exemption provisions are self-implementing, i.e. there is no requirement to obtain PSCAA concurrence on exemptions, provided that sufficient records are kept documenting the exemption.[2]

Almost all physical and operational changes to the WWTP that are proposed in the Plan constitute “establishment of a new source” subject to NSR unless the change is an exempted activity.

Wastewater Treatment and Solids Management Activities

In general, wastewater treatment activities, including solids processing other than anaerobic digestion, are exempt from air permitting requirements per Reg. 1 §6.03(c)(93) (last revision date September 24, 2015)

> *Municipal sewer systems, including wastewater treatment plants and lagoons, PROVIDED THAT they do not use anaerobic digesters or chlorine sterilization.*

In meetings with PSCAA regarding this Plan, PSCAA staff indicated that the modifications included in the Plan appeared to qualify for the municipal wastewater treatment exemption. Note that this guidance is informal; formal exemption determinations are made only after submittal of project permitting information.

Non-Exempt Equipment

The exemption from permitting is for wastewater treatment activities and processes only; it does not apply to ancillary equipment that does not meet PSCAA exemption criteria. For example, installation of equipment for handling or mixing bulk dry materials might require a NOC application. Accordingly, the design should include an assessment of whether there are specific equipment items or activities that might not be exempt from permitting. As noted previously, records documenting the exemption assessment should be maintained.

If the WWTP expansion should require a change to emergency engines, the added engine capacity is potentially subject to NSR unless specific conditions are met.

Per Reg. 1 §6.03(c)(3) (last revision date September 24, 2015), standby engines are generally exempt from air permitting requirements provided the engine operates less than 500 hours per year and the WWTP does not have a power curtailment agreement that offers lower rates:

> *(3) Stationary internal combustion engines having a rated capacity:*
>
> *(A) <50 horsepower output;*

---

1 See definition of “modification” in WAC 173-400-030.

2 A request for formal concurrence regarding an exemption determination typically requires submittal of a NOC application and payment of permit fees.

> *(B) Used solely for instructional purposes at research, teaching, or educational facilities; or*
>
> *(C) Portable or standby units operated <500 hours per year, PROVIDED THAT they are not operated at a facility with a power supply contract that offers a lower rate in exchange for the power supplier's ability to curtail energy consumption with prior notice.*

Note that even if the engines are exempt from air permitting, the engines must still be selected and operated in accordance with US EPA regulations governing stationary internal combustion engines.[3]

REPLACEMENT OR SUBSTANTIAL ALTERATION OF EXISTING EMISSION CONTROLS

When there is an existing control device on a piece of equipment, that equipment cannot be replaced or altered without filing a NOC application, per WAC 173-400-114 (effective December 29, 2012, and incorporated by reference into PSCAA Regulation 1, Article 6).

> *(1) Any person proposing to replace or substantially alter the emission control technology installed on an existing stationary source or emission unit shall file a notice of construction application with the appropriate authority, or with ecology in areas or for sources over which ecology has jurisdiction. Replacement or substantial alteration of control technology does not include routine maintenance, repair or similar parts replacement.*
>
> *(2) A project to replace or substantially alter emission control technology at an existing stationary source that results in an increase in emissions of any air contaminant is subject to new source review as provided in WAC 173-400-110. For any other project to replace or significantly alter control technology the permitting authority may:*
>
> *(a) Require that the owner or operator employ RACT for the affected emission unit;*
>
> *(b) Prescribe reasonable operation and maintenance conditions for the control equipment; and*
>
> *(c) Prescribe other requirements as authorized by chapter 70.94 RCW.*

WAC 173-400-114 applies to any replacement or substantial alteration of any existing emissions control device even if the underlying process is otherwise exempt from new source review. Thus, a NOC application will be required for replacement or substantial alteration of any existing odor control devices at the WWTP.

Note also that WAC 173-400-114 applies only to existing emission control units. Therefore, the WWTP may voluntarily place an emissions control device on a newly constructed or uncontrolled existing source without filing a NOC application. However, after the emissions controls are installed, the emissions controls may not be replaced or altered without filing a NOC application and receiving an AO.

NOC applicability for odor control equipment in the Facility Plan are summarized in **Table 9-1**.

3 See 40 CFR 60 Subparts IIII and JJJJ and 40 CFR 63 Subparts YYYY and ZZZZ.

Table 9-1. Summary of Notice of Construction Applicability for Odor Control Units

Plant Area	NOC Applicability		Discussion
	At Installation	Future Changes	
Headworks	No	Yes	Because the existing headworks is being entirely removed, the new headworks is considered new construction and is exempt from review.
Primary Clarifiers	No	NA	The primary clarifiers are being entirely removed. Although NOC application is not required, notice to PSCAA of equipment removal is needed.
Aeration Basins	No	NA	Because the existing aeration basins are being removed and replaced with new and expanded basins, the new basins are considered new construction and are exempt from review.
Solids Building	Yes (if equipment is modified)	Yes	Because the solids building will remain, any substantial change in odor controls is alteration of emissions control technology at an existing source.

When reviewing a NOC application for replacement or substantial alteration of existing emissions controls, PSCAA requires that the new or altered equipment use RACT.

RACT is determined for the project during permit issuance. The RACT evaluation is typically stated in numeric limits, such as maximum outlet concentrations or minimum removal percentages in control equipment.

RACT review commences by identifying the pollutants to be controlled by the project. A review is then conducted to determine emissions limits or performance requirements that have been included in recent projects for similar facilities. Vendor statements of equipment performance also will be included in the evaluation. In recent PSCAA AOs for odor control scrubbers, RACT pollutants have included hydrogen sulfide, reduced sulfur compounds (such as mercaptans), amines, ammonia, and non-methane volatile organics.

RECOMMENDATIONS

Based on the review of air permitting issues, the following steps should be taken:

1. Include air emissions issues in the project concepts and criteria.

   Concepts and criteria should identify project features for which a NOC application is required and a description of design information that will be needed to prepare the NOC application. The description should address information likely to be needed for RACT assessment. Exemptions from air permitting also can be documented at this stage.

2. Prepare and submit needed NOC applications when the design is sufficiently complete to prepare a complete application.

   This can happen as early as 30-percent design stage when basic project design assumptions and equipment performance requirements are set. If preparing a complete application requires vendor specific information, it might not be possible to submit the application until preliminary equipment selection is complete.

9.4 LAND USE AND CONSTRUCTION PERMITTING

To construct the proposed WWTP improvements, coordination with and permit approvals from several regulatory agencies will be required. The following sections detail the existing regulated resources onsite, summarize previous coordination with regulatory staff, and provide an analysis of anticipated permit constraints and requirements based on current design concepts. This discussion does not address permits related to the ongoing operation of the WWTP (i.e. NPDES permits); those were previously discussed in **Chapter 3**. The permits needed and associated efforts should continue to be refined as the design of the expansion advances and further coordination with regulatory agencies occurs.

9.4.1 Existing Environmental Resources and Potential Impacts

OUTFALL CREEK

Figure C-2 Existing Site Overview in **Appendix C** shows a watercourse named Outfall Creek present upslope of and piped through the WWTP. Outfall Creek originates southeast of the WWTP near the intersection of Braemar Drive and 76th Avenue W, and generally flows south in open channel sections adjacent to residences and culverted sections under existing roadway crossings. On parcel no. 27040700101800, the creek flows into a vertical corrugated steel pipe outfitted with a conical debris barrier, and is then piped beneath parcel nos. 27040700101800 and 27040700105700 and the WWTP (pipes ranging from 24- to 30-inch diameter), until its outlet to Browns Bay in Puget Sound under the Burlington Northern Railway railroad tracks (via a 36-inch-diameter pipe). Outfall Creek is a Type F stream (i.e. known to be used by fish or meet the physical criteria to support fish). Within Edmonds jurisdiction, Type F anadromous fish bearing streams adjacent to reaches with anadromous fish access require a 100-foot buffer (Edmonds Municipal Code 23.90.040.D.1). Likewise, Type F streams in City jurisdiction require a 100-foot buffer (Lynnwood Municipal Code (LMC) 17.10.071).

The WWTP facility expansion is expected to require relocation and/or replacement of portions of the pipe network conveying Outfall Creek under the WWTP and downslope from parcel no. 27040700101800. As currently conceptualized, the WWTP expansion will permanently impact Outfall Creek and its regulated buffer. Anticipated implications of the project for regulated critical areas, including Outfall Creek, are further discussed in the sections that follow.

STEEP SLOPES

The planned expansion area contains steep slopes (up to 40-percent slopes), mapped by Edmonds and the City as landslide and erosion hazard areas and regulated as geologically hazardous critical areas. To expand the facility, extensive clearing and grading, including slope stabilization, would be needed to accommodate the new infrastructure. Construction activities within these areas is anticipated to require geotechnical analysis, reporting, and review by the local jurisdiction.

PUGET SOUND

The existing facility is located adjacent to Browns Bay in Puget Sound and consequently is within shoreline jurisdiction. Any substantial improvements completed within 200 feet of Puget Sound will be subject to the Shoreline Management Act and associated reviews.

9.4.2 Anticipated Permit Requirements

Permit requirements, project-specific triggers, and anticipated review timing are summarized in **Table 9-2**. Additional discussion and prior coordination with regulatory staff is summarized following the table.

Table 9-2. Anticipated Permit Requirements for Construction of the WWTP Expansion

Jurisdiction		Permit/Review	Review Timing	Reason
Local	City[1]	Boundary Line Adjustment (BLA)	3 to 4 months	Adjustment of boundary lines for Edmonds parcels annexed to City for WWTP expansion
		State Environmental Policy Act (SEPA)	Up to 2 months	WWTP improvements do not fit SEPA exempt categories
		Conditional Use Permit (CUP)	3 to 4 months	Expansion of the WWTP, an Essential Public Facility
		Land Use Variance	3 to 4 months	Deviation from development standards
		Shoreline Permit	3 to 4 months	Work within regulated shorelands
		Critical Areas	3 to 4 months	Impacts to Outfall Creek and geologically hazardous areas
		Project Design Review	1 to 2 months	>1,000 sf construction
		Demolition Permit	Up to 2 months	Demolition of existing structures
		Right-of-Way (ROW)	1 month	Construction in City ROW
		Building Permit	Up to 2 months	Construction of new structures
		Grading Permit	Up to 2 months	Proposed grading activities
		Public Works[2]	Up to 2 months	Various (see footnote)
State	Ecology	Construction Stormwater General Permit (CSWGP)	Up to 2 months	Land disturbance over 1 acre and discharge to state waters
		Section 401 Water Quality Certification	Up to 6 months	Disturbance to state waters and Section 404 Permit trigger
	DAHP	Cultural Resources[3]	3 to 4 months	Federal and/or state permit nexus

Table 9-2. Anticipated Permit Requirements for Construction of the WWTP Expansion (Cont.)

Jurisdiction		Permit/Review	Review Timing	Reason
	WDFW	Hydraulic Project Approval (HPA)	45 days	Activities involving work in or near waters of the state
Federal	U.S. Army Corps of Engineers (USACE)	Section 404 Permit[4]	Up to 12 months	Disturbance to Waters of the United States (WOTUS)
Federal	U.S. Army Corps of Engineers (USACE)	National Environmental Policy Act (NEPA)[5]	6 to 12 months	Federal nexus through Section 404 review process

[1] This table and permitting needs assessment assumes that annexation of parcels within Edmond's jurisdiction surrounding the existing Lynnwood WWTP will occur ahead of permitting efforts; consequently, local permitting will occur through the City as the primary local jurisdiction.

[2] The City's Public Works application form facilitates application for Critical Areas, Grading, ROW Use, Sewer System, Storm Drainage, Tree Removal, Water Main/Service, and other reviews.

[3] Re-piping of Outfall Creek and/or potential funding is anticipated to trigger a federal nexus for the project; consequently, cultural resources review and compliance is expected to occur under the Section 106 process of the National Historic Preservation Act (NHPA).

[4] Depending on USACE processing of the Section 404 Permit, permit review timing is highly variable. Nationwide permit types tend to be streamlined with reviews ranging from 3 to 6 months, whereas Individual permit types require upwards of 12 months, sometimes longer.

[5] NEPA compliance is a requirement of any federal permit review and/or projects involving federal funding or lands (referred to as a federal nexus). For the project, it is anticipated USACE will be the lead federal agency responsible for NEPA compliance. NEPA compliance typically includes several federal statutes, such as the Endangered Species Act, Section 106 of the NHPA, Coastal Zone Management, and others.

LOCAL – CITY OF LYNNWOOD

The City-owned parcels (nos. 27040700101800, 27040700105700, 27040700100900, and 27040700107100) planned for expansion are currently within Edmonds' city limits and purview. In September 2021, the City and Edmonds completed a Development Review Committee (DRC) meeting to discuss the project and potential local permit compliance. Both jurisdictions agreed that the preferred route for local permitting was City annexation of the parcels because this approach would mean only one local agency would be responsible for review and issuance of local permits. The need for additional interagency coordination between these jurisdictions was discussed at the DRC meeting. It is recommended that the City pursue annexation as a first step in advancing local permit compliance for the project.

Pre-Development Meeting

During design of the WWTP expansion, and prior to permit application preparation, a pre-development meeting with the City is recommended. This will give staff from the City's Development and Business Services, Planning, Public Works, and Fire Departments the opportunity to provide feedback on the preliminary facility design, identify any specialized studies, and determine permit application requirements and associated review timelines.

Boundary Line Adjustment

To allow for proposed WWTP facility expansion, the City may desire to undergo a BLA of the newly annexed parcels. The BLA process would allow the proposed facility expansion to occur with overall property and building setbacks for the combined parcel boundary, instead of individual setbacks for each parcel. Without the BLA process, the City will be limited to land use code setbacks for each separate parcel, ultimately constraining the City from installing improvements on the site as they are currently conceptualized. In addition to the BLA process, designation of zoning for the newly annexed parcels may be needed. RH2 recommends the BLA process be included as a topic of discussion at the pre-development meeting and occur prior to or concurrent with City land use permitting.

SEPA

The project is anticipated to require compliance with SEPA per Chapter 17.02 LMC. It is assumed the City would act as lead agency for SEPA review, determination, and publication. Additional discussion with the City's Planning Department to coordinate the SEPA review process will be needed.

Conditional Use Permit

The existing facility is considered an "Essential Public Facility" (EPF) per LMC 21.03.318. Chapter 21.73 LMC requires that EPFs proposing expansion obtain a CUP. The CUP process is coordinated with other land use permit reviews like SEPA, BLA, Critical Areas, and others. CUPs require public participation and a review process with a hearing examiner's decision.

Land Use Variance

The existing WWTP is in the City's Public (P-1) zone. The area currently planned for expansion is within Edmonds' zoning jurisdiction. However, assuming annexation is feasible, it is anticipated the City would designate the newly acquired parcels in the P-1 zone as well. Therefore, it is expected the expansion would be subject to the development standards for the P-1 zone outlined in LMC 21.44.200 and summarized in **Table 9-3**.

Table 9-3. Lynnwood Public Zone Development Standards

Zone	Minimum Setbacks (ft)[1]			Height	Lot Coverage
	From Public Street	From Property Line Adjoining Single-Family Zone/Use	From Other Property Line		
P-1	15	50	25	None	≤35 percent

[1] Minimum setbacks shall be increased by 1 foot for each foot of height exceeding 45 feet for proposed buildings.

As site design advances and coordination with the City occurs via the pre-development meeting, it will be prudent to discuss development standards. If the site design varies from the development standards, the project could trigger a Land Use Variance process. This process would occur in conjunction with land use permitting for the project.

Shoreline Management Act Review

The existing facility is located within regulated shorelands, subject to the provisions of the Shoreline Management Act (SMA). The City's *Shoreline Master Program* (2018 Periodic Update) (SMP) details existing conditions associated with the shoreline environment on and adjacent to the City's WWTP. The existing WWTP facility parcel (no. 27040700105800) is the sole land within the City's shoreline jurisdiction. Lands waterward of the ordinary high water mark (OHWM) of Puget Sound are designated by the City as Aquatic shoreline environment, whereas areas landward and within 200 feet of the OHWM are designated as High Intensity shoreline environment. Additionally, those areas seaward of the extreme low tide line are Shorelines of Statewide Significance within the WWTP parcel and City SMA jurisdiction. **Figure 9-1** displays the City's SMA shorelines.

Figure 9-1 – Lynnwood SMP Excerpt – Figure C4: Shorelines of Statewide Significance and Shorelands Maps (Dated 7/11/2018)

Based on the City's SMP, expansion of the WWTP and associated lower site facility improvements (wastewater treatment facility and/or utility uses) are anticipated to trigger a Shoreline Substantial Development Permit review process. As design advances for the site improvements, additional coordination with the City will determine precise pathways for the project's SMA compliance.

Critical Areas

Geologically hazardous areas (landslide and erosion hazards) and Outfall Creek are critical areas present on the existing WWTP parcel and surrounding City-owned Edmonds jurisdiction parcels. These critical areas will be regulated under the City's Critical Areas Code (Chapter 17.10 LMC).

Expansion of the WWTP facility is anticipated to involve significant clearing and grading activities, including slope stabilization, which will require geotechnical investigation and reporting, consistent with LMC 17.10.104.

Similarly, proposed expansion upslope of the existing facility is expected to involve impacts to and re-piping of Outfall Creek, as well as permanent and temporary impacts to the stream buffer. Alteration of Outfall Creek will be regulated under LMC 17.10.073 and 17.10.074. A Critical Areas Report (CAR) will need to be prepared to address existing stream conditions and proposed alterations, consistent with LMC 17.10.072. Compensatory mitigation will be required to offset impacts; mitigation will need to be coordinated with and meet requirements of the City, Washington Department of Fish and Wildlife (WDFW), the Tulalip and/or Muckleshoot Indian Tribes, USACE, and the National Marine Fisheries Service. Because WWTP facility expansion will permanently impact a large portion of the Outfall Creek stream buffer and opportunity for on-site mitigation is limited, it is likely off-site buffer mitigation will be needed for the project. Additional discussion is provided below regarding mitigation expectations.

Project Design Review

Project design review (PDR) is expected for WWTP expansion because construction activities will disturb over 1,000 square feet (sf). The PDR application typically requires a conceptual site plan addressing grading, drainage, lighting, signs, and landscaping plans; a statement of consistency with zoning criteria; a completed SEPA checklist; and product specifications. Additional discussion with the City is recommended at the pre-development meeting for PDR applicability and needs.

Demolition Permit

Demolition of existing structures would require a Demolition Permit from the City. As design advances for the site improvements, the need for this permit will be discussed with the City.

Building Permit

The expansion of the WWTP facility will require coordination with the City to ensure consistency with building codes and design criteria. A commercial Building Permit, including Electrical, Mechanical, Fire, and Plumbing reviews, is expected.

Grading Permit

Excavation to construct the facility expansion will trigger a Grading Permit, applied for using the City's Public Works application form.

Right-of-Way Permit

Construction activities occurring in Bertola Road or 76th Avenue W will require a ROW Permit, either through the City or Edmonds in the case of 76th Avenue W.

Public Works Application

The City's Public Works application form facilitates critical areas review, grading, ROW use, sanitary sewer system, storm drainage review, tree removal, water main service or installation, and other public works related reviews. As design is advanced, coordination with the City should occur to confirm applicable reviews and application requirements. It is assumed that several, if not all, of these reviews will be needed and reviewed concurrently under a single Public Works application.

Outreach to Neighboring Properties

It is recommended that the City engage the property owners in the City of Edmonds which neighbor the WWTP. As previously noted, the project proposes some significant potential benefits to nearby properties through the removal of primary clarifiers, chlorine gas handling equipment and the SSI. However, outreach should seek to educate the neighboring property owners on the drivers, benefits and potential impacts of the project in order to elicit their feedback from the outset of this project.

STATE

HPA – WDFW

Outfall Creek is regulated as a Type F water of the state under the Washington Hydraulic Code (Chapter 220-660 WAC and Chapter 77.55 of the Revised Code of Washington (RCW)). WWTP facility expansion improvements that will impact Outfall Creek require HPA.

An on-site meeting with a WDFW area habitat biologist (AHB) was held in July 2021 to review the project. Expansion of the WWTP is anticipated to involve tying into, relocating, and/or re-piping a portion of the piped segment of Outfall Creek upslope of and within the footprint of the existing facility. Consequently, the WDFW AHB explained that current Hydraulic Code standards require the replacement culvert be sized for fish passage per WDFW's *Water Crossing Design Guidelines* (2013). Based on the observed bankfull widths of Outfall Creek, a replacement culvert that accommodates fish passage would be on the order of more than 10 feet in width. The AHB indicated WDFW's preference would be to daylight Outfall Creek if it could feasibly be accomplished on or adjacent to the existing WWTP; however, space and grades on the site and in the vicinity are very limited and/or confined. Additionally, property ownership presents challenges. Daylighting of Outfall Creek and/or upsizing a replacement culvert for fish passage is largely not feasible while still accommodating the WWTP facility improvements.

As currently conceptualized, the facility expansion would require the continued piping of Outfall Creek, constituting a long-term adverse impact and permanent loss of fish passage to a Water of the State. As such, mitigation likely would need to be designed and agreed upon with stakeholders including, but not limited to, WDFW, the Tulalip Tribes, Muckleshoot Indian Tribe, and USACE. Such mitigation would be separate from, but should be coordinated with, City requirements to compensate for stream buffer impacts.

A reach assessment of Outfall Creek is recommended as a first step in coordinating project improvements and viable compensatory mitigation. Early involvement of stakeholders in project design and permitting will be crucial to obtaining permit approvals in a timely manner.

Cultural Resources Review – DAHP

The facility expansion site is mapped by the Washington State Department of Archaeology and Historic Preservation (DAHP) as areas with “high risk” and “very high risk” of encountering yet-undiscovered historic or cultural resources. As such, conducting a cultural resources study for the WWTP expansion to accompany the SEPA checklist is advised. However, if any part of the project receives funding from a Washington state agency, then Governor’s Executive Order (GEO) 21-02 review process would be triggered, and the cultural resources review would be elevated from the SEPA level. Moreover, if the project requires a USACE permit, the cultural resources review process would be through Section 106 of the NHPA instead of GEO 21-02 or SEPA. Section 106 review would be part of NEPA compliance conducted by USACE as the lead federal agency. If another federal agency becomes involved in the project (e.g., through funding), NEPA and Section 106 compliance would be coordinated by those jurisdictions. For project compliance, the City should hire a qualified archaeologist to review the project and site, conduct investigations, and write a survey report. The cultural resources survey would be used to consult with DAHP and affected Indian Tribes on the project’s anticipated cultural resources impacts.

Section 401 Water Quality Certification – Ecology

With anticipated Outfall Creek work, Section 404 of the Clean Water Act (CWA) is triggered and USACE review is expected. Consequently, the project would need to obtain a Section 401 Water Quality Certification through Ecology. Additional coordination with USACE and Ecology would be required to determine whether Individual or Nationwide Section 401 review is applicable. Individual Section 401 reviews can be triggered with certain Nationwide Permit types and usually require upwards of 6 months to complete.

CSWGP – Ecology

Construction is anticipated to disturb more than 1 acre of land and potentially discharge construction stormwater to a state water; therefore, a CSWGP will be required by Ecology.

Washington State Department of Natural Resources (DNR)

The City has an easement from DNR for the outfall of the WWTP. DNR should be consulted regarding any potential changes to the outfall that necessitate work within this easement.

FEDERAL

Section 404 Permit – USACE

Outfall Creek is anticipated to be classified as WOTUS; therefore, impacts associated with the relocation of its conveyance pipe are regulated by USACE under Section 404 of the CWA. It is likely that Section 404 compliance could be achieved through a Nationwide Permit review process; however, a lengthier Individual Permit review process may be needed. Coordination with USACE during early project design is recommended as Section 404 review could require a lengthy duration.

Compensatory mitigation actions developed for compliance with the City's Critical Areas regulations and the HPA also would need to meet requirements for the Section 404 permit.

If project design requires impacts to the outfall of Outfall Creek at Puget Sound, then compliance with Section 10 of the Rivers and Harbors Appropriation Act of 1899 also would be required, which would be reviewed concurrently with Section 404.

NEPA

The need for a federal permit triggers compliance with NEPA. At this time, NEPA compliance is anticipated to be completed by USACE as part of the Section 404 review process.

NEPA compliance requires subsidiary reviews, such as Section 106, toxic/hazardous materials reviews, and Endangered Species Act (ESA) compliance, among others, as applicable. The nature of proposed improvements will dictate the level of documentation and compliance needed for these subsidiary reviews. Given the current conceptualized site design, NEPA is expected to involve Section 106, ESA, Coastal Zone Management consistency, and water quality reviews.

9.4.3 Permitting Next Steps for WWTP Expansion

The following is a summary of the recommended next steps in permitting the WWTP expansion:

- Initiate annexation of subject parcels from Edmonds to City jurisdiction. Complete BLA and zoning designation for the newly annexed parcels, as needed.
- Arrange a pre-development meeting with City departmental staff.
- Conduct environmental site investigations and a reach assessment of Outfall Creek.
- Coordinate with WDFW, Tribes, and USACE regarding project design, impacts to Outfall Creek, and mitigation options.
- Discuss and identify potential stream buffer mitigation options with City Planning staff.

This permitting analysis was based on current concepts for the WWTP expansion, available environmental data, applicable regulations, and preliminary discussions with regulatory staff. Consequently, this assessment is limited and permit requirements should be confirmed during expansion design through further coordination with the regulatory agencies.

9.5 CAPITAL PROJECTS PLAN

Based on the phasing plan identified in **9.2 Phasing of Recommended Improvements** and the planning and permitting considerations outlined in **9.3 WWTP Permitting** and **9.4 Land Use and Construction Permitting**, this section outlines the projected overall schedule for the proposed improvements and the capital expense associated with this schedule.

9.5.1 Schedule

A conceptual estimate of the overall schedule for the three phases of improvements is shown in **Figure 9-2**.

Figure 9-2 – Conceptual Estimate of Overall Schedule for Improvements

Task	Year (Quarter)																					
	2022				2023				2024				2025				2026				2027-2028	2029-2031
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1-4	1-4
Planning																						
Facility Plan																						
GSP																						
Ecology Approval																						
Design & Permitting																						
Survey/Geotech.																						
Permitting																						
Phase 1 Design																						
Phase 2 Design																						
Phase 3 Design																						
Construction																						
Phase 1																						
Phase 2																						
Phase 3																						

9.5.2 Capital Projection

Based on the schedule shown in **Figure 9-2**, **Table 9-4** projects the estimated annual capital expenditures to complete the three phases of improvements. This estimate is based on the estimated capital costs for each project identified in **Chapter 8** and shown here in 2021 dollars.

Table 9-4. WWTP Capital Improvement Plan

Task	Costs in 2021 Dollars (Millions)										Total
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	
Design & Permitting											**$19.5**
Survey/Geotechnical		$0.3									$0.3
Permitting		$0.5	$1.1	$1.1			$1.2				$3.9
Phase 1 Design			$1.4								$1.4
Phase 2 Design			$4.6	$4.6							$9.3
Phase 3 Design							$4.6				$4.6
Construction											**$188.2**
Phase 1				$17.5							$17.5
Phase 2					$37.8	$37.8	$37.8				$113.3
Phase 3								$19.1	$19.1	$19.1	$57.4
Total	**$0.0**	**$0.8**	**$7.1**	**$23.3**	**$37.8**	**$37.8**	**$43.6**	**$19.1**	**$19.1**	**$19.1**	**$207.7**

9.6 OTHER CONSIDERATIONS AND NEXT STEPS

9.6.1 Complete General Sewer Plan and Submit Plans

The City's GSP will be completed in 2022. The population growth, flow, and loading projections from the GSP were used in the analyses of this Plan. The GSP also will review off-site improvements that could potentially be used to reduce the WWTP improvements identified in this Plan. If no feasible, significant off-site improvements are recommended, the WWTP Capital Improvement Plan (CIP) projects identified in this Plan will be included in the overall CIP and financial plan in the GSP.

The GSP and this Plan should be submitted concurrently to Ecology for review. These plans need to be approved to allow for the CIP projects to commence.

9.6.2 Preliminary Design or Project-Specific Engineering Report

As recommended in **Chapter 8**, a preliminary design effort or project-specific engineering report is recommended for at least the liquid stream (secondary treatment) improvements. This work would memorialize the findings of the NRE and additional nutrient monitoring and provide the detailed design criteria for the secondary treatment improvements. This criterion would be intended to guide Ecology through the drafting of nutrient limits in the City's future NPDES discharge permit. If the City collaborates with Ecology and other entities on the potential full-scale demonstration of CFR-DAS at the City, an engineering report could be used to outline a strategy for the demonstration, monitoring, and eventual adoption of the chosen treatment technology.

9.6.3 Funding Strategy

The 2022 GSP will outline the financial impacts of the proposed CIP to rate payers. This information will be used to formulate a funding strategy to complete the projects. The City needs to begin improvements soon to rectify deficiencies and expand capacity, regardless of the future need for TIN reduction. However, there may be opportunities for funding due to the City's early adoption of a developmental technology that can be used for TIN reduction. Ideally, early adoption of promising developmental technologies, which could provide a benefit to a broad base of potential users, would be incentivized to offset the risks and potential added cost of being the first to implement the technology. This consideration should be part of any potential funding strategy for the WWTP improvements.

9.6.4 Early Adoption of Emerging Technology

The analyses provided in this Plan detail the physical constraints of the existing WWTP, which significantly challenge the implementation of improvements to expand capacity. For the City, larger aeration basins are needed to support the projected growth in flow and loading and, as previously shown, the maximal aeration basin tankage should be constructed during the project to maximize the treatment capacity of the site. This approach will allow for the removal of primary treatment to facilitate the needed reconfiguration of the site.

By maximizing the aeration basin tankage on the site, the recommended WWTP configuration in **Chapter 8** can likely provide secondary treatment capacity (treating for the current conventional parameters of biochemical oxygen demand and total suspended solids) with moderate densification of the activated sludge allowing for increased mixed liquor concentration and clarifier solids loading rates. This configuration will substantially increase the operability and reliability of the WWTP. If current permit limits were maintained, the likelihood of consistent permit compliance is high.

To meet the potential low effluent TIN limit of 3 mg/L as proposed by the PSNGP, significant densification of the activated sludge would be necessary to provide a longer solids retention time and support substantially increased mixed liquor concentration and clarifier solids loading rates above conventional design criteria. The recommended configuration would not be substantially changed to provide TIN reduction; the operation and controls would be altered to densify the activated sludge more aggressively. As shown in **Chapter 8**, such densification could potentially be achieved in the maximum available aeration basin tankage volume of 2.75 million gallons, but the risk of inconsistent permit compliance substantially increases. This risk is due to the need to densify to levels that are considered to be emerging or developmental. As analyzed in **Chapter 6**, other secondary treatment technology options were reviewed and it was noted that, in order to meet a low TIN limit at the City's site, any applicable technology is considered to be emerging or developmental for this application.

6.3.5 Discussion on Established and Emerging Technologies of **Chapter 6** discusses the guidance in the Orange Book for assessment and implementation of "new or developmental" technologies. A full-scale or representative pilot would be the recommended approach for any of the secondary treatment technologies applicable to the City, but as discussed in **Chapter 6**, it is unlikely that this is achievable. Alternatively, a full-scale demonstration could be pursued at another facility, although it would be challenging to find and implement a location to perform a representative demonstration.

As previously noted, the fundamentals of the CFR-DAS process are currently being demonstrated at other facilities with the closest notable locations being the Cashmere, Washington and the Peshastin, Washington facilities. While neither of these facilities could be utilized to simulate a full-scale demonstration of equivalence to Lynnwood, they show that properly designed densified activated sludge systems can provide exceptional reduction of TIN and high capacity relative to footprint. The analyses of **Chapter 6** showed that CFR-DAS will provide the highest increase in capacity with the most sustainable approach to secondary treatment for the City. Further, it will make use of the best available secondary treatment knowledge in order for the City to proactively prepare for future TIN limits while remaining within the current scope of necessary improvements. CFR-DAS will meet the intent of AKART, but it is considered to be emerging, and ultralow numerical TIN limits cannot be guaranteed at all conditions at this time.

The potential for low TIN effluent limits will create a similar scenario for other Puget Sound dischargers, in which the constraints of each facility will necessitate reliance on new or developmental technologies that cannot undergo a full-scale or representative pilot. Such facilities also will look for an applicable location to perform full-scale demonstration of such technologies. Lynnwood offers a unique opportunity to be an early adopter of CFR-DAS and could provide a full-scale demonstration of TIN reduction with the challenges of wet weather flows, cold temperatures, and constrained tankage. Other Puget Sound dischargers would have the opportunity to learn from this facility for the purposes of guiding their own selection and design of facility upgrades for TIN reduction.

The City should continue a dialog with Ecology through the review of this Plan and beyond to develop a framework for implementing CFR-DAS. The City and Ecology could partner in the full-scale demonstration of the promising developmental technology, which could be applicable to a broad base of users within the watershed and beyond.

Appendix A

NPDES and PSNGP Permits

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Issuance Date: February 8, 2019
Effective Date: March 1, 2019
Expiration Date: February 29, 2024

National Pollutant Discharge Elimination System
Waste Discharge Permit No. WA0024031

State of Washington
DEPARTMENT OF ECOLOGY
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington
and
The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1342 et seq.

City of Lynnwood
19100 44th Avenue West
Lynnwood, WA 98046

is authorized to discharge in accordance with the Special and General Conditions that follow.

Plant Location:
City of Lynnwood Wastewater Treatment Plant
17000 76th Avenue West
Edmonds, WA 98026

Receiving Water:
Browns Bay – Puget Sound

Treatment Type:
Activated sludge

Rachel McCrea
Water Quality Section Manager
Northwest Regional Office
Washington State Department of Ecology

Table of Contents

Summary of Permit Report Submittals

Refer to the Special and General Conditions of this permit for additional submittal requirements.

Permit Section	Submittal	Frequency	First Submittal Date
S3.A	**Discharge Monitoring Report (DMR)**	**Monthly**	**April 15, 2019**
S3.A	**Discharge Monitoring Report (DMR)**	**Quarterly**	**July 15, 2019**
S3.A	**Discharge Monitoring Report (DMR)**	**Annual**	**January 15, 2020**
S3.F	Reporting Permit Violations	As necessary	
S4.B	Plans for Maintaining Adequate Capacity	As necessary	
S4.D	Notification of New or Altered Sources	As necessary	
S4.E	**Infiltration and Inflow Evaluation**	**Annual**	**June 30, 2019**
S5.F	Bypass Notification	As necessary	
S5.G	**O&M Manual Update**	**1/permit cycle**	**March 31, 2019**
S6.A.5	**Pretreatment Annual Report**	**Annual**	**March 31, 2019**
S6.A.6	Request to make changes to pretreatment program	As necessary	
S8.C.3	**Acute Toxicity: Compliance Monitoring Reports**	**Quarterly**	**July 30, 2019**
S8.D	Acute Toxicity: Response to noncompliance reporting	As necessary	
S8.D	Acute Toxicity: TI/RE Plan	As necessary	
S9.A.2	**Chronic Toxicity: Characterization**	**2/permit cycle**	**January 30, 2023** **July 30, 2023**
S10	**Outfall Evaluation**	**1/permit cycle**	**December 31, 2021**
S11	**Application for Permit Renewal**	**1/permit cycle**	**August 31, 2023**
G1	Notice of Change in Authorization	As necessary	
G4	Reporting Planned Changes	As necessary	
G5	Engineering Report for Construction or Modification Activities	As necessary	
G7	Notice of Permit Transfer	As necessary	
G10	Duty to Provide Information	As necessary	
G20	Compliance Schedules	As necessary	
G21	Contract Submittal	As necessary	

Special Conditions

S1. Discharge limits

S1.A. Effluent limits

All discharges and activities authorized by this permit must comply with the terms and conditions of this permit. The discharge of any of the following pollutants more frequently than, or at a level in excess of, that identified and authorized by this permit violates the terms and conditions of this permit.

Beginning on the effective date of this permit, the Permittee may discharge treated domestic wastewater to Browns Bay – Puget Sound at the permitted location subject to compliance with the following limits:

Effluent Limits: Outfall 001 Latitude: 47.8478 Longitude: -122.3425		
Parameter	**Average Monthly** [a]	**Average Weekly** [b]
Carbonaceous Biochemical Oxygen Demand (5-day) ($CBOD_5$)	25 milligrams/liter (mg/L) 1,543 pounds/day (lbs/day) 85% removal of influent $CBOD_5$	40 mg/L 2,469 lbs/day
Total Suspended Solids (TSS)	30 mg/L 1,851 lbs/day 85% removal of influent TSS	45 mg/L 2,777 lbs/day
Parameter	**Minimum**	**Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria [c]	200/100 milliliter (mL)	400/100 mL
Parameter	**Average Monthly**	**Maximum Daily** [d]
Total Residual Chlorine	278 µg/L	728 µg/L
The effluent limit for acute toxicity is: No acute toxicity detected in a test concentration representing the acute critical effluent concentration (ACEC). The ACEC means the maximum concentration of effluent during critical conditions at the boundary of the acute mixing zone, defined in Section 8 of this permit. The ACEC equals 1.8% effluent. See S8 for more information.		

a	Average monthly effluent limit means the highest allowable average of daily discharges over a calendar month. To calculate the discharge value to compare to the limit, add the value of each daily discharge measured during a calendar month and divide this sum by the total number of daily discharges measured. See footnote c for fecal coliform calculations.
b	Average weekly discharge limit means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges' measured during that week. See footnote c for fecal coliform calculations.
c	Ecology provides directions to calculate the monthly and the weekly geometric mean in publication No. 04-10-020, Information Manual for Treatment Plant Operators available at: https://fortress.wa.gov/ecy/publications/SummaryPages/0410020.html
d	Maximum daily effluent limit is the highest allowable daily discharge. The daily discharge is the average discharge of a pollutant measured during a calendar day. For pollutants with limits expressed in units of mass, calculate the daily discharge as the total mass of the pollutant discharged over the day. This does not apply to pH or temperature.

S1.B. Mixing zone authorization

Mixing zone for Outfall 001

The following paragraphs define the maximum boundaries of the mixing zones:

Chronic mixing zone

The mixing zone is an oblong circle around the discharge ports that is 837 feet long by 596 feet wide. The mixing zone extends from the bottom to the top of the water column. The concentration of pollutants at the edge of the chronic zone must meet chronic aquatic life criteria and human health criteria.

Acute mixing zone

The mixing zone is an oblong circle around the discharge ports that is 301 feet long by 59.6 feet wide. The mixing zone extends from the bottom to the top of the water column. The concentration of pollutants at the edge of the acute zone must meet acute aquatic life criteria.

Available Dilution (dilution factor)	
Acute Aquatic Life Criteria	56
Chronic Aquatic Life Criteria	217
Human Health Criteria - Carcinogen	217
Human Health Criteria - Non-carcinogen	217

S2. Monitoring requirements

S2.A. Monitoring schedule

The Permittee must monitor in accordance with the following schedule and the requirements specified in Appendix A.

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
(1) Wastewater influent			
Wastewater Influent means the raw sewage flow from the collection system into the treatment facility. Sample the wastewater entering the headworks of the treatment plant excluding any side-stream returns from inside the plant.			
Biochemical Oxygen Demand (BOD_5)	mg/L	1/week [a]	24-hour composite [b]
BOD_5	lbs/day [c]	1/week	Calculated
$CBOD_5$	mg/L	5/week [a]	24-hour composite
TSS	mg/L	5/week	24-hour composite
TSS	lbs/day	5/week	Calculated
(2) Final wastewater effluent			
Final Wastewater Effluent means wastewater exiting the last treatment process or operation. Typically, this is after or at the exit from the chlorine contact chamber or other disinfection process. The Permittee may take effluent samples for the BOD_5 analysis before or after the disinfection process. If taken after, the Permittee must dechlorinate and reseed the sample.			
Flow	mgd	Continuous [d]	Metered/recorded
$CBOD_5$	mg/L	5/week	24-hour composite
$CBOD_5$	lbs/day	5/week	Calculated

Parameter	Units & Speciation	Minimum Sampling Frequency	Sample Type
$CBOD_5$	% removal [e]	5/week	Calculated
TSS	mg/L	5/week	24-hour composite
TSS	lbs/day	5/week	Calculated
TSS	% removal	5/week	Calculated
Fecal Coliform [f]	# /100 ml	Daily [a]	Grab [i]
pH [g]	Standard Units	Continuous	Metered/recorded
Total Residual Chlorine	µg/L	Daily	Grab
Temperature [h]	Degrees centigrade (°C)	Continuous	Measurement
(3) Effluent characterization – final wastewater effluent			
The final wastewater effluent characterization data must be submitted in the quarterly DMR reports.			
Total Ammonia	mg/L as N	Quarterly [j]	24-hour composite
Nitrate plus Nitrite (N)	mg/L as N	Quarterly	24-hour composite
Total Kjeldahl Nitrogen (TKN)	mg/L as N	Quarterly	24-hour composite
Total Phosphorus	mg/L as P	Quarterly	24-hour composite
Soluble Reactive Phosphorus	mg/L as P	Quarterly	24-hour composite
(4) Permit renewal application requirements – final wastewater effluent			
Permit renewal application effluent monitoring data must be submitted in the quarterly DMR reports.			
Dissolved Oxygen	mg/L	Quarterly	Grab
Total Dissolved Solids	mg/L	Quarterly	24-hour composite
Total Hardness	mg/L	Quarterly	24-hour composite
(5) Whole effluent toxicity testing – final wastewater effluent			
Acute Toxicity Testing – Compliance	See S8	Quarterly	24-hour composite
Chronic Toxicity Testing – Characterization	See S9	2/permit cycle	24-hour composite
(6) Pretreatment testing – influent, effluent, and biosolids. See Special Condition S6.			
The Permittee must monitor influent, effluent, and biosolids from the treatment system for parameters noted below according to the indicated schedule. The Permittee must conduct all monitoring following instructions in Special Condition S6.B. In addition to fulfilling required pretreatment monitoring, the Permittee may use the results of effluent sampling done according to the following schedule for testing required for the next permit application. The schedule for pH below applies only to influent and biosolids since the effluent monitoring schedules above require more frequent monitoring for that parameter. Oil and grease monitoring applies only to influent and effluent.			
pH (influent and biosolids)	Standard units	Quarterly	Grab
Oil and Grease (influent and effluent)	mg/L	Quarterly	Grab
Cyanide	micrograms/liter (µg/L)	Quarterly	Grab
Total Phenolic Compounds	µg/L	Quarterly	Grab
Priority Pollutants (PP) – Total Metals	µg/L; nanograms (ng/L) for mercury	Quarterly	24-hour composite Grab for mercury
PP – Volatile Organic Compounds	µg/L	Once per year [a]	Grab
PP – Acid-extractable Compounds	µg/L	Once per year	24-hour composite
PP – Base-neutral Compounds	µg/L	Once per year	24-hour composite
PP – Pesticides/PCBs	ug/L	Once per year	24-hour composite

a	1/week means one time during each calendar week. 5/week means five times during each calendar week. Daily means one per day. Once per year means one time during each calendar year.
b	24-hour composite means a series of individual samples collected over a 24-hour period into a single container, and analyzed as one sample.

Parameter		Units & Speciation	Minimum Sampling Frequency	Sample Type
c	Calculated means figured concurrently with the respective sample, using the following formula: Concentration (in mg/L) X Flow (in MGD) X Conversion Factor (8.34) = lbs/day			
d	Continuous means uninterrupted except for brief lengths of time for calibration, power failure, or unanticipated equipment repair or maintenance. The time interval for the associated data logger must be no greater than 30 minutes.			
e	% removal = $\frac{\text{Influent concentration (mg/L)} - \text{Effluent concentration (mg/L)}}{\text{Influent concentration (mg/L)}} \times 100$ Calculate the percent (%) removal of BOD_5 and TSS using the above equation.			
f	Report a numerical value for fecal coliforms following the procedures in Ecology's *Information Manual for Wastewater Treatment Plant Operators*, Publication Number 04-10-020 available at: https://fortress.wa.gov/ecy/publications/SummaryPages/0410020.html . Do not report a result as too numerous to count (TNTC).			
g	The Permittee must report the instantaneous maximum and minimum pH daily. Do not average pH values.			
h	If measuring temperature continuously, the Permittee must determine and report a daily maximum from half-hour measurements in a 24-hour period. Continuous monitoring instruments must achieve an accuracy of 0.2 degrees C and the Permittee must verify accuracy annually.			
i	Grab means an individual sample collected over a fifteen (15)-minute, or less, period.			
j	Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must begin quarterly monitoring for the quarter beginning on 4/1/2019 and submit results by 7/15/2019.			

S2.B. Sampling and analytical procedures

Samples and measurements taken to meet the requirements of this permit must represent the volume and nature of the monitored parameters. The Permittee must conduct representative sampling of any unusual discharge or discharge condition, including bypasses, upsets, and maintenance-related conditions that may affect effluent quality.

Sampling and analytical methods used to meet the monitoring requirements specified in this permit must conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 (or as applicable in 40 CFR subchapters N [Parts 400–471] or O [Parts 501-503]) unless otherwise specified in this permit . Ecology may only specify alternative methods for parameters without permit limits and for those parameters without an EPA approved test method in 40 CFR Part 136.

S2.C. Flow measurement, field measurement, and continuous monitoring devices

The Permittee must:

1. Select and use appropriate flow measurement, field measurement, and continuous monitoring devices and methods consistent with accepted scientific practices.
2. Install, calibrate, and maintain these devices to ensure the accuracy of the measurements is consistent with the accepted industry standard, the manufacturer's recommendation, and approved O&M manual procedures for the device and the wastestream.
3. Calibrate continuous monitoring instruments weekly unless it can demonstrate a longer period is sufficient based on monitoring records. The Permittee:
   a. May calibrate apparatus for continuous monitoring of dissolved oxygen by air calibration.
   b. Must calibrate continuous pH measurement instruments using a grab sample analyzed in the lab with a pH meter calibrated with standard buffers and analyzed within 15 minutes of sampling.
   c. Must calibrate continuous chlorine measurement instruments using a grab sample analyzed in the laboratory within 15 minutes of sampling.
4. Use field measurement devices as directed by the manufacturer and do not use reagents beyond their expiration dates.
5. Establish a calibration frequency for each device or instrument in the O&M manual that conforms to the frequency recommended by the manufacturer.
6. Maintain calibration records for at least three years.

S2.D. Laboratory accreditation

The Permittee must ensure that all monitoring data required by Ecology for permit specified parameters is prepared by a laboratory registered or accredited under the provisions of chapter 173-50 WAC, *Accreditation of Environmental Laboratories*. Flow, temperature, settleable solids, conductivity, pH, and internal process control parameters are exempt from this requirement. The Permittee must obtain accreditation for conductivity and pH if it must receive accreditation or registration for other parameters.

S2.E. Request for reduction in monitoring

The Permittee may request a reduction of the sampling frequency after twelve (12) months of monitoring. Ecology will review each request and at its discretion grant the request when it reissues the permit or by a permit modification.

The Permittee must:

1. Provide a written request.
2. Clearly state the parameters for which it is requesting reduced monitoring.
3. Clearly state the justification for the reduction.

S3. Reporting and recording requirements

The Permittee must monitor and report in accordance with the following conditions. Falsification of information submitted to Ecology is a violation of the terms and conditions of this permit.

S3.A. Discharge monitoring reports

The first monitoring period begins on the effective date of the permit (unless otherwise specified). The Permittee must:

1. Summarize, report, and submit monitoring data obtained during each monitoring period on the electronic discharge monitoring report (DMR) form provided by Ecology within the Water Quality Permitting Portal. Include data for each of the parameters tabulated in Special Condition S2 and as required by the form. Report a value for each day sampling occurred (unless specifically exempted in the permit) and for the summary values (when applicable) included on the electronic form.
2. Ensure that DMRs are electronically submitted no later than the dates specified below, unless otherwise specified in this permit.
3. The Permittee must also submit an electronic copy of the laboratory report as an attachment using WQWebDMR. The contract laboratory reports must also include information on the chain of custody, QA/QC results, and documentation of accreditation for the parameter.
4. Submit DMRs for parameters with the monitoring frequencies specified in S2 (monthly, quarterly, annual, etc.) at the reporting schedule identified below. The Permittee must:
    a. Submit **monthly** DMRs by the 15th day of the following month.
    b. Submit **quarterly DMRs** by the 15th day of the month following the monitoring period. Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must submit the first quarterly DMR on **July 15, 2019,** for the quarter beginning on April 1, 2019.
    c. Submit **annual DMRs** by January 15 for the previous calendar year. The annual sampling period is the calendar year. The Permittee must submit the first annual DMR on **January 15, 2020,** for the 2019 calendar year.
5. Enter the “No Discharge” reporting code for an entire DMR, for a specific monitoring point, or for a specific parameter as appropriate, if the Permittee did not discharge wastewater or a specific pollutant during a given monitoring period.
6. Report single analytical values below detection as “less than the detection level (DL)” by entering < followed by the numeric value of the detection level (e.g. < 2.0) on the DMR. If the method used did not meet the minimum DL and quantitation level (QL) identified in the permit, report the actual QL and DL in the comments or in the location provided.

7. Report single analytical values between the detection level (DL) and the quantitation level (QL) by entering the estimated value, the code for estimated value/below quantitation limit (j) and any additional information in the comments. Submit a copy of the laboratory report as an attachment using WQWebDMR.
8. **Not** report zero for bacteria monitoring. Report as required by the laboratory method.
9. Calculate and report an arithmetic average value for each day for bacteria if multiple samples were taken in one day.
10. Calculate the geometric mean values for bacteria (unless otherwise specified in the permit) using:
    a. The reported numeric value for all bacteria samples measured above the detection value except when it took multiple samples in one day. If the Permittee takes multiple samples in one day it must use the arithmetic average for the day in the geometric mean calculation.
    b. The detection value for those samples measured below detection.
11. Report the test method used for analysis in the comments if the laboratory used an alternative method not specified in the permit and as allowed in Appendix A.
12. Calculate average values and calculated total values (unless otherwise specified in the permit) using:
    a. The reported numeric value for all parameters measured between the detection value and the quantitation value for the sample analysis.
    b. One-half the detection value (for values reported below detection) if the lab detected the parameter in another sample from the same monitoring point for the reporting period.
    c. Zero (for values reported below detection) if the lab did not detect the parameter in another sample for the reporting period.
13. Report single-sample grouped parameters (for example: priority pollutants, PAHs, pulp and paper chlorophenolics, TTOs) on the WQWebDMR form and include: sample date, concentration detected, detection limit (DL) (as necessary), and laboratory quantitation level (QL) (as necessary).

S3.B. Permit submittals and schedules

The Permittee must use the Water Quality Permitting Portal – Permit Submittals application (unless otherwise specified in the permit) to submit all other written permit-required reports by the date specified in the permit.

When another permit condition requires submittal of a paper (hard-copy) report, the Permittee must ensure that it is postmarked or received by Ecology no later than the dates specified by this permit. Send these paper reports to Ecology at:

Water Quality Permit Coordinator
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

S3.C. Records retention

The Permittee must retain records of all monitoring information for a minimum of three (3) years. Such information must include all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit. The Permittee must extend this period of retention during the course of any unresolved litigation regarding the discharge of pollutants by the Permittee or when requested by Ecology.

S3.D. Recording of results

For each measurement or sample taken, the Permittee must record the following information:

1. The date, exact place, method, and time of sampling or measurement.
2. The individual who performed the sampling or measurement.
3. The dates the analyses were performed.
4. The individual who performed the analyses.
5. The analytical techniques or methods used.
6. The results of all analyses.

S3.E. Additional monitoring by the Permittee

If the Permittee monitors any pollutant more frequently than required by Special Condition S2 of this permit, then the Permittee must include the results of such monitoring in the calculation and reporting of the data submitted in the Permittee's DMR unless otherwise specified by Special Condition S2.

S3.F. Reporting permit violations

The Permittee must take the following actions when it violates or is unable to comply with any permit condition:

1. Immediately take action to stop, contain, and cleanup unauthorized discharges or otherwise stop the noncompliance and correct the problem.
2. If applicable, immediately repeat sampling and analysis. Submit the results of any repeat sampling to Ecology within thirty (30) days of sampling.

a. Immediate reporting

The Permittee must immediately report to Ecology and the Department of Health, Shellfish Program, and the Local Health Jurisdiction (at the numbers listed below), all:

- Failures of the disinfection system.
- Collection system overflows.
- Plant bypasses discharging to marine surface waters.
- Any other failures of the sewage system (pipe breaks, etc.).

Northwest Regional Office	425-649-7000
Department of Health, Shellfish Program	360-236-3330 (business hours) 360-789-8962 (after business hours)
Snohomish Health District, Environmental Health Division	425-339-5250 (business hours) 425-339-5295 (after business hours)

Additionally, for any sanitary sewer overflow (SSO) that discharges to a municipal separate storm sewer system (MS4), the Permittee must notify the appropriate MS4 owner or operator.

b. Twenty-four-hour reporting

The Permittee must report the following occurrences of noncompliance by telephone, to Ecology at the telephone numbers listed above, within 24 hours from the time the Permittee becomes aware of any of the following circumstances:

1. Any noncompliance that may endanger health or the environment, unless previously reported under immediate reporting requirements.
2. Any unanticipated bypass that causes an exceedance of an effluent limit in the permit (See Part S5.F, "Bypass Procedures").
3. Any upset that causes an exceedance of an effluent limit in the permit (See G.15, "Upset").
4. Any violation of a maximum daily or instantaneous maximum discharge limit for any of the pollutants in Section S1.A of this permit.
5. Any overflow prior to the treatment works, whether or not such overflow endangers health or the environment or exceeds any effluent limit in the permit.

c. Report within five days

The Permittee must also submit a written report within five days of the time that the Permittee becomes aware of any reportable event under subparts a or b, above. The report must contain:

1. A description of the noncompliance and its cause.
2. The period of noncompliance, including exact dates and times.

3. The estimated time the Permittee expects the noncompliance to continue if not yet corrected.
4. Steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.
5. If the noncompliance involves an overflow prior to the treatment works, an estimate of the quantity (in gallons) of untreated overflow.

d. Waiver of written reports

Ecology may waive the written report required in subpart c, above, on a case-by-case basis upon request if the Permittee has submitted a timely oral report.

e. All other permit violation reporting

The Permittee must report all permit violations, which do not require immediate or within 24 hours reporting, when it submits monitoring reports for S3.A ("Reporting"). The reports must contain the information listed in subpart c, above. Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with the terms and conditions of this permit or the resulting liability for failure to comply.

S3.G. Other reporting

a. Spills of oil or hazardous materials

The Permittee must report a spill of oil or hazardous materials in accordance with the requirements of RCW 90.56.280 and chapter 173-303-145. You can obtain further instructions at the following website: https://ecology.wa.gov/About-us/Get-involved/Report-an-environmental-issue/Report-a-spill .

b. Failure to submit relevant or correct facts

Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application, or in any report to Ecology, it must submit such facts or information promptly.

S3.H. Maintaining a copy of this permit

The Permittee must keep a copy of this permit at the facility and make it available upon request to Ecology inspectors.

S4. Facility loading

S4.A. Design criteria

The flows or waste loads for the permitted facility must not exceed the following design criteria:

Maximum Month Design Flow (MMDF)	7.4 MGD
BOD_5 Influent Loading for Maximum Month	15,120 lb/day
TSS Influent Loading for Maximum Month	15,120 lb/day

S4.B. Plans for maintaining adequate capacity

a. Conditions triggering plan submittal

The Permittee must submit a plan and a schedule for continuing to maintain capacity to Ecology when:

1. The actual flow or waste load reaches 85 percent of any one of the design criteria in S4.A for three consecutive months.
2. The projected plant flow or loading would reach design capacity within five years.

b. Plan and schedule content

The plan and schedule must identify the actions necessary to maintain adequate capacity for the expected population growth and to meet the limits and requirements of the permit. The Permittee must consider the following topics and actions in its plan.

1. Analysis of the present design and proposed process modifications
2. Reduction or elimination of excessive infiltration and inflow of uncontaminated ground and surface water into the sewer system
3. Limits on future sewer extensions or connections or additional waste loads
4. Modification or expansion of facilities
5. Reduction of industrial or commercial flows or waste loads

Engineering documents associated with the plan must meet the requirements of WAC 173-240-060, "Engineering Report," and be approved by Ecology prior to any construction.

S4.C. Duty to mitigate

The Permittee must take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment.

S4.D. Notification of new or altered sources

1. The Permittee must submit written notice to Ecology whenever any new discharge or a substantial change in volume or character of an existing discharge into the wastewater treatment plant is proposed which:
   a. Would interfere with the operation of, or exceed the design capacity of, any portion of the wastewater treatment plant.
   b. Is not part of an approved general sewer plan or approved plans and specifications.
   c. Is subject to pretreatment standards under 40 CFR Part 403 and Section 307(b) of the Clean Water Act.

2. This notice must include an evaluation of the wastewater treatment plant's ability to adequately transport and treat the added flow and/or waste load, the quality and volume of effluent to be discharged to the treatment plant, and the anticipated impact on the Permittee's effluent [40 CFR 122.42(b)].

S4.E. Infiltration and inflow evaluation

1. The Permittee must prepare a report documenting I/I status and program implementation. The I/I Report must be prepared and submitted annually to the WQWebPortal. The first report is due by June 30, 2019, and annually thereafter. The report must include the following information from the previous calendar year:
   a. A summary of infiltration and inflow. Guidance regarding the content of an acceptable I/I report and sample I/I report form is included in Appendix I of the *Information Manual for Treatment Plant Operators*, https://fortress.wa.gov/ecy/publications/SummaryPages/0410020.html.
   b. A summary of repairs and collection system projects completed to monitor or specifically target I/I reduction, including, but not limited to, I/I corrective measures listed in the *Lynnwood Infiltration and Inflow Study* (Gray & Osborne, Inc., March 2011). .
   c. A summary of illicit connection discovery, enforcement, removal and City code review as described in the *Lynnwood Infiltration and Inflow Study* (Gray & Osborne, Inc., March 2011).

S5. Operation and maintenance

The Permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances), which are installed to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance also includes keeping a daily operation logbook (paper or electronic), adequate laboratory controls, and appropriate quality assurance procedures. This provision of the permit requires the Permittee to operate backup or auxiliary facilities or similar systems only when the operation is necessary to achieve compliance with the conditions of this permit.

S5.A. Certified operator

This permitted facility must be operated by an operator certified by the state of Washington for at least a Class III plant. This operator must be in responsible charge of the day-to-day operation of the wastewater treatment plant. An operator certified for at least a Class II plant must be in charge during all regularly scheduled shifts. The Permittee must notify Ecology when the operator in charge at the facility changes. It must provide the new operator's name and certification level and provide the name of the operator leaving the facility.

S5.B. Operation and maintenance program

The Permittee must:

1. Institute an adequate operation and maintenance program for the entire sewage system.

2. Keep maintenance records on all major electrical and mechanical components of the treatment plant, as well as the sewage system and pumping stations. Such records must clearly specify the frequency and type of maintenance recommended by the manufacturer and must show the frequency and type of maintenance performed.
3. Make maintenance records available for inspection at all times.

S5.C. Short-term reduction

The Permittee must schedule any facility maintenance, which might require interruption of wastewater treatment and degrade effluent quality, during non-critical water quality periods and carry this maintenance out according to the approved O&M manual or as otherwise approved by Ecology.

If a Permittee contemplates a reduction in the level of treatment that would cause a violation of permit discharge limits on a short-term basis for any reason, and such reduction cannot be avoided, the Permittee must:

1. Give written notification to Ecology, if possible, thirty (30) days prior to such activities.
2. Detail the reasons for, length of time of, and the potential effects of the reduced level of treatment.

This notification does not relieve the Permittee of its obligations under this permit.

S5.D. Electrical power failure

The Permittee must ensure that adequate safeguards prevent the discharge of untreated wastes or wastes not treated in accordance with the requirements of this permit during electrical power failure at the treatment plant and/or sewage lift stations. Adequate safeguards include, but are not limited to, alternate power sources, standby generator(s), or retention of inadequately treated wastes.

The Permittee must maintain Reliability Class II (EPA 430-99-74-001) at the wastewater treatment plant. Reliability Class II requires a backup power source sufficient to operate all vital components and critical lighting and ventilation during peak wastewater flow conditions. Vital components used to support the secondary processes (i.e., mechanical aerators or aeration basin air compressors) need not be operable to full levels of treatment, but must be sufficient to maintain the biota.

S5.E. Prevent connection of inflow

The Permittee must strictly enforce its sewer ordinances and not allow the connection of inflow (roof drains, foundation drains, etc.) to the sanitary sewer system.

S5.F. Bypass procedures

A bypass is the intentional diversion of waste streams from any portion of a treatment facility. This permit prohibits all bypasses except when the bypass is for essential maintenance, as authorized in Special Condition S5.F.1, or is approved by Ecology as an anticipated bypass following the procedures in S5.F.2.

1. Bypass for essential maintenance without the potential to cause violation of permit limits or conditions.

   This permit allows bypasses for essential maintenance of the treatment system when necessary to ensure efficient operation of the system. The Permittee may bypass the treatment system for essential maintenance only if doing so does not cause violations of effluent limits. The Permittee is not required to notify Ecology when bypassing for essential maintenance. However the Permittee must comply with the monitoring requirements specified in Special Condition S2.B.

2. Anticipated bypasses for non-essential maintenance

   Ecology may approve an anticipated bypass under the conditions listed below. This permit prohibits any anticipated bypass that is not approved through the following process.

   a. If a bypass is for non-essential maintenance, the Permittee must notify Ecology, if possible, at least ten (10) days before the planned date of bypass. The notice must contain:

      - A description of the bypass and the reason the bypass is necessary.
      - An analysis of all known alternatives which would eliminate, reduce, or mitigate the potential impacts from the proposed bypass.
      - A cost-effectiveness analysis of alternatives.
      - The minimum and maximum duration of bypass under each alternative.
      - A recommendation as to the preferred alternative for conducting the bypass.
      - The projected date of bypass initiation.
      - A statement of compliance with SEPA.
      - A request for modification of water quality standards as provided for in WAC 173-201A-410, if an exceedance of any water quality standard is anticipated.
      - Details of the steps taken or planned to reduce, eliminate, and prevent recurrence of the bypass.

   b. For probable construction bypasses, the Permittee must notify Ecology of the need to bypass as early in the planning process as possible. The Permittee must consider the analysis required above during the project planning and design process. The project-specific engineering report as well as the plans and specifications must include details of probable construction bypasses to the extent practical. In cases where the Permittee determines the probable need to bypass early, the Permittee must continue to analyze conditions up to and including the construction period in an effort to minimize or eliminate the bypass.

c. Ecology will determine if the Permittee has met the conditions of Special Condition S5.F.2 a and b and consider the following prior to issuing a determination letter, an administrative order, or a permit modification as appropriate for an anticipated bypass:

- If the Permittee planned and scheduled the bypass to minimize adverse effects on the public and the environment.
- If the bypass is unavoidable to prevent loss of life, personal injury, or severe property damage. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass.
- If feasible alternatives to the bypass exist, such as:
  - The use of auxiliary treatment facilities.
  - Retention of untreated wastes.
  - Stopping production.
  - Maintenance during normal periods of equipment downtime, but not if the Permittee should have installed adequate backup equipment in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance.
  - Transport of untreated wastes to another treatment facility.

S5.G. Operations and maintenance (O&M) manual

a. O&M manual submittal and requirements

The Permittee must:

1. Update the operations and maintenance (O&M) manual that meets the requirements of 173-240-080 WAC and submit it to Ecology for approval by **March 31, 2019.**
2. Submit to Ecology for review and approval substantial changes or updates to the O&M manual whenever it incorporates them into the manual.
3. Keep the approved O&M manual at the permitted facility.
4. Follow the instructions and procedures of this manual.

b. O&M manual components

In addition to the requirements of WAC 173-240-080(1) through (5), the O&M manual must be consistent with the guidance in Table G1-3 in the *Criteria for Sewage Works Design* (Orange Book), 2008. The O&M manual must include:

1. Emergency procedures for cleanup in the event of wastewater system upset or failure.
2. A review of system components which if failed could pollute surface water or could impact human health. Provide a procedure for a routine schedule of checking the function of these components.
3. Wastewater system maintenance procedures that contribute to the generation of process wastewater.
4. Reporting protocols for submitting reports to Ecology to comply with the reporting requirements in the discharge permit.
5. Any directions to maintenance staff when cleaning or maintaining other equipment or performing other tasks which are necessary to protect the operation of the wastewater system (for example, defining maximum allowable discharge rate for draining a tank, blocking all floor drains before beginning the overhaul of a stationary engine).
6. The treatment plant process control monitoring schedule.
7. Minimum staffing adequate to operate and maintain the treatment processes and carry out compliance monitoring required by the permit.

S6. Pretreatment

S6.A. General requirements

1. The Permittee must implement the Industrial Pretreatment Program in accordance with the legal authorities, policies, procedures, and financial provisions described in the Permittee's approved pretreatment program submittal entitled "Industrial Pretreatment Program" and dated August 28, 1984; any approved revisions thereto; and the General Pretreatment Regulations (40 CFR Part 403). At a minimum, the Permittee must undertake the following pretreatment implementation activities:

   a. Enforce categorical pretreatment standards under Section 307(b) and (c) of the Federal Clean Water Act (hereinafter, the Act), prohibited discharge standards as set forth in 40 CFR 403.5, local limits specified in Section 14.60.318 of the City of Lynnwood Municipal Code, or state standards, whichever are most stringent or apply at the time of issuance or modification of a local industrial waste discharge permit. Locally derived limits are defined as pretreatment standards under Section 307(d) of the Act and are not limited to categorical industrial facilities.

b. Issue industrial waste discharge permits to all significant industrial users [SIUs, as defined in 40 CFR 403.3(v)(i)(ii)] contributing to the treatment system, including those from other jurisdictions. Industrial waste discharge permits must contain, as a minimum, all the requirements of 40 CFR 403.8 (f)(l)(iii). The Permittee must coordinate the permitting process with Ecology regarding any industrial facility that may possess a State Waste Discharge Permit issued by Ecology. Once issued, an industrial waste discharge permit takes precedence over a state-issued waste discharge permit.

c. Maintain and update, as necessary, records identifying the nature, character, and volume of pollutants contributed by industrial users to the POTW. The Permittee must maintain records for at least a three-year period.

d. Perform inspections, surveillance, and monitoring activities on industrial users to determine or confirm compliance with pretreatment standards and requirements. The Permittee must conduct a thorough inspection of SIUs annually. The Permittee must conduct regular local monitoring of SIU wastewaters commensurate with the character and volume of the wastewater but not less than once per year. The Permittee must collect and analyze samples in accordance with 40 CFR Part 403.12(b)(5)(ii)-(v) and 40 CFR Part 136.

e. Enforce and obtain remedies for noncompliance by any industrial users with applicable pretreatment standards and requirements. Once it identifies violations, the Permittee must take timely and appropriate enforcement action to address the noncompliance. The Permittee's action must follow its enforcement response procedures and any amendments, thereof.

f. Publish, at least annually in the largest daily newspaper in the Permittee's service area, a list of all non-domestic users which, at any time in the previous 12 months, were in significant noncompliance as defined in 40 CFR 403.8(f)(2)(vii).

g. If the Permittee elects to conduct sampling of an SIU's discharge in lieu of requiring user self-monitoring, it must satisfy all requirements of 40 CFR Part 403.12. This includes monitoring and record keeping requirements of Sections 403.12(g) and (o). For SIUs subject to categorical standards (CIUs), the Permittee may either complete baseline and initial compliance reports for the CIU (when required by 403.12(b) and (d)) or require these of the CIU. The Permittee must ensure that it provides SIUs the results of sampling in a timely manner, inform SIUs of their right to sample, their obligations to report any sampling they do, to respond to noncompliance, and to submit other notifications. These include a slug load report (403.12(f)), notice of changed discharge (403.12(j)), and hazardous waste notifications (403.12(p)). If sampling for the SIU, the Permittee must not sample less than once in every six-month period unless the Permittee's approved program includes procedures for reduction of monitoring for Middle-Tier or Non-Significant Categorical Users per 403.12(e)(2) and (3) and those procedures have been followed.

h. Develop and maintain a data management system designed to track the status of the Permittee's industrial user inventory, industrial user discharge characteristics, and compliance status.

i. Maintain adequate staff, funds, and equipment to implement its pretreatment program.

j. Establish, where necessary, contracts or legally binding agreements with contributing jurisdictions to ensure compliance with applicable pretreatment requirements by commercial or industrial users within these jurisdictions. These contracts or agreements must identify the agency responsible to perform the various implementation and enforcement activities in the contributing jurisdiction. In addition, the Permittee must develop a Memorandum of Understanding (or Inter-local Agreement) that outlines the specific roles, responsibilities, and pretreatment activities of each jurisdiction.

2. The Permittee must implement the Accidental Spill Prevention Program described in the approved Industrial Pretreatment Program dated August 28, 1984.

3. The Permittee must evaluate, at least once every two years, whether each Significant Industrial User needs a plan to control slug discharges. For purposes of this section, a slug discharge is any discharge of a non-routine, episodic nature, including but not limited to an accidental spill or non-customary batch discharge. The Permittee must make the results of this evaluation available to Ecology upon request. If the Permittee decides that a slug control plan is needed, the plan must contain, at a minimum, the following elements:

   a. Description of discharge practices, including non-routine batch discharges.

   b. Description of stored chemicals.

   c. Procedures for immediately notifying the Permittee of slug discharges, including any discharge that would violate a prohibition under 40 CFR 403.5(b), with procedures for follow-up written notification within five days.

   d. If necessary, procedures to prevent adverse impact from accidental spills, including inspection and maintenance of storage areas, handling and transfer of materials, loading and unloading operations, control of plant site run-off, worker training, building of containment structures or equipment, measures for containing toxic organic pollutants (including solvents), and/or measures and equipment necessary for emergency response.

4. Whenever Ecology determines that any waste source contributes pollutants to the Permittee's treatment works in violation of Section (b), (c), or (d) of Section 307 of the Act, and the Permittee has not taken adequate corrective action, Ecology will notify the Permittee of this determination. If the Permittee fails to take appropriate enforcement action within 30 days of this notification, Ecology may take appropriate enforcement action against the source or the Permittee.

5. Pretreatment Report

   The Permittee must provide to Ecology an annual report that briefly describes its program activities during the previous calendar year. The Permittee must start submitting the annual report electronically, via the WQWebPortal, by December 21, 2020, in accordance with 403.12(i).

   The Permittee must submit the first annual report to Ecology by **March 31, 2019**. The report must include the following information:

   a. An updated non-domestic inventory.

   b. Results of wastewater sampling at the treatment plant as specified in S6.B. The Permittee must calculate removal rates for each pollutant and evaluate the adequacy of the existing local limits in Section 2.4 of Ordinance 2247-07 in prevention of treatment plant interference, pass through of pollutants that could affect receiving water quality, and sludge contamination.

   c. Status of program implementation, including:

      - Any substantial modifications to the pretreatment program as originally approved by Ecology, including staffing and funding levels.
      - Any interference, upset, or permit violations experienced at the POTW that are directly attributable to wastes from industrial users.
      - Listing of industrial users inspected and/or monitored, and a summary of the results.
      - Listing of industrial users scheduled for inspection and/or monitoring for the next year, and expected frequencies.
      - Listing of industrial users notified of promulgated pretreatment standards and/or local standards as required in 40 CFR 403.8(f)(2)(iii). The list must indicate which industrial users are on compliance schedules and the final date of compliance for each.
      - Listing of industrial users issued industrial waste discharge permits.
      - Planned changes in the approved local pretreatment program (see Subsection A.7, below).

   d. Status of compliance activities, including:

      - Listing of industrial users that failed to submit baseline monitoring reports or any other reports required under 40 CFR 403.12 and in Chapter 6 of the Permittee's pretreatment program, dated August 28, 1984.

- Listing of industrial users that were at any time during the reporting period not complying with federal, state, or local pretreatment standards or with applicable compliance schedules for achieving those standards, and the duration of such noncompliance.
- Summary of enforcement activities and other corrective actions taken or planned against non-complying industrial users. The Permittee must supply to Ecology a copy of the public notice of facilities that were in significant noncompliance.

6. The Permittee must request and obtain approval from Ecology before making any significant changes to the approved local pretreatment program. The Permittee must follow the procedure in 40 CFR 403.18 (b) and (c).

S6.B. Monitoring requirements

The Permittee must:

1. Monitor its influent, effluent, and sludge for the priority pollutants identified in Tables II and III of Appendix D of 40 CFR Part 122 as amended, any compounds identified because of Special Condition S6.B.4, and any other pollutants expected from non-domestic sources using U.S. EPA-approved procedures for collection, preservation, storage, and analysis.
2. Test influent, effluent, and sludge samples for the priority pollutant metals (Table III, 40 CFR 122, Appendix D) on a quarterly basis throughout the term of this permit.
3. Test influent, effluent, and sludge samples for the organic priority pollutants (Table II, 40 CFR 122, Appendix D) on an annual basis. The Permittee may use the data collected for application purposes using Appendix A test methods to meet this requirement.
4. Sample POTW influent and effluent on a day when industrial discharges are occurring at normal-to-maximum levels.
5. Obtain 24-hour composite samples for the analysis of acid and base/neutral extractable compounds and metals.
6. Collect grab samples at equal intervals for a total of four grab samples per day for the analysis of volatile organic compounds. The laboratory may run a single analysis for volatile pollutants (Method 624) for each monitoring day by compositing equal volumes of each grab sample directly in the GC purge and trap apparatus in the laboratory, with no less than 1 ml of each grab included in the composite.
7. Ensure that all reported test data for metals represents the total amount of the constituents present in all phases, whether solid, suspended, or dissolved elemental or combined, including all oxidation states unless otherwise indicated.

8. Handle, prepare, and analyze all wastewater samples taken for GC/MS analysis in accordance with the U.S. EPA Methods 624 and 625 (October 26, 1984).

9. Collect a sludge sample concurrently with a wastewater sample as a single grab of residual sludge. Sludge organic priority pollutant sampling and analysis must conform to U.S. EPA Methods 624 and 625 unless the Permittee requests an alternate method and Ecology has approved. Sludge metals priority pollutant sampling and analysis must conform to U.S. EPA SW 846 6000/7000 Series Methods unless the Permittee requests an alternate method and Ecology has approved.

10. Collect grab samples for cyanide, phenols, and oils. Measure hexane soluble oils (or equivalent) only in the influent and effluent.

11. Make a reasonable attempt to identify all other substances and quantify all pollutants shown to be present by gas chromatograph/mass spectrometer (GC/MS) analysis per 40 CFR 136, Appendix A, Methods 624 and 625, in addition to quantifying pH, oil and grease, and all priority pollutants.

    The Permittee should attempt to make determinations of pollutants for each fraction, which produces identifiable spectra on total ion plots (reconstructed gas chromatograms). The Permittee should attempt to make determinations from all peaks with responses 5% or greater than the nearest internal standard. The 5% value is based on internal standard concentrations of 30 μg/l, and must be adjusted downward if higher internal standard concentrations are used or adjusted upward if lower internal standard concentrations are used. The Permittee may express results for non-substituted aliphatic compounds as total hydrocarbon content.

12. Use a laboratory whose computer data processing programs are capable of comparing sample mass spectra to a computerized library of mass spectra, with visual confirmation by an experienced analyst.

13. Conduct additional sampling and appropriate testing to determine concentration and variability, and to evaluate trends for all detected substances determined to be pollutants.

S6.C. Reporting of monitoring results

The Permittee must include a summary of monitoring results in the Annual Pretreatment Report.

S6.D. Local limit development

As sufficient data become available, the Permittee, in consultation with Ecology, must reevaluate its local limits in order to prevent pass through or interference. If Ecology determines that any pollutant present causes pass through or interference, or exceeds established sludge standards, the Permittee must establish new local limits or revise existing local limits as required by 40 CFR 403.5. Ecology may also require the Permittee to revise or establish local limits for any pollutant discharged from the POTW that has a reasonable potential to exceed the Water

Quality Standards, Sediment Standards, or established effluent limits, or causes whole effluent toxicity. Ecology makes this determination in the form of an Administrative Order.

Ecology may modify this permit to incorporate additional requirements relating to the establishment and enforcement of local limits for pollutants of concern. Any permit modification is subject to formal due process procedures under state and federal law and regulation.

S7. Solid wastes

S7.A. Solid waste handling

The Permittee must handle and dispose of all solid waste material in such a manner as to prevent its entry into state ground or surface water.

S7.B. Leachate

The Permittee must not allow leachate from its solid waste material to enter state waters without providing all known, available, and reasonable methods of treatment, nor allow such leachate to cause violations of the State Surface Water Quality Standards, Chapter 173-201A WAC, or the State Ground Water Quality Standards, Chapter 173-200 WAC. The Permittee must apply for a permit or permit modification as may be required for such discharges to state ground or surface waters.

S8. Acute toxicity

S8.A. Effluent limit for acute toxicity

The effluent limit for acute toxicity is:

No acute toxicity detected in a test concentration representing the acute critical effluent concentration (ACEC).

The ACEC means the maximum concentration of effluent during critical conditions at the boundary of the acute mixing zone, defined in Section S1.B of this permit. The ACEC equals 1.8% effluent.

S8.B. Compliance with the effluent limit for acute toxicity

Compliance with the effluent limit for acute toxicity means the results of the testing specified in Section C show no statistically significant difference in survival between the control and the ACEC.

If the test results show a statistically significant difference in survival between the control and the ACEC, and Ecology had not determined the test result to be anomalous under Section D, and the test is otherwise valid, the result is a violation of the effluent limit for acute toxicity. The Permittee must immediately conduct the additional testing described in Section D.

The Permittee must determine the statistical significance by conducting a hypothesis test at the 0.05 level of significance (Appendix H, EPA/600/4-89/001). If the difference in survival between the control and the ACEC is less than 10%, the Permittee must conduct the hypothesis test at the 0.01 level of significance.

S8.C. *Compliance testing for acute toxicity*

The Permittee must:

1. Perform the acute toxicity tests with 100% effluent, the ACEC, and a control, or with a full dilution series.
2. Conduct quarterly acute toxicity testing on the final effluent. Testing must begin by April 1, 2019. Quarters means January through March, April through June, July through September, and October through December.
3. Submit a quarterly written report to Ecology within 45 days of sampling and starting no later than **July 30, 2019**. Each subsequent report is due on April 30th, July 30th, October 30th, and January 30th of each year. Further instructions on testing conditions and test report content are in Section E, below.
4. The Permittee must perform compliance tests using each of the species and protocols listed below on a rotating basis:

Acute Toxicity Tests	Species	Method
Fathead minnow 96-hour static-renewal test	*Pimephales promelas*	EPA-821-R-02-012
Daphnid 48-hour static test	*Ceriodaphnia dubia, Daphnia pulex,* or *Daphnia magna*	EPA-821-R-02-012

S8.D. *Response to noncompliance with the effluent limit for acute toxicity*

If a toxicity test conducted under Section C determines a statistically significant difference in response between the ACEC and the control, using the statistical test described in Section B, the Permittee must begin additional testing within one week from the time of receiving the test results. The Permittee must:

1. Conduct one additional test each week for four consecutive weeks, using the same test and species as the failed compliance test.
2. Test at least five effluent concentrations and a control to determine appropriate point estimates. One of these effluent concentrations must equal the ACEC. The results of the test at the ACEC will determine compliance with the effluent limit for acute toxicity as described in Section B.
3. Return to the original monitoring frequency in Section C after completion of the additional compliance monitoring.

Anomalous test results: If a toxicity test conducted under Section C indicates noncompliance with the acute toxicity limit and the Permittee believes that the test result is anomalous, the Permittee may notify Ecology that the compliance test result may be anomalous. The Permittee may take one additional sample for toxicity testing and wait for notification from Ecology before completing the additional testing. The Permittee must submit the notification with the report of the compliance test result and identify the reason for considering the compliance test result to be anomalous.

If Ecology determines that the test result was not anomalous, the Permittee must complete all of the additional monitoring required in this section. Or,

If the one additional sample fails to comply with the effluent limit for acute toxicity, then the Permittee must complete all of the additional monitoring required in this section. Or,

If Ecology determines that the test result was anomalous, the one additional test result will replace the anomalous test result for the purpose of determining compliance with the acute toxicity limit.

If all of the additional testing in S8.D.1 complies with the permit limit, the Permittee must submit a report to Ecology on possible causes and preventive measures for the transient toxicity event, which triggered the additional compliance monitoring. This report must include a search of all pertinent and recent facility records, including:

- Operating records
- Monitoring results
- Inspection records
- Spill reports
- Weather records
- Production records
- Raw material purchases
- Pretreatment records, etc.

If the additional testing in this section shows another violation of the acute toxicity limit, the Permittee must submit a Toxicity Identification/Reduction Evaluation (TI/RE) plan to Ecology within sixty (60) days after the sample date (WAC 173-205-100(2)).

S8.E. Sampling and reporting requirements

1. The Permittee must submit all reports for toxicity testing in accordance with the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. Reports must contain toxicity data, bench sheets, and reference toxicant results for test methods. In addition, the Permittee must submit toxicity test data in electronic format (CETIS export file preferred) for entry into Ecology's database.
2. The Permittee must collect 24-hour composite effluent samples or grab samples for toxicity testing. The Permittee must cool the samples to 0 - 6 degrees Celsius during collection and send them to the lab immediately upon completion. The lab must begin the toxicity testing as soon as possible but no later than 36 hours after sampling was completed.
3. The laboratory must conduct water quality measurements on all samples and test solutions for toxicity testing, as specified in the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*.

4. All toxicity tests must meet quality assurance criteria and test conditions specified in the most recent versions of the EPA methods listed in Subsection C and the Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. If Ecology determines any test results to be invalid or anomalous, the Permittee must repeat the testing with freshly collected effluent.
5. The laboratory must use control water and dilution water meeting the requirements of the EPA methods listed in Section A or pristine natural water of sufficient quality for good control performance.
6. The Permittee must chemically dechlorinate final effluent samples for whole effluent toxicity testing with sodium thiosulfate just prior to test initiation. Do not add more sodium thiosulfate than is necessary to neutralize the chlorine. Provide in the test report the calculations to determine the amount of sodium thiosulfate necessary to just neutralize the chlorine in the sample.
7. The Permittee may choose to conduct a full dilution series test during compliance testing in order to determine dose response. In this case, the series must have a minimum of five effluent concentrations and a control. The series of concentrations must include the acute critical effluent concentration (ACEC). The ACEC equals 1.8% effluent.
8. All whole effluent toxicity tests, effluent screening tests, and rapid screening tests that involve hypothesis testing must comply with the acute statistical power standard of 29% as defined in WAC 173-205-020. If the test does not meet the power standard, the Permittee must repeat the test on a fresh sample with an increased number of replicates to increase the power.

S9. Chronic toxicity

S9.A. Testing when there is no permit limit for chronic toxicity

The Permittee must:

1. Conduct chronic toxicity testing on the final effluent twice; once in the 4^{th} quarter (October - December 2022) and once in the 2^{nd} quarter (April – June 2023) prior to submission of the application for permit renewal.
2. Submit a written report to Ecology within 45 days of sampling. The Permittee must submit the first report by **January 30, 2023,** and the second report by **July 30, 2023**. Further instructions on testing conditions and test report content are in Section B below.
3. Conduct chronic toxicity testing during effluent characterization on a series of at least five concentrations of effluent and a control. This series of dilutions must include the acute critical effluent concentration (ACEC). The ACEC equals 1.8% effluent. The series of dilutions should also contain the CCEC of 0.46% effluent.
4. Compare the ACEC to the control using hypothesis testing at the 0.05 level of significance as described in Appendix H, EPA/600/4-89/001.

5. Perform chronic toxicity tests with all of the following species and the most recent version of the following protocols:

Saltwater Chronic Test	Species	Method
Topsmelt survival and growth	Atherinops affinis	EPA/600/R-95/136
Mysid shrimp survival and growth	*Americamysis bahia* (formerly *Mysidopsis bahia*)	EPA-821-R-02-014

S9.B. Sampling and reporting requirements

1. The Permittee must submit all reports for toxicity testing in accordance with the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. Reports must contain toxicity data, bench sheets, and reference toxicant results for test methods. In addition, the Permittee must submit toxicity test data in electronic format (CETIS export file preferred) for entry into Ecology's database.

2. The Permittee must collect 24-hour composite effluent samples or grab samples for toxicity testing. The Permittee must cool the samples to 0 - 6 degrees Celsius during collection and send them to the lab immediately upon completion. The lab must begin the toxicity testing as soon as possible but no later than 36 hours after sampling was completed.

3. The laboratory must conduct water quality measurements on all samples and test solutions for toxicity testing, as specified in the most recent version of Ecology Publication No. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*.

4. All toxicity tests must meet quality assurance criteria and test conditions specified in the most recent versions of the EPA methods listed in Section C and the Ecology Publication no. WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. If Ecology determines any test results to be invalid or anomalous, the Permittee must repeat the testing with freshly collected effluent.

5. The laboratory must use control water and dilution water meeting the requirements of the EPA methods listed in Subsection C or pristine natural water of sufficient quality for good control performance.

6. The Permittee must chemically dechlorinate final effluent samples for whole effluent toxicity testing with sodium thiosulfate just prior to test initiation. Do not add more sodium thiosulfate than is necessary to neutralize the chlorine. Provide in the test report the calculations to determine the amount of sodium thiosulfate necessary to just neutralize the chlorine in the sample.

7. The Permittee may choose to conduct a full dilution series test during compliance testing in order to determine dose response. In this case, the series must have a minimum of five effluent concentrations and a control. The series of concentrations must include the CCEC and the ACEC. The CCEC and the ACEC may either substitute for the effluent concentrations that are closest to them in the dilution series or be extra effluent concentrations. The CCEC equals 0.46% effluent. The ACEC equals 1.8% effluent.

8. All whole effluent toxicity tests that involve hypothesis testing must comply with the chronic statistical power standard of 39% as defined in WAC 173-205-020. If the test does not meet the power standard, the Permittee must repeat the test on a fresh sample with an increased number of replicates to increase the power.

S10. Outfall Evaluation

The Permittee must inspect the submerged portion of the outfall line and diffuser to document its integrity and continued function. If conditions allow for a photographic verification, the Permittee must include such verification in the report. The Permittee must submit the inspection report to Ecology through the Water Quality Permitting Portal – Permit Submittals application by **December 31, 2021**. The Permittee must submit hard copies of any video files to Ecology as required by Permit Condition S3.B. The Portal does not support submittal of video files.

The inspector must at minimum:

- Assess the physical condition of the outfall pipe, diffuser, and associated couplings.
- Determine the extent of sediment accumulation in the vicinity of the diffuser.
- Ensure diffuser ports are free of obstructions and are allowing uniform flow.
- Confirm physical location (latitude/longitude) and depth (at MLLW) of the diffuser section of the outfall.
- Assess physical condition of the submarine line.
- Assess physical condition of anchors used to secure the submarine line.

S11. Application for permit renewal or modification for facility changes

The Permittee must submit an application for renewal of this permit by **August 31, 2023.**

The Permittee must also submit a new application or addendum at least one hundred eighty (180) days prior to commencement of discharges, resulting from the activities listed below, which may result in permit violations. These activities include any facility expansions, production increases, or other planned changes, such as process modifications, in the permitted facility.

General Conditions

G1. Signatory requirements

1. All applications submitted to Ecology must be signed and certified.

    a. In the case of corporations, by a responsible corporate officer. For the purpose of this section, a responsible corporate officer means:

    - A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions for the corporation, or
    - The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

    b. In the case of a partnership, by a general partner.

    c. In the case of sole proprietorship, by the proprietor.

    d. In the case of a municipal, state, or other public facility, by either a principal executive officer or ranking elected official.

    Applications for permits for domestic wastewater facilities that are either owned or operated by, or under contract to, a public entity shall be submitted by the public entity.

2. All reports required by this permit and other information requested by Ecology must be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

    a. The authorization is made in writing by a person described above and submitted to Ecology.

    b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under paragraph G1.2, above, is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph G1.2, above, must be submitted to Ecology prior to or together with any reports, information, or applications to be signed by an authorized representative.

4. Certification. Any person signing a document under this section must make the following certification:

   "I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

G2. Right of inspection and entry

The Permittee must allow an authorized representative of Ecology, upon the presentation of credentials and such other documents as may be required by law:

1. To enter upon the premises where a discharge is located or where any records must be kept under the terms and conditions of this permit.
2. To have access to and copy, at reasonable times and at reasonable cost, any records required to be kept under the terms and conditions of this permit.
3. To inspect, at reasonable times, any facilities, equipment (including monitoring and control equipment), practices, methods, or operations regulated or required under this permit.
4. To sample or monitor, at reasonable times, any substances or parameters at any location for purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act.

G3. Permit actions

This permit may be modified, revoked and reissued, or terminated either at the request of any interested person (including the Permittee) or upon Ecology's initiative. However, the permit may only be modified, revoked and reissued, or terminated for the reasons specified in 40 CFR 122.62, 40 CFR 122.64 or WAC 173-220-150 according to the procedures of 40 CFR 124.5.

1. The following are causes for terminating this permit during its term, or for denying a permit renewal application:
   a. Violation of any permit term or condition.
   b. Obtaining a permit by misrepresentation or failure to disclose all relevant facts.
   c. A material change in quantity or type of waste disposal.

  d. A determination that the permitted activity endangers human health or the environment, or contributes to water quality standards violations and can only be regulated to acceptable levels by permit modification or termination.
  e. A change in any condition that requires either a temporary or permanent reduction, or elimination of any discharge or sludge use or disposal practice controlled by the permit.
  f. Nonpayment of fees assessed pursuant to RCW 90.48.465.
  g. Failure or refusal of the Permittee to allow entry as required in RCW 90.48.090.

2. The following are causes for modification but not revocation and reissuance except when the Permittee requests or agrees:
   a. A material change in the condition of the waters of the state.
   b. New information not available at the time of permit issuance that would have justified the application of different permit conditions.
   c. Material and substantial alterations or additions to the permitted facility or activities which occurred after this permit issuance.
   d. Promulgation of new or amended standards or regulations having a direct bearing upon permit conditions, or requiring permit revision.
   e. The Permittee has requested a modification based on other rationale meeting the criteria of 40 CFR Part 122.62.
   f. Ecology has determined that good cause exists for modification of a compliance schedule, and the modification will not violate statutory deadlines.
   g. Incorporation of an approved local pretreatment program into a municipality's permit.
3. The following are causes for modification or alternatively revocation and reissuance:
   a. When cause exists for termination for reasons listed in 1.a through 1.g of this section, and Ecology determines that modification or revocation and reissuance is appropriate.
   b. When Ecology has received notification of a proposed transfer of the permit. A permit may also be modified to reflect a transfer after the effective date of an automatic transfer (General Condition G7) but will not be revoked and reissued after the effective date of the transfer except upon the request of the new Permittee.

G4. Reporting planned changes

The Permittee must, as soon as possible, but no later than one hundred eighty (180) days prior to the proposed changes, give notice to Ecology of planned physical alterations or additions to the permitted facility, production increases, or process modification which will result in:

1. The permitted facility being determined to be a new source pursuant to 40 CFR 122.29(b).
2. A significant change in the nature or an increase in quantity of pollutants discharged.
3. A significant change in the Permittee's sludge use or disposal practices. Following such notice, and the submittal of a new application or supplement to the existing application, along with required engineering plans and reports, this permit may be modified, or revoked and reissued pursuant to 40 CFR 122.62(a) to specify and limit any pollutants not previously limited. Until such modification is effective, any new or increased discharge in excess of permit limits or not specifically authorized by this permit constitutes a violation.

G5. Plan review required

Prior to constructing or modifying any wastewater control facilities, an engineering report and detailed plans and specifications must be submitted to Ecology for approval in accordance with chapter 173-240 WAC. Engineering reports, plans, and specifications must be submitted at least one hundred eighty (180) days prior to the planned start of construction unless a shorter time is approved by Ecology. Facilities must be constructed and operated in accordance with the approved plans.

G6. Compliance with other laws and statutes

Nothing in this permit excuses the Permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations.

G7. Transfer of this permit

In the event of any change in control or ownership of facilities from which the authorized discharge emanate, the Permittee must notify the succeeding owner or controller of the existence of this permit by letter, a copy of which must be forwarded to Ecology.

1. Transfers by Modification

   Except as provided in paragraph (2) below, this permit may be transferred by the Permittee to a new owner or operator only if this permit has been modified or revoked and reissued under 40 CFR 122.62(b)(2), or a minor modification made under 40 CFR 122.63(d), to identify the new Permittee and incorporate such other requirements as may be necessary under the Clean Water Act.

2. Automatic Transfers

   This permit may be automatically transferred to a new Permittee if:

   a. The Permittee notifies Ecology at least thirty (30) days in advance of the proposed transfer date.
   b. The notice includes a written agreement between the existing and new Permittees containing a specific date transfer of permit responsibility, coverage, and liability between them.

c. Ecology does not notify the existing Permittee and the proposed new Permittee of its intent to modify or revoke and reissue this permit. A modification under this subparagraph may also be minor modification under 40 CFR 122.63. If this notice is not received, the transfer is effective on the date specified in the written agreement.

G8. Reduced production for compliance

The Permittee, in order to maintain compliance with its permit, must control production and/or all discharges upon reduction, loss, failure, or bypass of the treatment facility until the facility is restored or an alternative method of treatment is provided. This requirement applies in the situation where, among other things, the primary source of power of the treatment facility is reduced, lost, or fails.

G9. Removed substances

Collected screenings, grit, solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters must not be resuspended or reintroduced to the final effluent stream for discharge to state waters.

G10. Duty to provide information

The Permittee must submit to Ecology, within a reasonable time, all information which Ecology may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee must also submit to Ecology upon request, copies of records required to be kept by this permit.

G11. Other requirements of 40 CFR

All other requirements of 40 CFR 122.41 and 122.42 are incorporated in this permit by reference.

G12. Additional monitoring

Ecology may establish specific monitoring requirements in addition to those contained in this permit by administrative order or permit modification.

G13. Payment of fees

The Permittee must submit payment of fees associated with this permit as assessed by Ecology.

G14. Penalties for violating permit conditions

Any person who is found guilty of willfully violating the terms and conditions of this permit is deemed guilty of a crime, and upon conviction thereof shall be punished by a fine of up to ten thousand dollars ($10,000) and costs of prosecution, or by imprisonment in the discretion of the court. Each day upon which a willful violation occurs may be deemed a separate and additional violation.

Any person who violates the terms and conditions of a waste discharge permit may incur, in addition to any other penalty as provided by law, a civil penalty in the amount of up to ten thousand dollars ($10,000) for every such violation. Each and every such violation is a separate and distinct offense, and in case of a continuing violation, every day's continuance is deemed to be a separate and distinct violation.

G15. Upset

Definition – “Upset” means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limits because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

An upset constitutes an affirmative defense to an action brought for noncompliance with such technology-based permit effluent limits if the requirements of the following paragraph are met.

A Permittee who wishes to establish the affirmative defense of upset must demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

1. An upset occurred and that the Permittee can identify the cause(s) of the upset.
2. The permitted facility was being properly operated at the time of the upset.
3. The Permittee submitted notice of the upset as required in Special Condition S3.F.
4. The Permittee complied with any remedial measures required under S3.F of this permit.

In any enforcement action the Permittee seeking to establish the occurrence of an upset has the burden of proof.

G16. Property rights

This permit does not convey any property rights of any sort, or any exclusive privilege.

G17. Duty to comply

The Permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

G18. Toxic pollutants

The Permittee must comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if this permit has not yet been modified to incorporate the requirement.

G19. Penalties for tampering

The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two (2) years per violation, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this condition, punishment shall be a fine of not more than $20,000 per day of violation, or by imprisonment of not more than four (4) years, or by both.

G20. Compliance schedules

Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit must be submitted no later than fourteen (14) days following each schedule date.

G21. Service agreement review

The Permittee must submit to Ecology any proposed service agreements and proposed revisions or updates to existing agreements for the operation of any wastewater treatment facility covered by this permit. The review is to ensure consistency with chapters 90.46 and 90.48 RCW as required by RCW 70.150.040(9). In the event that Ecology does not comment within a thirty-day (30) period, the Permittee may assume consistency and proceed with the service agreement or the revised/updated service agreement.

Appendix A

LIST OF POLLUTANTS WITH ANALYTICAL METHODS, DETECTION LIMITS AND QUANTITATION LEVELS

The Permittee must use the specified analytical methods, detection limits (DLs) and quantitation levels (QLs) in the following table for permit and application required monitoring unless:

- Another permit condition specifies other methods, detection levels, or quantitation levels.
- The method used produces measurable results in the sample and EPA has listed it as an EPA-approved method in 40 CFR Part 136.

If the Permittee uses an alternative method, not specified in the permit and as allowed above, it must report the test method, DL, and QL on the discharge monitoring report or in the required report.

If the Permittee is unable to obtain the required DL and QL in its effluent due to matrix effects, the Permittee must submit a matrix-specific detection limit (MDL) and a quantitation limit (QL) to Ecology with appropriate laboratory documentation.

When the permit requires the Permittee to measure the base neutral compounds in the list of priority pollutants, it must measure all of the base neutral pollutants listed in the table below. The list includes EPA required base neutral priority pollutants and several additional polynuclear aromatic hydrocarbons (PAHs). The Water Quality Program added several PAHs to the list of base neutrals below from Ecology's Persistent Bioaccumulative Toxics (PBT) List. It only added those PBT parameters of interest to Appendix A that did not increase the overall cost of analysis unreasonably.

Ecology added this appendix to the permit in order to reduce the number of analytical "non-detects" in permit-required monitoring and to measure effluent concentrations near or below criteria values where possible at a reasonable cost.

The lists below include conventional pollutants (as defined in CWA section 502(6) and 40 CFR Part 122.), toxic or priority pollutants as defined in CWA section 307(a)(1) and listed in 40 CFR Part 122 Appendix D, 40 CFR Part 401.15 and 40 CFR Part 423 Appendix A), and nonconventionals. 40 CFR Part 122 Appendix D (Table V) also identifies toxic pollutants and hazardous substances which are required to be reported by dischargers if expected to be present. This permit Appendix A list does not include those parameters.

CONVENTIONAL POLLUTANTS

Pollutant	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] *µg/L unless specified*	Quantitation Level (QL)[2] *µg/L unless specified*
Biochemical Oxygen Demand		SM5210-B		2 mg/L
Biochemical Oxygen Demand, Soluble		SM5210-B [3]		2 mg/L
Fecal Coliform		SM 9221E,9222	N/A	Specified in method - sample aliquot dependent
Oil and Grease (HEM) (Hexane Extractable Material)		1664 A or B	1,400	5,000
pH		SM4500-H^+ B	N/A	N/A
Total Suspended Solids		SM2540-D		5 mg/L

NONCONVENTIONAL POLLUTANTS

Pollutant & CAS No. (if available)	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
Alkalinity, Total		SM2320-B		5 mg/L as CaCO3
Aluminum, Total	7429-90-5	200.8	2.0	10
Ammonia, Total (as N)		SM4500-NH3-B and C/D/E/G/H		20
Barium Total	7440-39-3	200.8	0.5	2.0
BTEX (benzene +toluene + ethylbenzene + m,o,p xylenes)		EPA SW 846 8021/8260	1	2
Boron, Total	7440-42-8	200.8	2.0	10.0
Chemical Oxygen Demand		SM5220-D		10 mg/L
Chloride		SM4500-Cl B/C/D/E and SM4110 B		Sample and limit dependent
Chlorine, Total Residual		SM4500 Cl G		50.0
Cobalt, Total	7440-48-4	200.8	0.05	0.25
Color		SM2120 B/C/E		10 color units
Dissolved oxygen		SM4500-OC/OG		0.2 mg/L
Flow		Calibrated device		
Fluoride	16984-48-8	SM4500-F E	25	100
Hardness, Total		SM2340B		200 as CaCO3
Iron, Total	7439-89-6	200.7	12.5	50
Magnesium, Total	7439-95-4	200.7	10	50
Manganese, Total	7439-96-5	200.8	0.1	0.5
Molybdenum, Total	7439-98-7	200.8	0.1	0.5
Nitrate + Nitrite Nitrogen (as N)		SM4500-NO3- E/F/H		100
Nitrogen, Total Kjeldahl (as N)		SM4500-N_{org}B/C and SM4500NH_3-B/C/D/EF/G/H		300
NWTPH Dx [4]		Ecology NWTPH Dx	250	250
NWTPH Gx [5]		Ecology NWTPH Gx	250	250
Phosphorus, Total (as P)		SM 4500 PB followed by SM4500-PE/PF	3	10
Salinity		SM2520-B		3 practical salinity units or scale (PSU or PSS)
Settleable Solids		SM2540 -F		Sample and limit dependent
Soluble Reactive Phosphorus (as P)		SM4500-P E/F/G	3	10
Sulfate (as mg/L SO_4)		SM4110-B		0.2 mg/L
Sulfide (as mg/L S)		SM4500-S^2F/D/E/G		0.2 mg/L
Sulfite (as mg/L SO_3)		SM4500-SO3B		2 mg/L
Temperature (max. 7-day avg.)		Analog recorder or use micro-recording devices known as thermistors		0.2º C

NONCONVENTIONAL POLLUTANTS

Pollutant & CAS No. (if available)	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] µg/L unless specified	Quantitation Level (QL)[2] µg/L unless specified
Tin, Total	7440-31-5	200.8	0.3	1.5
Titanium, Total	7440-32-6	200.8	0.5	2.5
Total Coliform		SM 9221B, 9222B, 9223B	N/A	Specified in method - sample aliquot dependent
Total Organic Carbon		SM5310-B/C/D		1 mg/L
Total dissolved solids		SM2540 C		20 mg/L

PRIORITY POLLUTANTS	PP #	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] *µg/L unless specified*	Quantitation Level (QL)[2] *µg/L unless specified*
METALS, CYANIDE & TOTAL PHENOLS					
Antimony, Total	114	7440-36-0	200.8	0.3	1.0
Arsenic, Total	115	7440-38-2	200.8	0.1	0.5
Beryllium, Total	117	7440-41-7	200.8	0.1	0.5
Cadmium, Total	118	7440-43-9	200.8	0.05	0.25
Chromium (hex) dissolved	119	18540-29-9	SM3500-Cr C	0.3	1.2
Chromium, Total	119	7440-47-3	200.8	0.2	1.0
Copper, Total	120	7440-50-8	200.8	0.4	2.0
Lead, Total	122	7439-92-1	200.8	0.1	0.5
Mercury, Total	123	7439-97-6	1631E	0.0002	0.0005
Nickel, Total	124	7440-02-0	200.8	0.1	0.5
Selenium, Total	125	7782-49-2	200.8	1.0	1.0
Silver, Total	126	7440-22-4	200.8	0.04	0.2
Thallium, Total	127	7440-28-0	200.8	0.09	0.36
Zinc, Total	128	7440-66-6	200.8	0.5	2.5
Cyanide, Total	121	57-12-5	335.4	5	10
Cyanide, Weak Acid Dissociable	121		SM4500-CN I	5	10
Cyanide, Free Amenable to Chlorination (Available Cyanide)	121		SM4500-CN G	5	10
Phenols, Total	65		EPA 420.1		50

PRIORITY POLLUTANTS	PP #	CAS Number (if available)	Recommended Analytical Protocol	Detection (DL)[1] *µg/L unless specified*	Quantitation Level (QL)[2] *µg/L unless specified*
ACID COMPOUNDS					
2-Chlorophenol	24	95-57-8	625.1	3.3	9.9
2,4-Dichlorophenol	31	120-83-2	625.1	2.7	8.1
2,4-Dimethylphenol	34	105-67-9	625.1	2.7	8.1
4,6-dinitro-o-cresol (2-methyl-4,6,-dinitrophenol)	60	534-52-1	625.1/1625B	24	72
2,4 dinitrophenol	59	51-28-5	625.1	42	126

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL) [2] *µg/L unless specified***
ACID COMPOUNDS					
2-Nitrophenol	57	88-75-5	625.1	3.6	10.8
4-Nitrophenol	58	100-02-7	625.1	2.4	7.2
Parachlorometa cresol (4-chloro-3-methylphenol)	22	59-50-7	625.1	3.0	9.0
Pentachlorophenol	64	87-86-5	625.1	3.6	10.8
Phenol	65	108-95-2	625.1	1.5	4.5
2,4,6-Trichlorophenol	21	88-06-2	625.1	2.7	8.1

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL) [2] *µg/L unless specified***
VOLATILE COMPOUNDS					
Acrolein	2	107-02-8	624	5	10
Acrylonitrile	3	107-13-1	624	1.0	2.0
Benzene	4	71-43-2	624.1	4.4	13.2
Bromoform	47	75-25-2	624.1	4.7	14.1
Carbon tetrachloride	6	56-23-5	624.1/601 or SM6230B	2.8	8.4
Chlorobenzene	7	108-90-7	624.1	6.0	18.0
Chloroethane	16	75-00-3	624/601	1.0	2.0
2-Chloroethylvinyl Ether	19	110-75-8	624	1.0	2.0
Chloroform	23	67-66-3	624.1 or SM6210B	1.6	4.8
Dibromochloromethane (chlordibromomethane)	51	124-48-1	624.1	3.1	9.3
1,2-Dichlorobenzene	25	95-50-1	624	1.9	7.6
1,3-Dichlorobenzene	26	541-73-1	624	1.9	7.6
1,4-Dichlorobenzene	27	106-46-7	624	4.4	17.6
Dichlorobromomethane	48	75-27-4	624.1	2.2	6.6
1,1-Dichloroethane	13	75-34-3	624.1	4.7	14.1
1,2-Dichloroethane	10	107-06-2	624.1	2.8	8.4
1,1-Dichloroethylene	29	75-35-4	624.1	2.8	8.4
1,2-Dichloropropane	32	78-87-5	624.1	6.0	18.0
1,3-dichloropropene (mixed isomers)(1,2-dichloropropylene) [6]	33	542-75-6	624.1	5.0	15.0
Ethylbenzene	38	100-41-4	624.1	7.2	21.6
Methyl bromide (Bromomethane)	46	74-83-9	624/601	5.0	10.0
Methyl chloride (Chloromethane)	45	74-87-3	624	1.0	2.0
Methylene chloride	44	75-09-2	624.1	2.8	8.4
1,1,2,2-Tetrachloroethane	15	79-34-5	624.1	6.9	20.7
Tetrachloroethylene	85	127-18-4	624.1	4.1	12.3
Toluene	86	108-88-3	624.1	6.0	18.0
1,2-Trans-Dichloroethylene (Ethylene dichloride)	30	156-60-5	624.1	1.6	4.8
1,1,1-Trichloroethane	11	71-55-6	624.1	3.8	11.4

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL) [2] *µg/L unless specified***
VOLATILE COMPOUNDS					
1,1,2-Trichloroethane	14	79-00-5	624.1	5.0	15.0
Trichloroethylene	87	79-01-6	624.1	1.9	5.7
Vinyl chloride	88	75-01-4	624/SM6200B	1.0	2.0

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL) [2] *µg/L unless specified***
BASE/NEUTRAL COMPOUNDS (compounds in bold are Ecology PBTs)					
Acenaphthene	1	83-32-9	625.1	1.9	5.7
Acenaphthylene	77	208-96-8	625.1	3.5	10.5
Anthracene	78	120-12-7	625.1	1.9	5.7
Benzidine	5	92-87-5	625.1	44	132
Benzyl butyl phthalate	67	85-68-7	625.1	2.5	7.5
Benzo(*a*)anthracene	72	56-55-3	625.1	7.8	23.4
Benzo(b)fluoranthene (3,4-benzofluoranthene) [7]	74	205-99-2	610/625.1	4.8	14.4
Benzo(j)fluoranthene [7]		**205-82-3**	625	0.5	1.0
Benzo(k)fluoranthene (11,12-benzofluoranthene) [7]	75	207-08-9	610/625.1	2.5	7.5
Benzo(r,s,t)pentaphene		**189-55-9**	625	1.3	5.0
Benzo(*a*)pyrene	73	50-32-8	610/625.1	2.5	7.5
Benzo(*ghi*)Perylene	79	191-24-2	610/625.1	4.1	12.3
Bis(*2-chloroethoxy)*methane	43	111-91-1	625.1	5.3	15.9
Bis(*2-chloroethyl*)ether	18	111-44-4	611/625.1	5.7	17.1
Bis(*2-chloroisopropyl*)ether	42	39638-32-9	625	0.5	1.0
Bis(*2-ethylhexyl*)phthalate	66	117-81-7	625.1	2.5	7.5
4-Bromophenyl phenyl ether	41	101-55-3	625.1	1.9	5.7
2-Chloronaphthalene	20	91-58-7	625.1	1.9	5.7
4-Chlorophenyl phenyl ether	40	7005-72-3	625.1	4.2	12.6
Chrysene	76	218-01-9	610/625.1	2.5	7.5
Dibenzo (a,h)acridine		**226-36-8**	610M/625M	2.5	10.0
Dibenzo (a,j)acridine		**224-42-0**	610M/625M	2.5	10.0
Dibenzo(a-*h*)anthracene (1,2,5,6-dibenzanthracene)	82	53-70-3	625.1	2.5	7.5
Dibenzo(a,e)pyrene		192-65-4	610M/625M	2.5	10.0
Dibenzo(a,h)pyrene		189-64-0	625M	2.5	10.0
3,3-Dichlorobenzidine	28	91-94-1	605/625.1	16.5	49.5
Diethyl phthalate	70	84-66-2	625.1	1.9	5.7
Dimethyl phthalate	71	131-11-3	625.1	1.6	4.8
Di-n-butyl phthalate	68	84-74-2	625.1	2.5	7.5
2,4-dinitrotoluene	35	121-14-2	609/625.1	5.7	17.1
2,6-dinitrotoluene	36	606-20-2	609/625.1	1.9	5.7
Di-n-octyl phthalate	69	117-84-0	625.1	2.5	7.5

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
BASE/NEUTRAL COMPOUNDS (compounds in bold are Ecology PBTs)					
1,2-Diphenylhydrazine (*as Azobenzene*)	37	122-66-7	1625B	5.0	20
Fluoranthene	39	206-44-0	625.1	2.2	6.6
Fluorene	80	86-73-7	625.1	1.9	5.7
Hexachlorobenzene	9	118-74-1	612/625.1	1.9	5.7
Hexachlorobutadiene	52	87-68-3	625.1	0.9	2.7
Hexachlorocyclopentadiene	53	77-47-4	1625B/625	2.0	4.0
Hexachloroethane	12	67-72-1	625.1	1.6	4.8
Indeno(*1,2,3-cd*)Pyrene	83	193-39-5	610/625.1	3.7	11.1
Isophorone	54	78-59-1	625.1	2.2	6.6
3-Methyl cholanthrene		**56-49-5**	625	2.0	8.0
Naphthalene	55	91-20-3	625.1	1.6	4.8
Nitrobenzene	56	98-95-3	625.1	1.9	5.7
N-Nitrosodimethylamine	61	62-75-9	607/625	2.0	4.0
N-Nitrosodi-n-propylamine	63	621-64-7	607/625	0.5	1.0
N-Nitrosodiphenylamine	62	86-30-6	625	1.0	2.0
Perylene		**198-55-0**	625	1.9	7.6
Phenanthrene	81	85-01-8	625.1	5.4	16.2
Pyrene	84	129-00-0	625.1	1.9	5.7
1,2,4-Trichlorobenzene	8	120-82-1	625.1	1.9	5.7

PRIORITY POLLUTANT	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
DIOXIN					
2,3,7,8-Tetra-Chlorodibenzo-P-Dioxin (2,3,7,8 TCDD)	129	1746-01-6	1613B	1.3 pg/L	5 pg/L

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
PESTICIDES/PCBs					
Aldrin	89	309-00-2	608.3	4.0 ng/L	12 ng/L
alpha-BHC	102	319-84-6	608.3	3.0 ng/L	9.0 ng/L
beta-BHC	103	319-85-7	608.3	6.0 ng/L	18 ng/L
gamma-BHC (Lindane)	104	58-89-9	608.3	4.0 ng/L	12 ng/L
delta-BHC	105	319-86-8	608.3	9.0 ng/L	27 ng/L
Chlordane [8]	91	57-74-9	608.3	14 ng/L	42 ng/L
4,4'-DDT	92	50-29-3	608.3	12 ng/L	36 ng/L
4,4'-DDE	93	72-55-9	608.3	4.0 ng/L	12 ng/L
4,4' DDD	94	72-54-8	608.3	11ng/L	33 ng/L
Dieldrin	90	60-57-1	608.3	2.0 ng/L	6.0 ng/L
alpha-Endosulfan	95	959-98-8	608.3	14 ng/L	42 ng/L
beta-Endosulfan	96	33213-65-9	608.3	4.0 ng/L	12 ng/L

PRIORITY POLLUTANTS	**PP #**	**CAS Number (if available)**	**Recommended Analytical Protocol**	**Detection (DL)[1] *µg/L unless specified***	**Quantitation Level (QL)[2] *µg/L unless specified***
PESTICIDES/PCBs					
Endosulfan Sulfate	97	1031-07-8	608.3	66 ng/L	198 ng/L
Endrin	98	72-20-8	608.3	6.0 ng/L	18 ng/L
Endrin Aldehyde	99	7421-93-4	608.3	23 ng/L	70 ng/L
Heptachlor	100	76-44-8	608.3	3.0 ng/L	9.0 ng/L
Heptachlor Epoxide	101	1024-57-3	608.3	83 ng/L	249 ng/L
PCB-1242 [9]	106	53469-21-9	608.3	0.065	0.195
PCB-1254	107	11097-69-1	608.3	0.065	0.195
PCB-1221	108	11104-28-2	608.3	0.065	0.195
PCB-1232	109	11141-16-5	608.3	0.065	0.195
PCB-1248	110	12672-29-6	608.3	0.065	0.195
PCB-1260	111	11096-82-5	608.3	0.065	0.195
PCB-1016 [9]	112	12674-11-2	608.3	0.065	0.195
Toxaphene	113	8001-35-2	608.3	240 ng/L	720 ng/L

1. Detection level (DL) or detection limit means the minimum concentration of an analyte (substance) that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero as determined by the procedure given in 40 CFR part 136, Appendix B.
2. Quantitation Level (QL) also known as Minimum Level of Quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. It is equivalent to the concentration of the lowest calibration standard, assuming that the lab has used all method-specified sample weights, volumes, and cleanup procedures. The QL is calculated by multiplying the MDL by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer. (64 FR 30417).
   ALSO GIVEN AS:
   The smallest detectable concentration of analyte greater than the Detection Limit (DL) where the accuracy (precision & bias) achieves the objectives of the intended purpose. (Report of the Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs Submitted to the US Environmental Protection Agency, December 2007).
3. Soluble Biochemical Oxygen Demand method note: First, filter the sample through a Millipore Nylon filter (or equivalent) - pore size of 0.45-0.50 um (prep all filters by filtering 250 ml of laboratory grade deionized water through the filter and discard). Then, analyze sample as per method 5210-B.
4. NWTPH Dx - Northwest Total Petroleum Hydrocarbons Diesel Extended Range – see https://fortress.wa.gov/ecy/publications/documents/97602.pdf
5. NWTPH Gx - Northwest Total Petroleum Hydrocarbons Gasoline Extended Range – see https://fortress.wa.gov/ecy/publications/documents/97602.pdf
6. 1, 3-dichloroproylene (mixed isomers) You may report this parameter as two separate parameters: cis-1, 3-dichlorpropropene (10061-01-5) and trans-1, 3-dichloropropene (10061-02-6).
7. Total Benzofluoranthenes - Because Benzo(b)fluoranthene, Benzo(j)fluoranthene and Benzo(k)fluoranthene co-elute you may report these three isomers as total benzofluoranthenes.
8. Chlordane – You may report alpha-chlordane (5103-71-9) and gamma-chlordane (5103-74-2) in place of chlordane (57-74-9). If you report alpha and gamma-chlordane, the DL/PQLs that apply are 14/42 ng/L.
9. PCB 1016 & PCB 1242 – You may report these two PCB compounds as one parameter called PCB 1016/1242.

Issuance Date: December 1, 2021
Effective Date: January 1, 2022
Expiration Date: December 31, 2026

PUGET SOUND NUTRIENT GENERAL PERMIT

A National Pollutant Discharge Elimination System and State Waste Discharge General Permit

State of Washington
Department of Ecology
Olympia, Washington

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington
and
The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1251 et seq.

Until this permit expires, is modified or revoked, Permittees that have properly obtained coverage under this general permit are authorized to discharge nutrients in accordance with the conditions, which follow.

DEPARTMENT OF ECOLOGY
State of Washington

Vincent McGowan, P.E.
Water Quality Program Manager
Washington State Department of Ecology

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LIST OF TABLES

SUMMARY OF PERMIT REPORT SUBMITTALS

Refer to the Special and General Conditions within this permit for additional submittal requirements. Appendix A provides a list of definitions. Appendix B provides a list of acronyms.

Table 1. Summary of Permit Report Submittals

Permit Section	Submittal	Frequency	First Submittal Date
S2.A.1	Permit Application (Notice of Intent)	Once	For new Permittees: No later than 90 days following permit issuance
S4.C	Nitrogen Optimization Report for Dominant Loaders	Annually	March 31, 2023
S4.D	Corrective Action Engineering Report	As necessary	
S4.E	Nutrient Reduction Evaluation for Dominant Loaders	1/permit cycle	December 31, 2025
S5.C	Nitrogen Optimization Report for Moderate Loaders	Annually	March 31, 2023
S5.D	Corrective Action Engineering Report	As necessary	
S5.E	Nutrient Reduction Evaluation for Moderate Loaders	1/permit cycle	December 31, 2025
S6.B	Nitrogen Optimization Report for Small Loaders	1/permit cycle	March 31, 2026
S5.D	AKART Evaluation for Small Loaders	1/permit cycle	December 31, 2025
S9.A	Discharge Monitoring Reports (DMRs)	Monthly	Within 15 days of applicable monitoring period
G2	Notice of Change in Authorization	As necessary	As necessary
G7	Application for Permit Renewal	1/permit cycle	No later than 180 days before expiration
G20	Reporting Anticipated Non-Compliance	As necessary	As necessary

Table 2. Summary of Required On-Site Documentation

Permit Condition(s)	Document Title
S9.B.3	Original Sampling Records (Field notes, as applicable and Laboratory Reports)
S9.G.1.a	Copy of Permit Coverage Letter
S9.G.1.b	Copy of Puget Sound Nutrient General Permit
S9.G.1.c	Copies of Discharge Monitoring Reports
S9.G.1.d	Copies of attachment to the Annual or Single NOP Reports (as applicable)
S9.G.1.e	Copy of the Nutrient Reduction Evaluation or AKART Analysis (as applicable)

The Department of Ecology is committed to providing people with disabilities access to information and services by meeting or exceeding the requirements of the Americans with Disabilities Act (ADA), Section 504 and 508 of the Rehabilitation Act, and Washington State Policy #188.

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For document translation services, call Water Quality Reception at 360-407-6600. Por publicaciones en espanol, por favor llame Water Quality Reception al 360-407-6600.

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[1] https://ecology.wa.gov/About-us/Accountability-transparency/Our-website/Accessibility

SPECIAL CONDITIONS

S1. PERMIT COVERAGE

A. COVERAGE AREA AND ELIGIBLE DISCHARGES

This Puget Sound Nutrient General Permit (PSNGP) applies to the 58 publically owned ***domestic wastewater*** treatment plants (WWTPs) discharging into ***Washington Waters of the Salish Sea***, except for federal and Tribal lands and waters as specified in Special Condition S1.D. Table 3 identifies the WWTPs covered by this permit along with their individual ***NPDES*** permit number for reference. This proposed permit assigns a category to each WWTP based on their percentage of the ***total inorganic nitrogen*** **(TIN)** load currently discharged to Washington Waters of the Salish Sea. Special Condition S4 lists permit conditions and limits for the WWTPs with the **dominant (D) TIN loads**. Special Condition S5 lists the conditions and limits for the WWTPs with **moderate (M) loads**. Special Condition S6 lists the conditions and limits for the WWTPs with **small (S) loads**.

Table 3. List of Domestic WWTPs Discharging to Puget Sound

Wastewater Treatment Plant	Individual NPDES Permit Number	Category
Alderwood Sewage Treatment Plant (STP)	WA0020826	S
Anacortes WWTP	WA0020257	M
Bainbridge Island WWTP	WA0020907	S
Birch Bay Sewage Treatment Plant (STP)	WA0029556	M
Boston Harbor STP	WA0040291	S
Bremerton WWTP	WA0029289	M
Clallam Bay WWTP	WA0024431	S
Clallam Bay Corrections Center WWTP	WA0039845	S
Coupeville WWTP	WA0029378	S
Eastsound Orcas Village WWTP	WA0030911	S
Eastsound Sewer and Water District WWTP	WA0030571	S
Edmonds STP	WA0024058	M
Everett STP	WA0024490	D
Fisherman Bay STP	WA0030589	S
Friday Harbor STP	WA0023582	S
Gig Harbor WWTP	WA0023957	S
Hartstene Pointe STP	WA0038377	S
King County, Brightwater WWTP	WA0032247	D

Wastewater Treatment Plant	Individual NPDES Permit Number	Category
King County, South WWTP	WA0029581	D
King County, Vashon WWTP	WA0022527	S
King County, West Point WWTP	WA0029181	D
Kitsap County, Central Kitsap WWTP	WA0030520	M
Kitsap County, Kingston WWTP	WA0032077	S
Kitsap County, Manchester WWTP	WA0023701	S
Kitsap County Sewer District #7 Water Reclamation Facility (WRF)	WA0030317	S
La Conner STP	WA0022446	S
Lake Stevens Sewer District WWTP	WA0020893	M
Lakota WWTP	WA0022624	M
Langley WWTP	WA0020702	S
Lighthouse Point WRF/Blaine STP	WA0022641	M
LOTT Budd Inlet WRF	WA0037061	M
Lynnwood STP	WA0024031	M
Marysville STP	WA0022497	M
McNeil Island Special Commitment Center WWTP	WA0040002	S
Midway Sewer District WWTP	WA0020958	M
Miller Creek WWTP	WA0022764	M
Mt Vernon WWTP	WA0024074	M
Mukilteo Water and Wastewater District WWTP	WA0023396	S
Oak Harbor STP	WA0020567	S
Penn Cove WWTP	WA0029386	S
Pierce County Chambers Creek Regional WWTP	WA0039624	D
Port Angeles WWTP	WA0023973	M
Port Orchard WWTP (South Kitsap WRF)	WA0020346	M
Port Townsend STP	WA0037052	S
Post Point WWTP (Bellingham STP)	WA0023744	D
Redondo WWTP	WA0023451	M
Rustlewood WWTP	WA0038075	S
Salmon Creek WWTP	WA0022772	M

Wastewater Treatment Plant	Individual NPDES Permit Number	Category
Sekiu WWTP	WA0024449	S
Sequim WRF	WA0022349	S
Shelton WWTP	WA0023345	S
Skagit County Sewer District 2 Big Lake WWTP	WA0030597	S
Snohomish STP	WA0029548	M
Stanwood STP	WA0020290	S
Tacoma Central No. 1 WWTP	WA0037087	D
Tacoma North No. 3 WWTP	WA0037214	M
Tamoshan STP	WA0037290	S
WA Parks Larrabee WWTP	WA0023787	S

B. LIMITS ON COVERAGE

Coverage under this General Permit does not include discharges from WWTPs not listed in Table 3. Coverage under this General Permit also excludes all discharges from non-WWTP outfalls.

This permit does not cover the following discharges:

1. Discharges from facilities located on "Indian Country" as defined in 18 U.S.C. §1151, except portions of the Puyallup Reservation as noted below. Indian Country includes:
   a. All land within any Indian Reservation, notwithstanding the issuance of any patent, and including rights-of-way running through the reservation. This includes all federal, tribal, and Indian and non-Indian privately owned land within the reservation.
   b. All off-reservation Indian allotments, the Indian titles to which have not been extinguished, including rights-of-way running through the same.
   c. All off-reservation federal trust lands held for Native American Tribes.

   Puyallup Exception: Following the *Puyallup Tribes of Indians Land Settlement Act of 1989*, 25 U.S.C. §1773,the permit does apply to land within the Puyallup Reservation except for discharges to surface water on land held in trust by the federal government.
2. Discharges from activities operated by any department, agency, or instrumentality of the executive, legislative, and judicial branches of the Federal Government of the United States, or another entity, such as a private contractor, performing industrial activity for any such department, agency, or instrumentality.

3. Discharges from any industrial or privately owned domestic wastewater treatment plant into Washington waters of the Salish Sea.
4. Discharges from domestic WWTPs entering tributary watersheds to Washington waters of the Salish Sea, upstream of Ecology ambient monitoring stations.

S2. APPLICATION FOR COVERAGE

A. OBTAINING PERMIT COVERAGE

1. The ***owner/operator*** seeking coverage under this permit must apply for permit coverage within the following time limits.
   a. Existing facilities are WWTPs in operation prior to the effective date of this permit, January 1, 2022 and are identified in Table 3.
   b. The owner/operator of an existing domestic wastewater treatment plant must submit a complete application for coverage no later than ninety (90) ***days*** after the issuance date of this permit. Upon submittal of a complete application for coverage (also called a ***Notice of Intent*** or NOI) ***Ecology*** will issue a decision on permit coverage pursuant to Special Condition S2.C.

B. HOW TO APPLY FOR PERMIT COVERAGE

The owner/operator seeking coverage under this permit must do the following:

1. Submit to Ecology, a complete application for coverage using the permit specific Notice of Intent through Ecology's Water Quality Permitting Portal: https://secureaccess.wa.gov/ecy/wqwebportal. The ***applicant*** must submit this application for coverage electronically. For more information about the WQWebPortal, visit Ecology's WQWebPortal guidance webpage[2].
2. A responsible person, as defined in General Condition G2, must sign the signature page of the NOI and submit it to Ecology.
3. Public Notice
   a. Public notice of the application for coverage is not required for the facilities subject to this general permit because they are all existing facilities.
   b. The owner/operator of an existing facility with coverage under the Puget Sound Nutrient General Permit (***Permittee***) wanting to modify their permit coverage must comply with public notice requirements specified in Special Condition S2.D.2.

C. PERMIT COVERAGE EFFECTIVE DATE

Permit coverage begins on the day Ecology issues the coverage letter to the applicant.

[2] https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Water-quality-permits-guidance/WQWebPortal-guidance

D. MODIFICATION OF PERMIT COVERAGE

A permittee requesting a reduction in monitoring, or a change in action level, or otherwise requesting a modification of permit coverage, must submit a complete Modification of Coverage Form to Ecology. The Permittee must:

1. Apply for modification of coverage at least 60 days prior to the change necessitating the coverage modification.
2. Complete the public notice requirements in WAC 173-226-130(5) as part of a complete application for modification of coverage.
3. Comply with ***SEPA*** as part of a complete application for modification of coverage if undergoing a significant process change driven by a corrective action.

S3. COMPLIANCE WITH STANDARDS

A. Discharges must not cause or contribute to a violation of surface water quality standards (Chapter 173-201A WAC), sediment management standards (Chapter 173-204 WAC), or human health-based criteria in the Federal water quality criteria applicable to Washington (40 CFR Part 135.45). This permit does not authorize discharge in violation of water quality standards.

B. Ecology presumes that a Permittee complies with water quality standards unless discharge monitoring data or other ***site***-specific information demonstrates that a discharge causes or contributes to a violation of water quality standards, when the Permittee complies with the following conditions. The Permittee must fully comply with all permit conditions, including planning, ***optimization***, corrective actions (as necessary), sampling, monitoring, reporting, waste management, and recordkeeping conditions.

S4. NARRATIVE EFFLUENT LIMITS FOR WWTPS WITH DOMINANT TIN LOADS

A. APPLICABILITY AND NARRATIVE EFFLUENT LIMITS

Beginning on the effective date, each of the Permittees with dominant TIN loads listed in Table 5 may discharge TIN from the WWTP through the designated ***outfall(s)*** described in its individual NPDES permit. See Table 3 in Section S1.A for the load category assignment.

All discharges and activities authorized by this permit must comply with the terms and conditions of this permit. Each Permittee listed in Table 5 must comply with the facility specific or bubbled ***action levels*** and narrative effluent limits listed in Table 4, which constitute the suite of ***best management practices*** (BMPs) required for a water quality based effluent limit under 40 CFR 122.44(k).

Table 4. Narrative Effluent Limits for Dominant TIN Loaders

Parameter	Narrative Effluent Limit
Monitoring	Monitor and report per the requirements in S7.A.
Nitrogen Optimization Plan	Optimize treatment performance to stay below the action level. Submit Optimization Report annually per the requirements in S4.C
Nutrient Reduction Evaluation	Submit Nutrient Reduction Evaluation per the requirements in S4.E

B. TIN ACTION LEVELS

If the action level listed in Table 5 for individual WWTPs or the bubbled action levels listed for single jurisdictions in Table 6 are exceeded, the Permittee must employ corrective actions identified in S4.D.

The annual Action Level is the sum of monthly nutrient loads measured over one year. Ecology will assess this total once per year based on the Permittee's Annual Report.

Table 5. Dominant WWTPs and Total Inorganic Nitrogen Action Levels

Wastewater Treatment Plant	Individual NPDES Permit Number	Action Level, TIN lbs/year	Outfall Number
Everett STP	WA0024490	1,530,000	100/015
King County Brightwater WWTP [1]	WA0032247	1,810,000	001
King County South WWTP [1]	WA0029581	7,340,000	001
King County West Point WWTP [1]	WA0029181	6,670,000	001
Pierce County Chambers Creek Regional WWTP	WA0039624	1,880,000	001
Post Point WWTP (Bellingham STP)	WA0023744	993,000	001
Tacoma Central No. 1 WWTP [4]	WA0037087	2,410,000	001

Table 6. Bubbled Action Levels for Corrective Action Assessment

Jurisdiction	Bubbled Action Level, TIN lbs/year
King County	15,820,000

C. NITROGEN OPTIMIZATION PLAN AND REPORT

Each Permittee listed in Table 5 must develop, implement and maintain a Nitrogen Optimization Plan to evaluate operational strategies for maximizing nitrogen removal from the existing treatment plant to stay below the calculated action level. Each Permittee must document their actions taken, any action level exceedances, and apply an adaptive management approach at the WWTP. Permittees will quantify results with required monitoring under this Permit.

The Permittee must begin the actions described in this section immediately upon permit coverage. Documentation of Nitrogen Optimization Plan implementation must be submitted annually through the Annual Report (S9- Reporting Requirements). See Appendix C for Annual Report questions that satisfy the Nitrogen Optimization Plan requirements.

The Nitrogen Optimization Plan submitted by each Permittee in Table 5 must include the following components:

1. Treatment Process Performance Assessment

   Assess the nitrogen removal potential of the current treatment process and identify viable optimization strategies prior to implementation.

   a. *Treatment Assessment* Develop a method to evaluate potential optimization approaches for the existing treatment process. Use the evaluation to:

      i. Determine current (pre-optimization) process performance to determine the existing TIN removal performance for the WWTP.

      ii. Create a list of potential optimization strategies capable of meeting the action level at the WWTP prior to starting optimization. Update the assessment and list of options as necessary with each Annual Report.

   b. *Identify and evaluate optimization strategies.* From the list developed in S4.C.1.a.ii, identify viable optimization strategies for each WWTP owned and operated by the Permittee. Prioritize and update this list as necessary to continuously maintain a working set of strategies for meeting the action level with the existing treatment processes.

      The Permittee may exclude any optimization strategy from the initial list created in S4.C.a.ii that was considered but found to exceed a reasonable implementation cost or timeframe. Documentation must include an explanation of the rationale and financial criteria used in the exclusion determination. If the Permittee finds no viable optimization strategies exist for their current treatment processes, they must immediately proceed to the identification of a corrective action under S4.D.

c. *Initial Selection.* **As soon as possible and no later than July 1, 2022**, select at least one optimization strategy for implementation.

   Document the expected performance (i.e., % TIN removal or a calculated reduction in effluent load or concentration) for the initial optimization strategy prior to implementation.

2. Optimization Implementation

   All Permittees in Table 5 must document implementation of the selected optimization strategy (from S4.C.1.c) during the first reporting period in the first Annual Report due March 31, 2023. Permittees must document implementation during every reporting period thereafter. The documentation must include:

   a. *Strategy Implementation.* Describe how the permittee implemented the selected strategy during each reporting period, following permit coverage. Including:

      i. Initial implementation costs

      ii. Length of time for full implementation, including start date.

      iii. Any adaptive management applied to refine implementation during the reporting period.

      iv. Anticipated and unanticipated challenges.

      v. Any impacts to the overall treatment performance as a result of process changes.

   b. *Discharge Evaluation.* By March 31 each year beginning in 2023, each Permittee in Table 5 must review effluent data collected during the previous calendar year to determine whether TIN loads are increasing.

      i. Using all accredited monitoring data, determine facility's annual average TIN concentration and load from the reporting period. **If the annual TIN load exceeds the Action Level in Table 5 (or the applicable bubbled Action Level in Table 6) take the corrective actions in S4.D.**

      ii. Determine the treatment plant's TIN removal rate observed during the reporting period.

3. Influent Nitrogen Reduction Measures/Source Control

   Permittees in Table 5 must investigate opportunities to reduce influent TIN loads from septage handling practices, commercial, dense residential and industrial sources and submit documentation with the Annual Report. The investigation must:

a. Review non-residential sources of nitrogen and identify any possible pretreatment opportunities.

b. Identify potential strategies for reducing TIN from new multi-family/dense residential developments and commercial buildings.

D. ACTION LEVEL EXCEEDANCE CORRECTIVE ACTIONS

Permittees in Table 5 must evaluate whether or not they exceeded the facility specific action level or the bubbled action level (as applicable) and, if they did, implement corrective actions while continuing optimization.

1. If the Permittee determines in the Annual Report that they have exceeded their action level, they must:

    a. Identify possible factors that caused the action level exceedance.

    b. Identify whether modifications to the optimization strategy can improve performance.

    c. Assess whether a different strategy or combination of strategies may provide better overall process improvements.

    d. Document changes made to the optimization strategy, if any, while completing corrective action requirements.

        i. Provide a detailed description of the modified or new optimization strategy selected from the list developed in S4.C.1.b. Include an implementation schedule for any changes and, as necessary, use the treatment process assessment developed to evaluate anticipated results.

        ii. If the Permittee proposes no changes to the optimization strategy, they must provide reasons for not making changes.

2. With the next Annual Report, submit for review a proposed approach to reduce the annual effluent load by at least 10% below the action level listed in Table 5 for individual plants or Table 6 for multiple plants under a bubbled action level. This must be an abbreviated engineering report or technical memo, unless Ecology has previously approved a design document with the proposed solution. The proposed approach must utilize solutions that can be implemented as soon as possible. This may include influent load reduction strategies identified in S4.C.3.

    The engineering document must include:

        i. Brief summary of the treatment alternatives considered and why the proposed approach was selected. Include cost estimates for operation and maintenance;

        ii. The basic design information, including influent characterization;

        iii. A description of the proposed treatment approach and operation, including updates to the WWTP's process flow diagram;

   iv. Anticipated results from the proposed approach including expected effluent quality;

   v. Certification by a licensed professional engineer.

a. If a Permittee exceeds an action level two years in a row, or for a third year during the permit term, the Permittee must begin to reduce nitrogen loads by implementing the proposed approach submitted per S4.D.2 following Ecology's written approval of the proposed approach and implementation schedule.

b. Submit an update to the Permittee's Operation and Maintenance Manual no later than 6 months following implementation.

E. NUTRIENT REDUCTION EVALUATION

1. All permittees in Table 5, except for those who meet the exclusions listed in this paragraph, must prepare and submit an approvable Nutrient Reduction Evaluation (NRE) to Ecology for review by December 31, 2025. Permittees with multiple plants may submit a combined report. This combined report must include an evaluation for all plants owned and operated by the jurisdiction. Permittees that maintain an annual TIN average of < 10 mg/L and meet their action level throughout the permit term must submit a truncated NRE that satisfies S4.E.3-S4.E.5. Permittees that meet their action level throughout the permit term, maintain an annual average of < 10 mg/L TIN and a seasonal average of < 3 mg/L do not have to submit the NRE.

2. The NRE must include an all known, available and reasonable treatment (***AKART***) analysis for purposes of evaluating reasonable treatment alternatives capable of reducing total inorganic nitrogen (TIN). It must present an alternative representing the greatest TIN reduction that is reasonably feasible on an annual basis.

3. In addition, the NRE must assess other site-specific main stream treatment plant upgrades, the applicability of side stream treatment opportunities, alternative effluent management options (e.g., disposal to ground, reclaimed water beneficial uses), the viability of satellite treatment, and other nutrient reduction opportunities that could achieve a final effluent concentration of 3 mg/L TIN (or equivalent load reduction) on seasonal average (April – October) basis.

4. The analysis must be sufficiently complete that an engineering report may be developed for the preferred AKART alternative as well as the preferred alternatives to reach 3 mg/L TIN seasonally, without substantial alterations of concept or basic considerations. The final report must contain appropriate requirements as described in the following guidance (or most recent version):
    a. The Criteria for Sewage Works Design (ECY Publication No. 98-37, 2019)[3]
    b. Reclaimed Water Facilities Manual: The Purple Book (ECY Publication No. 15-10-024, 2019)[4]
5. The analysis conducted for the NRE must include the following elements:
    a. Wastewater Characterization
        i. Current flowrates and growth trends within the sewer service area.
        ii. Current influent and effluent quality.
    b. Treatment Technology Analysis
        i. Description of current treatment processes, including any modifications made for optimization or due to corrective actions.
        ii. Description of site limitations, constraints, or other treatment implementation challenges that exist.
        iii. Identification and screening of potential treatment technologies for meeting two different levels of treatment:
            1. AKART for nitrogen removal (annual basis), and
            2. 3 mg/L TIN (or equivalent load), as a seasonal average April - October
    c. Economic Evaluation
        i. Develop capital, operation and maintenance costs and 20 year net present value using the real discount rate in the most current Appendix C to Office of Management and Budget Circular No. A-94[5] for each technology alternative evaluated.
        ii. Provide cost per pound of nitrogen removed.
        iii. Provide details on basis for current wastewater utility rate structure, including:
            1. How utilities allocate and recover costs from customers.

[3] https://apps.ecology.wa.gov/publications/summarypages/9837.html
[4] https://apps.ecology.wa.gov/publications/SummaryPages/1510024.html
[5] https://www.whitehouse.gov/wp-content/uploads/2020/12/2020_Appendix-C.pdf

2. How frequently rate structures are reviewed.

3. The last time rates were adjusted and the reason for that adjustment.

iv. Provide impact to current rate structure for each alternative assessed.

d. Environmental Justice (EJ) Review

i. Evaluate the demographics within the sewer service area to identify communities of color, Tribes, indigenous communities, and low income populations.

ii. Identify areas within service area that exceed the median household income.

iii. Include an affordability assessment to identify how much overburdened communities identified in S4.E.5.d.i can afford to pay for the wastewater utility.

iv. Propose alternative rate structures or measures that can be taken to prevent adverse effects of rate increases on populations with economic hardship identified in S4.E.5.d.i.

v. Provide information on how recreational and commercial opportunities may be improved for communities identified in S4.E.5.d.i as a result of the treatment improvements identified.

e. Selection of the most reasonable treatment alternative based on the AKART assessment; and the selected alternative for achieving an effluent concentration of 3 mg/L TIN (or equivalent load reduction) based on an April – October seasonal average.

f. Viable implementation timelines that include funding, design, and construction for meeting both the AKART and seasonal average 3 mg/L TIN preferred alternatives.

S5. NARRATIVE EFFLUENT LIMITS FOR WWTPS WITH MODERATE TIN LOADS

A. APPLICABILITY AND NARRATIVE EFFLUENT LIMITS

Beginning on the effective date, each of the Permittees with moderate TIN loads listed in Table 8 may discharge TIN from the WWTP through the designated ***outfall(s)*** described in its individual NPDES permit. See Table 3 in Section S1.A for the load category assignment.

All discharges and activities authorized by this permit must comply with the terms and conditions of this permit. Each Permittee listed in Table 8 must comply with the facility specific or bubbled ***action levels*** and narrative effluent limits listed in Table 7, which constitute the suite of ***best management practices*** (BMPs) required for a water quality based effluent limit under 40 CFR 122.44(k).

Table 7. Narrative Effluent Limits for Moderate TIN Loaders

Parameter	Narrative Effluent Limit
Monitoring	Monitor and report per the requirements in S7.B.
Nitrogen Optimization Plan	Optimize treatment performance to stay below the action level. Submit Optimization Report annually per the requirements in S5.C
Nutrient Reduction Evaluation	Submit Nutrient Reduction Evaluation per the requirements in S5.E

B. TIN ACTION LEVELS

If the action level listed in Table 8 for individual WWTPs or the bubbled action levels listed for single jurisdictions in Table 9 are exceeded, the Permittee must employ corrective actions identified in S5.D.

The annual Action Level is the sum of monthly nutrient loads measured over one year. Ecology will assess this total once per year based on the Permittee's Annual Report.

Table 8. Moderate WWTPs and Total Inorganic Nitrogen Action Levels

Wastewater Treatment Plant	Individual NPDES Permit Number	Action Level, TIN lbs/year	Outfall Number
Anacortes WWTP	WA0020257	167,000	001
Birch Bay Sewage Treatment Plant (STP)	WA0029556	66,400	001
Blaine STP (Lighthouse Point WRF)	WA0022641	18,200	001
Bremerton WWTP	WA0029289	602,000	001
Kitsap County Central Kitsap WWTP	WA0030520	306,000	001
Edmonds STP	WA0024058	432,000	001
Lake Stevens Sewer District WWTP	WA0020893	127,000	002
Lakota WWTP [1]	WA0022624	597,000	001

Wastewater Treatment Plant	Individual NPDES Permit Number	Action Level, TIN lbs/year	Outfall Number
LOTT Budd Inlet WWTF	WA0037061	338,000	001
Lynnwood STP	WA0024031	340,000	001
Marysville STP	WA0022497	592,000	100/001
Midway Sewer District WWTP	WA0020958	625,500	001
Miller Creek WWTP [2]	WA0022764	297,000	001
Mt Vernon WWTP	WA0024074	396,000	004
Port Angeles WWTP	WA0023973	177,000	001/002
Port Orchard WWTP (South Kitsap WRF)	WA0020346	215,000	001
Redondo WWTP [1]	WA0023451	249,000	001
Salmon Creek WWTP [2]	WA0022772	199,000	001
Snohomish STP	WA0029548	83,600	001
Tacoma North No. 3 WWTP	WA0037214	339,000	001

Table 9. Bubbled Action Levels for Corrective Action Assessment

Jurisdiction	Bubbled Action Level, TIN lbs/year
Lakehaven Water and Sewer District [1]	846,000
Southwest Suburban Sewer District [2]	496,000

C. NITROGEN OPTIMIZATION PLAN AND REPORT

Each Permittee listed in Table 8 must develop, implement and maintain a Nitrogen Optimization Plan to evaluate operational strategies for maximizing nitrogen removal from the existing treatment plant to stay below the calculated action level. Each Permittee must document their actions taken, any action level exceedances, and apply an adaptive management approach at the WWTP. Permittees will quantify results with required monitoring under this Permit.

The Permittee must begin the actions described in this section immediately upon permit coverage. Documentation of Nitrogen Optimization Plan implementation must be submitted annually through the Annual Report (S9- Reporting Requirements). See Appendix D for annual report questions that satisfy the Nitrogen Optimization Plan requirements.

The Nitrogen Optimization Plan submitted by each Permittee in Table 8 must include the following components:

1. Treatment Process Performance Assessment

   Assess the nitrogen removal potential of the current treatment process and identify viable optimization strategies prior to implementation.

   a. *Treatment Assessment.* Develop a method to evaluate potential optimization approaches for the existing treatment process. Use the evaluation to:

      i. Evaluate current (pre-optimization) process performance to determine the existing TIN removal performance for the WWTP.

      ii. Create a list of potential optimization strategies capable of meeting the action level at the WWTP prior to starting optimization. Update the assessment and list of options as necessary with each Annual Report.

   b. *Identify and evaluate optimization strategies.* From the list developed in S5.C.1.a.ii, identify viable optimization strategies for each WWTP owned and operated by the Permittee. Prioritize and update this list as necessary to continuously maintain a working set of strategies for meeting the action level with the existing treatment processes.

      The Permittee may exclude any optimization strategy from the initial list created in S5.C.a.ii that was considered but found to exceed a reasonable implementation cost or timeframe. Documentation must include an explanation of the rationale and financial criteria used in the exclusion determination. If the Permittee finds no viable optimization strategies exist for their current treatment processes, they must immediately proceed to the identification of a corrective action under S5.D.

   c. *Initial Selection.* **As soon as possible and no later than July 1, 2022** select at least one optimization strategy for implementation.

      Document the expected performance (i.e., % TIN removal or a calculated reduction in effluent load or concentration) for the initial optimization strategy prior to implementation.

2. Optimization Implementation

   All Permittees in Table 8 must document implementation of the selected optimization strategy (from S5.C.1.c) during the first reporting period in the first Annual Report due March 31, 2023. Permittees must document implementation during every reporting period thereafter. The documentation must include:

   a. *Strategy Implementation.* Describe how the permittee implemented the selected strategy during each reporting period, following permit coverage. Including:

      i. Initial implementation costs

      ii. Length of time for full implementation, including start date.

iii. Any adaptive management applied to refine implementation during the reporting period.

iv. Anticipated and unanticipated challenges.

v. Any impacts to the overall treatment performance as a result of process changes.

b. *Discharge Evaluation.* By March 31 each year beginning in 2023, each Permittee in Table 8 must review effluent data collected during the previous calendar year to determine whether TIN loads are increasing.

i. Using all accredited monitoring data, determine facility's annual average TIN concentration and load from the reporting period. **If the annual TIN load exceeds the Action Level in Table 8 (or the applicable bubbled Action Level in Table 9) take the corrective actions in S5.D.**

ii. Determine the treatment plant's TIN removal rate observed during the reporting period.

3. Influent Nitrogen Reduction Measures/Source Control

Permittees in Table 8 must investigate opportunities to reduce influent TIN loads from septage handling practices, commercial, dense residential and industrial sources and submit documentation with the Annual Report. The investigation must:

a. Review non-residential sources of nitrogen and identify any possible pretreatment opportunities.

b. Identify potential strategies for reducing TIN from new multi-family/dense residential developments and commercial buildings.

D. ACTION LEVEL EXCEEDANCE CORRECTIVE ACTIONS

Permittees in Table 8 must evaluate whether or not they exceeded the facility specific action level or the bubbled action level (as applicable) and, if they did, implement corrective actions while continuing optimization.

1. If the Permittee determines in the Annual Report that they have exceeded their action level, they must:

a. Identify possible factors that caused the action level exceedance.

b. Identify whether modifications to the optimization strategy can improve performance.

c. Assess whether a different strategy or combination of strategies may provide better overall process improvements.

d. Document changes made to the optimization strategy, if any, while completing corrective action requirements.

i. Provide a detailed description of the modified or new optimization strategy selected from the list developed in S5.C.1.b. Include an implementation schedule for any changes and, as necessary, use the treatment process assessment developed to evaluate anticipated results.

ii. If the Permittee proposes no changes to the optimization strategy, they must provide reasons for not making changes.

2. With the next Annual Report, submit for review a proposed approach to reduce the annual effluent load below the action level listed in either Table 8 or Table 9 (as applicable for those jurisdictions) for the duration of the permit term. This must be an abbreviated engineering report or technical memo, unless Ecology has previously approved a design document with the proposed solution. The proposed approach must utilize solutions that can be implemented as soon as possible. This may include influent load reduction strategies identified in S5.C.3.

   The engineering document must include:

   i. Brief summary of the treatment alternatives considered and why the proposed approach was selected. Include cost estimates for operation and maintenance;

   ii. The basic design information, including influent characterization;

   iii. A description of the proposed treatment approach and operation, including updates to the WWTP's process flow diagram;

   iv. Anticipated results from the proposed approach including expected effluent quality;

   v. Certification by a licensed professional engineer.

b. If a Permittee exceeds an action level two years in a row, or for a third year during the permit term, the Permittee must begin to reduce nitrogen loads by implementing the proposed approach submitted per S5.D.2 following Ecology's written approval of the proposed approach and implementation schedule.

c. Submit an update to the Permittee's Operation and Maintenance Manual no later than 6 months following implementation.

E. NUTRIENT REDUCTION EVALUATION

1. Permittees in Table 8, except for those who meet the exclusions listed in this paragraph, must prepare and submit an approvable Nutrient Reduction Evaluation (NRE) to Ecology for review by December 31, 2025. Permittees with multiple plants may submit a combined report. This combined report must include an evaluation for all plants owned and operated by the jurisdiction. Permittees that maintain an annual TIN average of < 10 mg/L and meet their action level throughout the permit term must submit a truncated NRE that satisfies S5.E.3-S5.E.5. Permittees that meet their action level throughout the permit term, maintain an annual average of < 10 mg/L TIN and a seasonal average of < 3 mg/L do not have to submit the NRE.
2. The NRE must include an all known, available and reasonable treatment (***AKART***) analysis for purposes of evaluating reasonable treatment alternatives capable of reducing total inorganic nitrogen (TIN). It must present an alternative representing the greatest TIN reduction that is reasonably feasible on an annual basis.
3. In addition, the NRE must assess other site- specific main stream treatment plant upgrades, the applicability of side stream treatment opportunities, alternative effluent management options (e.g., disposal to ground, reclaimed water beneficial uses), the viability of satellite treatment, and other nutrient reduction opportunities that could achieve a final effluent concentration of 3 mg/L TIN (or equivalent load reduction) on seasonal average (April – October) basis.
4. The analysis must be sufficiently complete that an engineering report may be developed for the preferred AKART alternative as well as the preferred alternatives to reach 3 mg/L TIN seasonally, without substantial alterations of concept or basic considerations. The final report must contain appropriate requirements as described in the following guidance (or most recent version):
    a. The Criteria for Sewage Works Design (ECY Publication No. 98-37, 2019)[6]
    b. Reclaimed Water Facilities Manual: The Purple Book (ECY Publication No. 15-10-024, 2019)[7]
5. The analysis conducted for the NRE must include the following elements:
    a. Wastewater Characterization
        i. Current flowrates and growth trends within the sewer service area.
        ii. Current influent and effluent quality.
    b. Treatment Technology Analysis

[6] https://apps.ecology.wa.gov/publications/summarypages/9837.html
[7] https://apps.ecology.wa.gov/publications/SummaryPages/1510024.html

i. Description of current treatment processes, including any modifications made for optimization or due to corrective actions.

ii. Description of site limitations, constraints, or other treatment implementation challenges that exist.

iii. Identification and screening of potential treatment technologies for meeting two different levels of treatment:

1. AKART for nitrogen removal (annual basis), and

2. 3 mg/L TIN (or equivalent load), as a seasonal average (April through October)

c. Economic Evaluation

i. Develop capital, operation and maintenance costs and 20 year net present value using the real discount rate in the most current Appendix C to Office of Management and Budget Circular No. A-94[8] for each technology alternative evaluated.

ii. Provide cost per pound of nitrogen removed.

iii. Provide details on basis for current wastewater utility rate structure, including:

1. How utilities allocate and recover costs from customers.

2. How frequently rate structures are reviewed.

3. The last time rates were adjusted and the reason for that adjustment.

iv. Provide impact to current rate structure for each alternative assessed.

d. Environmental Justice (EJ) Review

i. Evaluate the demographics within the sewer service area to identify communities of color, Tribes, indigenous communities, and low income populations.

ii. Identify areas within service area that exceed the median household income.

iii. Include an affordability assessment to identify how much overburdened communities identified in S5.E.5.d.i can afford to pay for the wastewater utility.

iv. Propose alternative rate structures or measures that can be taken to prevent adverse effects of rate increases on populations with economic hardship identified in S5.E.5.d.i.

[8] https://www.whitehouse.gov/wp-content/uploads/2020/12/2020_Appendix-C.pdf

v. Provide information on how recreational and commercial opportunities may be improved for communities identified in S5.E.5.d.i as a result of the treatment improvements identified.

e. Selection of the most reasonable treatment alternative based on the AKART assessment; and the selected alternative for achieving an effluent concentration of 3 mg/L TIN (or equivalent load reduction) based on an April through October seasonal average.

f. Viable implementation timelines that include funding, design, and construction for meeting both the AKART and seasonal average 3 mg/L TIN preferred alternatives.

S6. NARRATIVE EFFLUENT LIMITS FOR WWTPS WITH SMALL TIN LOADS

A. APPLICABILITY AND NARRATIVE EFFLUENT LIMITS

Beginning on the effective date, each of the Permittees with small TIN loads listed in Table 11 may discharge total inorganic nitrogen from the WWTP through each facility's designated outfall. See Table 3 in Section S1.A for the load category assignment.

All discharges and activities authorized by this permit must comply with the terms and conditions of this permit. Each Permittee listed in Table 11 must comply with the narrative effluent limits listed in Table 10 which constitute the suite of BMPs required for a narrative water quality based effluent limit under 40 CFR 122.44(k).

Table 10.Narrative Effluent Limits for WWTPs with Small TIN Loads

Parameter	Narrative Effluent Limit
Monitoring	Monitor and report per the requirements in S7.C.
Nitrogen Optimization Plan	Submit one Optimization Report per the requirements in S6.B
AKART Analysis	Submit an AKART Analysis per the requirements in S6.C

Table 11.Permittees with Small TIN Loads

Wastewater Treatment Plant	Individual NPDES Permit Number	Outfall Number
Alderwood STP	WA0020826	001
Bainbridge Island WWTP	WA0020907	001
Boston Harbor STP	WA0040291	001
Clallam Bay STP	WA0024431	001
Clallam Bay Corrections Center STP	WA0039845	001
Coupeville STP	WA0029378	001
Eastsound Orcas Village WWTP	WA0030911	001
Eastsound Sewer and Water District WWTP	WA0030571	001
Fisherman Bay STP	WA0030589	001
Friday Harbor STP	WA0023582	001
Gig Harbor WWTP	WA0023957	001
Hartstene Pointe STP	WA0038377	001
King County Vashon WWTP	WA0022527	001
Kitsap County Kingston WWTP	WA0032077	001
Kitsap County Manchester WWTP	WA0023701	001
Kitsap County Sewer District #7 Water Reclamation Facility (WRF)	WA0030317	001
La Conner STP	WA0022446	001
Langley WWTP	WA0020702	001
McNeil Island Special Commitment Center WWTP	WA0040002	001
Mukilteo Water and Wastewater District WWTP	WA0023396	001
Oak Harbor STP	WA0020567	003
Penn Cove WWTP	WA0029386	001
Port Townsend STP	WA0037052	001
Rustlewood STP	WA0038075	001
Sekiu WWTP	WA0024449	001
Sequim WRF	WA0022349	001
Shelton WWTP	WA0023345	001

Wastewater Treatment Plant	Individual NPDES Permit Number	Outfall Number
Skagit County Sewer District 2 Big Lake WWTP	WA0030597	001
Stanwood STP	WA0020290	001
Tamoshan STP	WA0037290	001
WA Parks Larrabee WWTP	WA0023787	001

B. NITROGEN OPTIMIZATION PLAN AND REPORT

Each Permittee listed in Table 11 must develop, implement, and maintain a Nitrogen Optimization Plan to evaluate and implement operational strategies for maximizing nitrogen removal from the existing treatment plant during the permit term. Permittees must document their actions taken and apply an adaptive management approach at the WWTP. Permittees will quantify results with required monitoring under this Permit.

The Permittee must begin the actions described in this section immediately upon permit coverage. Documentation of Nitrogen Optimization Plan implementation must be submitted through the Single Report (S9- Reporting Requirements). See Appendix E for report questions that satisfy the Nitrogen Optimization Plan requirements. This report must be submitted by March 31, 2026.

The Nitrogen Optimization Plan submitted by each Permittee in Table 11 must include the following components:

1. Treatment Process Performance Assessment

   Each Permittee listed in Table 11 must assess the nitrogen removal potential of the current treatment process and have the ability to evaluate optimization strategies prior to implementation.

   a. *Evaluation.* Each Permittee in Table 11 must develop a treatment process assessment method for purposes of evaluating optimization approaches during the permit term.

      i. Evaluate current (pre-optimization) process performance. Determine the empirical TIN removal rate for the WWTP.

      ii. Develop an initial assessment approach to evaluate possible optimization strategies at the WWTP prior to and after implementation.

      iii. Determine the optimization goal for the WWTP. Develop and document a prioritized list of optimization strategies capable of achieving the optimization goal for each WWTP owned and operated by the Permittee. Update this list as necessary to continuously maintain a selection of strategies for achieving each optimization goal identified.

iv. The Permittee may exclude from the initial selection any optimization strategy considered but found to exceed a reasonable implementation cost or timeframe. Documentation must include an explanation of the rationale and financial criteria used for the exclusion determination.

b. *Initial Selection.* **By December 31, 2022** identify the optimization strategy selected for implementation.

   Document the expected % TIN removal (or the expected reduction in effluent load) for the optimization strategy prior to implementation.

2. Optimization Implementation

   Permittees in Table 11 must document implementation of the selected optimization strategy (from S6.B.1.b) as it is applied to the existing treatment process during the reporting period. Permittees must document adaptive management applied to optimization strategies following initial implementation through the permit term.

   a. *Strategy Implementation.* Describe how the selected strategy was implemented during the reporting period, following permit coverage. Including:

      i. Initial implementation costs.

      ii. Length of time for full implementation, including start date.

      iii. Anticipated and unanticipated challenges.

      iv. Any impacts to the overall treatment performance as a result of process changes.

   b. *Load Evaluation.* Each Permittee listed in Table 11 must review effluent data collected during the reporting period to determine whether TIN loads are increasing.

      i. Using all accredited monitoring data, determine the facility's annual average TIN concentration and load for each year during the reporting period.

      ii. Determine the treatment plant's TIN removal rate at the end of each year. Compare the removal rate with the pre-optimization rate identified in S6.B.1.a.i.

   c. *Strategy Assessment.* Quantify the results of the implemented strategy and compare to the performance metric identified in S6.B.1.b.

      If the TIN loading increased, apply adaptive management, re-evaluate the optimization strategies and the resulting performance to identify the reason. Select a new optimization strategy for implementation and/or revise implementation for better performance. Document any updates to the implementation schedule and overall plan.

3. Influent Nitrogen Reduction Measures/Source Control

   Permittees in Table 11 must investigate opportunities to reduce influent TIN loads from septage handling practices, commercial, dense residential and industrial sources and submit documentation with the Annual Report. The investigation must:

   a. Review non-residential sources of nitrogen and identify any possible pretreatment opportunities.

   b. Identify strategies for reducing TIN from new multi-family/dense residential developments and commercial buildings.

C. AKART ANALYSIS

1. Permittees in Table 11, except for those who meet the exclusions listed in this paragraph, must prepare and submit an approvable all known, available and reasonable treatment (AKART) analysis to Ecology for purposes of evaluating reasonable treatment alternatives capable of reducing total inorganic nitrogen (TIN). Permittees must submit this report by December 31, 2025. Permittees that maintain an annual TIN average of < 10 mg/L and do not document an increase in load through their DMRs do not have to submit this analysis.

2. The analysis must contain appropriate requirements as described in the following guidance (or the most recent version):

   a. The Criteria for Sewage Works Design (ECY Publication No. 98-37, 2019)[9]

   b. Reclaimed Water Facilities Manual: The Purple Book (ECY Publication No. 15-10-024, 2019)[10]

3. The AKART analysis must include the following elements:

   a. Wastewater Characterization

      i. Current volumes, flowrates and growth trends

      ii. Current influent and effluent quality

   b. Treatment Technology Analysis

      i. Description of current treatment processes

      ii. Identification and screening of potential treatment technologies for TIN reduction that achieves AKART for nitrogen removal

   c. Economic Evaluation

[9] https://apps.ecology.wa.gov/publications/documents/9837.pdf

[10] https://apps.ecology.wa.gov/publications/SummaryPages/1510024.html

i. Develop capital, operation and maintenance costs and 20 year net present value using the real discount rate in the most current Appendix C to Office of Management and Budget Circular No. A-94[11] for each technology alternative evaluated.

ii. Provide cost per pound of nitrogen removed

iii. Provide details on basis for current wastewater utility rate structure, including:

1. How utilities allocate and recover costs from customers.

2. How frequently rate structures are reviewed.

3. The last time rates were adjusted and the reason for that adjustment.

iv. Provide impact to current rate structure for each alternative assessed.

d. Environmental Justice (EJ) Review

i. Evaluate the demographics within the sewer service area to identify communities of color, Tribes, indigenous communities, and low income populations.

ii. Identify areas within the service area that exceed the median household income.

iii. Include an affordability assessment to identify how much overburdened communities identified in S6.C.3.d.i can afford to pay for the wastewater utility.

iv. Propose alternative rate structures or measures that can be taken to prevent adverse effects of rate increases on populations with economic hardship identified in S6.C.3.d.i.

v. Provide information on how recreation and commercial opportunities may be improved for communities identified in S6.C.3.d.i as a result of the treatment improvements identified.

e. Selection of most reasonable treatment alternative.

f. Attainable implementation schedule that includes funding, design and construction of infrastructure improvement capable of achieving and maintaining AKART.

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[11] https://www.whitehouse.gov/wp-content/uploads/2020/12/2020_Appendix-C.pdf

S7. MONTORING SCHEDULES AND SAMPLING REQUIREMENTS

A. MONITORING REQUIREMENTS FOR DOMINANT LOADERS

Each permittee listed in Table 5 must monitor influent and effluent in accordance with the following schedule and requirements specified in Table 12 and 13, respectively. Influent and effluent monitoring locations must be representative. Permittees may use the monitoring locations identified in their individual NPDES permit. If a Permittee conducts additional sampling of required parameters during the month, they must report all results on the monthly DMR.

Table 12. Influent Sampling Requirements for Dominant Loaders

Wastewater influent means the raw sewage flow from the collection system into the treatment facility. Sample the wastewater entering the headworks of the treatment plant excluding any side-stream returns from inside the plant, if possible.

The Permittee must collect total ammonia, nitrate plus nitrite, and TKN samples during the same sampling event.

Parameter	Units & Specifications	Minimum Sampling or Calculation Frequency	Analytical Method [k]	Laboratory Quantitation Level [l]	Sample Type
$CBOD_5$	mg/L	2/week [b]	SM5210-B	2 mg/L	24-hour composite [e]
Total Ammonia	mg/L as N	2/week [b]	SM4500-NH_3-B/C/D/E/F/G/H	0.02 mg/L	24-hour composite [e]
Nitrate plus Nitrite Nitrogen	mg/L as N	1/month [c]	SM4500-NO_3-E/F/H	0.1 mg/L	24-hour composite [e]
Total Kjeldahl Nitrogen (TKN)	mg/L as N	1/month [c]	SM4500-N_{org}-B/C and SM4500-NH_3-B/C/D/E/F/G/H	0.3 mg/L	24-hour composite [e]

Table 13. Effluent Sampling Requirements for Dominant Loaders

Final wastewater effluent means wastewater exiting the last treatment process or operation. Typically, this is after or at the exit from the chlorine contact chamber or other disinfection process. The total ammonia, TKN, and nitrate plus nitrite samples must be taken during the same sampling event.

Parameter	Units & Specifications	Minimum Sampling or Calculation Frequency	Analytical Method [k]	Laboratory Quantitation Level [l]	Sample Type
Flow [f]	MGD	2/week [b]	--	--	Metered/ recorded
$CBOD_5$ [a]	mg/L	2/week [b]	SM5210-B	2 mg/L	24-hour composite [e]
Total Organic Carbon	mg/L	1/quarter [d]	SM5310-B/C/D	1 mg/L	24-hour composite [e]
Total Ammonia	mg/L as N	2/week [b]	SM4500-NH_3-B/C/D/E/F/G/H	0.02 mg/L	24-hour composite [e]
Nitrate plus Nitrite Nitrogen	mg/L as N	2/week [b]	SM4500-NO_3-E/F/H	0.1 mg/L	24-hour composite [e]
TKN	mg/L as N	1/month [c]	SM4500-N_{org}-B/C and SM4500-NH_3-B/C/D/E/F/G/H	0.3 mg/L	24-hour composite [e]
Total Inorganic Nitrogen	mg/L as N	2/week [b]	--	--	Calculated [g]
Total Inorganic Nitrogen	Lbs/day	2/week [b]	--	--	Calculated [h]
Average Monthly Total Inorganic Nitrogen	Lbs	1/month [c]	--	--	Calculated [i]
Annual Total Inorganic Nitrogen, year to date	Lbs	1/month [c]	--	--	Calculated [j]

Table 14. Footnotes for Influent and Effluent Monitoring Tables 12 and 13

Footnote	Information
a	Take effluent samples for the $CBOD_5$ analysis before or after the disinfection process. If taken after disinfection and chlorine is used, dechlorinate and reseed the sample.
b	2/*week* means two (2) times during each week
c	1/month means one (1) time during each month
d	Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must begin quarterly monitoring for the quarter beginning on 1/1/22 4/1/22 7/1/22 10/1/22 and submit results by 4/15/22, 7/15/22, 10/15/22, 1/15/22.
e	24-hour *composite* means a series of individual samples collected over a 24-hour period into a single container, and analyzed as one sample.
f	Report daily flows only on days when collecting total ammonia and nitrate plus nitrite samples.
g	TIN (mg/L) as N = Total Ammonia (mg/L as N) + Nitrate plus Nitrite (mg/L as N)
h	Calculate mass concurrently with the respective concentration of a sample, using the following formula: Concentration (in mg/L) X daily flow (in MGD) X Conversion Factor (8.34) = lbs/day
i	Calculate the monthly average total inorganic nitrogen load (lbs as N) using the following equation: $\text{Monthly average TIN load (lbs as N)} = ((\sum \text{Calculated TIN loads } (\frac{\text{lbs}}{\text{day}} as\ N)) / number\ of\ samples) \text{ x number of days in the calendar month}$
j	Calculate the annual total inorganic nitrogen, year to date using the following calculation: $\text{Annual TIN load (lbs as N)} = \sum \text{Monthly average TIN loads, to date}$
k	Or other equivalent EPA-approved method with the same or lower quantitation level
l	The Permittee must ensure laboratory results comply with the quantitation level (QL) specified in the table. However, if an alternative method from 40 CFR Part 136 is sufficient to produce measurable results in the sample, the Permittee may use that method for analysis. If the Permittee uses an alternative method it must report the test method and QL on the discharge monitoring report. If the permittee is unable to obtain the required QL due to matrix effects, the Permittee must report the matrix-specific method detection level (MDL) and QL on the DMR. The permittee must also upload the QA/QC documentation from the lab on the QL development.

B. MONITORING REQUIREMENTS FOR MODERATE LOADERS

Each permittee listed in Table 8 must monitor influent and effluent in accordance with the following schedule and requirements specified in Table 15 and 16, respectively. Influent and effluent monitoring locations must be representative. Permittees may use the monitoring locations identified in their individual NPDES permit. If a Permittee conducts additional sampling of required parameters during the month, they must report all results on the monthly DMR.

Table 15. Influent Sampling Requirements for Moderate Loaders

Wastewater influent means the raw sewage flow from the collection system into the treatment facility. Sample the wastewater entering the headworks of the treatment plant excluding any side-stream returns from inside the plant, if possible.

The Permittee must collect total ammonia, nitrate plus nitrite, and TKN samples during the same sampling event.

Parameter	Units & Specifications	Minimum Sampling or Calculation Frequency	Analytical Method [k]	Laboratory Quantitation Level [l]	Sample Type
$CBOD_5$	mg/L	1/week [b]	SM5210-B	2 mg/L	24-hour composite [e]
Total Ammonia	mg/L as N	1/week [b]	SM4500-NH_3-B/C/D/E/F/G/H	0.02 mg/L	24-hour composite [e]
Nitrate plus Nitrite Nitrogen	mg/L as N	1/month [c]	SM4500-NO_3-E/F/H	0.1 mg/L	24-hour composite [e]
Total Kjeldahl Nitrogen (TKN)	mg/L as N	1/month [c]	SM4500-N_{org}-B/C and SM4500-NH_3-B/C/D/E/F/G/H	0.3 mg/L	24-hour composite [e]

Table 16. Effluent Sampling Requirements for Moderate Loaders

Final wastewater effluent means wastewater exiting the last treatment process or operation. Typically, this is after or at the exit from the chlorine contact chamber or other disinfection process. The total ammonia, TKN, and nitrate plus nitrite samples must be taken during the same sampling event.

Parameter	Units & Specifications	Minimum Sampling or Calculation Frequency	Analytical Method [k]	Laboratory Quantitation Level [l]	Sample Type
Flow [f]	MGD	1/week [b]	--	--	Metered/ recorded
$CBOD_5$ [a]	mg/L	1/week [b]	SM5210-B	2 mg/L	24-hour composite [e]
Total Organic Carbon	mg/L	1/quarter [c]	SM5310-B/C/D	1 mg/L	24-hour composite [e]
Total Ammonia	mg/L as N	1/week [b]	SM4500-NH_3-B/C/D/E/F/G/H	0.02 mg/L	24-hour composite [e]
Nitrate plus Nitrite Nitrogen	mg/L as N	1/week [b]	SM4500-NO_3-E/F/H	0.1 mg/L	24-hour composite [e]
TKN	mg/L as N	1/month [c]	SM4500-N_{org}-B/C and SM4500-NH_3-B/C/D/E/F/G/H	0.3 mg/L	24-hour composite [e]
Total Inorganic Nitrogen	mg/L as N	1/week [b]	--	--	Calculated [g]
Total Inorganic Nitrogen	Lbs/day	1/week [b]	--	--	Calculated [h]
Average Monthly Total Inorganic Nitrogen	Lbs	1/month [c]	--	--	Calculated [i]
Annual Total Inorganic Nitrogen, year to date	Lbs	1/month [c]	--	--	Calculated [j]

Table 17. Footnotes for Influent and Effluent Monitoring Tables 15 and 16

Footnote	Information
a	Take effluent samples for the $CBOD_5$ analysis before or after the disinfection process. If taken after disinfection and chlorine is used, dechlorinate and reseed the sample.
b	1/*week* means one (1) times during each week
c	1/month means one (1) time during each month
d	Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must begin quarterly monitoring for the quarter beginning on 1/1/22 4/1/22 7/1/22 10/1/22 and submit results by 4/15/22, 7/15/22, 10/15/22, 1/15/22.
e	24-hour *composite* means a series of individual samples collected over a 24-hour period into a single container, and analyzed as one sample.
f	Report daily flows only on days when collecting total ammonia and nitrate plus nitrite samples.
g	TIN (mg/L) as N = Total Ammonia (mg/L as N) + Nitrate plus Nitrite (mg/L as N)
h	Calculate mass concurrently with the respective concentration of a sample, using the following formula: Concentration (in mg/L) X daily flow (in MGD) X Conversion Factor (8.34) = lbs/day
i	Calculate the monthly average total inorganic nitrogen load (lbs as N) using the following equation: $\text{Monthly average TIN load (lbs as N)} = ((\sum \text{Calculated TIN loads } (\frac{\text{lbs}}{\text{day}} as\ N)) / number\ of\ samples) \text{ x number of days in the calendar month}$
j	Calculate the annual total inorganic nitrogen, year to date using the following calculation: $\text{Annual TIN load (lbs as N)} = \sum \text{Monthly average TIN loads, to date}$
k	Or other equivalent EPA-approved method with the same or lower quantitation level
l	The Permittee must ensure laboratory results comply with the quantitation level (QL) specified in the table. However, if an alternative method from 40 CFR Part 136 is sufficient to produce measurable results in the sample, the Permittee may use that method for analysis. If the Permittee uses an alternative method it must report the test method and QL on the discharge monitoring report. If the permittee is unable to obtain the required QL due to matrix effects, the Permittee must report the matrix-specific method detection level (MDL) and QL on the DMR. The permittee must also upload the QA/QC documentation from the lab on the QL development.

C. MONITORING REQUIREMENTS FOR SMALL LOADERS

Each permittee listed in Table 11 must monitor influent and effluent in accordance with the following schedule and requirements specified in Table 18 and 19, respectively. Influent and effluent monitoring locations must be representative. Permittees may use the monitoring locations identified in their individual NPDES permit. If a Permittee conducts additional sampling of required parameters during the month, they must report all results on the monthly DMR.

Table 18. Influent Sampling Requirements for Small Loaders

Wastewater influent means the raw sewage flow from the collection system into the treatment facility. Sample the wastewater entering the headworks of the treatment plant excluding any side-stream returns from inside the plant, if possible.

The Permittee must collect total ammonia, nitrate plus nitrite, and TKN samples during the same sampling event.

Parameter	Units & Specifications	Minimum Sampling or Calculation Frequency	Analytical Method [j]	Laboratory Quantitation Level [k]	Sample Type
$CBOD_5$	mg/L	2/month [c]	SM5210-B	2 mg/L	24-hour composite [e]
Total Ammonia	mg/L as N	2/month [c]	SM4500-NH_3-B/C/D/E/F/G/H	0.02 mg/L	24-hour composite [e]
Nitrate plus Nitrite Nitrogen	mg/L as N	1/month [b]	SM4500-NO_3-E/F/H	0.1 mg/L	24-hour composite [e]
Total Kjeldahl Nitrogen (TKN)	mg/L as N	1/month [b]	SM4500-N_{org}-B/C and SM4500-NH_3-B/C/D/E/F/G/H	0.3 mg/L	24-hour composite [e]

Table 19. Effluent Sampling Requirements for Small Loaders

Final wastewater effluent means wastewater exiting the last treatment process or operation. Typically, this is after or at the exit from the chlorine contact chamber or other disinfection process. The total ammonia, TKN, and nitrate plus nitrite samples must be taken during the same sampling event.

Parameter	Units & Specifications	Minimum Sampling or Calculation Frequency	Analytical Method [k]	Laboratory Quantitation Level [l]	Sample Type
Flow [f]	MGD	2/month [c]	--	--	Metered/ recorded
$CBOD_5$ [a]	mg/L	2/month [c]	SM5210-B	2 mg/L	24-hour composite [e]
Total Organic Carbon	mg/L	1/quarter [d]	SM5310-B/C/D	1 mg/L	24-hour composite [e]
Total Ammonia	mg/L as N	2/month [c]	SM4500-NH_3-B/C/D/E/F/G/H	0.02 mg/L	24-hour composite [e]
Nitrate plus Nitrite Nitrogen	mg/L as N	2/month [c]	SM4500-NO_3-E/F/H	0.1 mg/L	24-hour composite [e]
TKN	mg/L as N	1/month [b]	SM4500-N_{org}-B/C and SM4500-NH_3-B/C/D/E/F/G/H	0.3 mg/L	24-hour composite [e]
Total Inorganic Nitrogen	mg/L as N	2/month [c]	--	--	Calculated [g]
Total Inorganic Nitrogen	Lbs/day	2/month [c]	--	--	Calculated [h]
Average Monthly Total Inorganic Nitrogen	Lbs	1/month [b]	--	--	Calculated [i]
Annual Total Inorganic Nitrogen, year to date	Lbs	1/month [b]	--	--	Calculated [j]

Table 20. Footnotes for Influent and Effluent Monitoring Tables 18 and 19

Footnote	Information
a	Take effluent samples for the $CBOD_5$ analysis before or after the disinfection process. If taken after disinfection and chlorine is used, dechlorinate and reseed the sample.
b	1/month means one (1) time during each month
c	2/month means two (2) times during each month and on a rotational basis throughout the days of the week, except weekends and holidays.
d	Quarterly sampling periods are January through March, April through June, July through September, and October through December. The Permittee must begin quarterly monitoring for the quarter beginning on 1/1/22 4/1/22 7/1/22 10/1/22 and submit results by 4/15/22, 7/15/22, 10/15/22, 1/15/22.
e	24-hour composite means a series of individual samples collected over a 24-hour period into a single container, and analyzed as one sample.
f	Report daily flows only on days when collecting total ammonia and nitrate plus nitrite samples.
g	TIN (mg/L) as N = Total Ammonia (mg/L as N) + Nitrate plus Nitrite (mg/L as N)
h	Calculate mass concurrently with the respective concentration of a sample, using the following formula: Concentration (in mg/L) X daily flow (in MGD) X Conversion Factor (8.34) = lbs/day
i	Calculate the monthly average total inorganic nitrogen load (lbs as N) using the following equation: $\text{Monthly average TIN load (lbs as N)} = ((\sum \text{Calculated TIN loads } (\frac{\text{lbs}}{\text{day}}\, as\ N)) / number\ of\ samples) \text{ x number of days in the calendar month}$
j	Calculate the annual total inorganic nitrogen, year to date using the following calculation: $\text{Annual TIN load (lbs as N)} = \sum \text{Monthly average TIN loads, to date}$
k	Or other equivalent EPA-approved method with the same or lower quantitation level
l	The Permittee must ensure laboratory results comply with the quantitation level (QL) specified in the table. However, if an alternative method from 40 CFR Part 136 is sufficient to produce measurable results in the sample, the Permittee may use that method for analysis. If the Permittee uses an alternative method it must report the test method and QL on the discharge monitoring report. If the permittee is unable to obtain the required QL due to matrix effects, the Permittee must report the matrix-specific method detection level (MDL) and QL on the DMR. The permittee must also upload the QA/QC documentation from the lab on the QL development.

D. SAMPLING AND ANALYTICAL PROCEDURES

Samples and measurements taken to meet the requirements of this permit must represent the volume and nature of the monitored parameters, including ***representative sampling*** of any unusual discharge or discharge condition, including authorized ***bypasses***, upsets, and maintenance-related conditions affecting effluent quality.

Sampling and analytical methods used to meet the monitoring requirements specified in this permit must conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants*[12] contained in 40 CFR 136[13] (or as applicable in 40 CFR subchapter N[14] [Parts 400-471] or 40 CFR subchapter O[15] [Parts 501-503]) unless otherwise specified in this permit.

E. FLOW MEASUREMENT

The Permittee must:

1. Select and use appropriate flow measurement and method consistent with accepted scientific practices.
2. Install, calibrate, and maintain these devices to ensure the accuracy of the measurements is consistent with the accepted industry standard, the manufacture's recommendation, and approved O&M manual procedures for the device and the wastestream.
3. Establish a calibration frequency for each device or instrument in the Permittee's O&M Manual that conforms to the frequency recommended by the manufacturer.
4. Maintain calibration records for at least three years.

F. LABORATORY ACCREDITATION

1. The Permittee must ensure that all monitoring data required by Ecology for permit specified parameters is prepared by a laboratory registered or accredited under the provisions of chapter 173-50 WAC, *Accreditation of Environmental Laboratories.* Flow and internal process control parameters are exempt from this requirement.

G. REQUEST FOR REDUCTION IN MONITORING

1. The Permittee may request a reduction of the sampling frequency after twelve (12) months of monitoring by demonstrating that the distribution of

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[12] https://www.ecfr.gov/cgi-bin/text-idx?SID=0e534d17f9783994a26ffee684d260c2&mc=true&node=pt40.25.136&rgn=div5

[13] https://www.ecfr.gov/cgi-bin/text-idx?SID=0e534d17f9783994a26ffee684d260c2&mc=true&node=pt40.25.136&rgn=div5

[14] https://www.ecfr.gov/cgi-bin/text-idx?SID=0e534d17f9783994a26ffee684d260c2&mc=true&tpl=/ecfrbrowse/Title40/40CIsubchapN.tpl

[15] https://www.ecfr.gov/cgi-bin/text-idx?SID=0e534d17f9783994a26ffee684d260c2&mc=true&tpl=/ecfrbrowse/Title40/40CIsubchapO.tpl

concentrations can be accurately represented with a lower sampling frequency. Ecology will review each request and at its discretion grant the request in writing when it reissues the permit coverage or by a permit coverage modification.

2. The Permittee must:

   a. Provide a written request.

   b. Clearly state the parameters for which it is requesting reduced monitoring.

   c. Clearly state the justification for the reduction.

S8. DISCHARGES TO 303(D) OR TMDL WATER BODIES

If EPA approves an applicable ***Total Maximum Daily Load*** (TMDL) that includes wasteload allocations for WWTPs owned and operated by the Permittee Ecology will address any permit requirements related to the approved TMDL in the Permittee's individual permit or through a modification of this permit.

S9. REPORTING AND RECORDKEEPING REQUIREMENTS

A. DISCHARGE MONITORING REPORTS

Permittees required to conduct ***water quality*** sampling in accordance with Special Conditions S7, and/or G12 (Additional Monitoring) must submit the results to Ecology. Permittees must submit the monthly DMR by the 15th day of the following month.

Permittees must submit monitoring data using Ecology's WQWebDMR program.

B. MONITORING REQUIREMENTS

1. Wastewater Sampling Frequency

    a. The Permittee must sample both the influent and effluent discharge location at the frequencies listed in Condition S7.A, S7.B and S7.C.

    b. Samples must be representative of the flow and characteristics of the discharge.

    c. Sampling is not required outside of normal working hours or during unsafe conditions.

2. Wastewater Sampling Locations

    Influent and effluent sampling locations must be representative. Permittees may use the compliance monitoring locations in their individual NPDES permit, prior to entry into waters of the state.

3. Wastewater Sampling Documentation

    For each sample taken, the Permittee must record and retain the following information:

    a. Sample date and time

    b. Sample location

    c. Method of sampling, and method of sample preservation, if applicable

    d. Individual who performed the sampling

4. Where wastewater monitoring requirements under this Permit mirror requirements in a Permittee's individual permit, the same result may be applied to both permits.

5. Additional Monitoring by the Permittee

    If the Permittee monitors any ***pollutant*** more frequently than required by this permit using test procedures specified by Condition S7, the Permittee must include the results of the extra monitoring in the calculation and reporting of the data submitted in the Permittee's DMR.

C. ANNUAL REPORT FOR DOMINANT LOADERS

1. No later than March 31 of each year, each Permittee listed in Table 5 must submit an Annual Report documenting optimization and the adaptive management used at their WWTP. The Permittee must submit their first annual report by March 31, 2023 for the reporting period that begins on January 1, 2022 and lasts through December 31, 2022. All subsequent Annual Reports must use the reporting period of the previous calendar year unless otherwise specified.
2. Permittees must submit Annual reports electronically using Ecology's Water Quality Permitting Portal (WQWebPortal) available on Ecology's website, unless otherwise directed by Ecology.
3. The Annual Report documenting the Nutrient Optimization Plan for Permittees listed in Table 5 must include the following:
    a. Submittal of the Annual Report form as provided by Ecology pursuant to S4.C, describing the status of the requirements of this Permit during the reporting period.
    b. Attachments to the Annual Report including summaries, descriptions, reports and other information as required, or as applicable, to meet the requirements of this Permit during the reporting period, or as a required submittal. Refer to Appendix C for Annual Report questions.
    c. Certification and signature pursuant to G2.D and notification of any changes to authorization pursuant to G2.C.

D. ANNUAL REPORT FOR MODERATE LOADERS

1. No later than March 31 of each year, each Permittee listed in Table 8 must submit an Annual Report documenting optimization and the adaptive management used at their WWTP. The Permittee must submit their first annual report by March 31, 2023 for the reporting period that begins on January 1, 2022 and lasts through December 31, 2022. All subsequent Annual Reports must use the reporting period of the previous calendar year unless otherwise specified.
2. Permittees must submit Annual reports electronically using Ecology's Water Quality Permitting Portal (WQWebPortal) available on Ecology's website, unless otherwise directed by Ecology.
3. The Annual Report documenting the Nutrient Optimization Plan for Permittees listed in Table 8 must include the following:
    a. Submittal of the Annual Report form as provided by Ecology pursuant to S5.C, describing the status of the requirements of this Permit during the reporting period.
    b. Attachments to the Annual Report including summaries, descriptions, reports and other information as required, or as applicable, to meet the requirements of this Permit during the reporting period, or as a required submittal. Refer to Appendix D for Annual Report questions.

   c. Certification and signature pursuant to G2.D and notification of any changes to authorization pursuant to G2.C.

E. REPORTING FOR SMALL LOADERS

1. No later than March 31, 2026 each Permittee listed in Table 11 must submit an Optimization Report documenting optimization and the adaptive management used at their WWTP. The reporting period for this report will be from January 1, 2022 through December 31, 2025.
2. Permittees must submit the Nitrogen Optimization Report electronically using Ecology's Water Quality Permitting Portal (WQWebPortal) available on Ecology's website, unless otherwise directed by Ecology.
3. The electronic report documenting the optimization for Permittees listed in Table 11 must include the following:
   a. Submittal of the Optimization Report form as provided by Ecology pursuant to S6.B, describing the status of the requirements of this Permit during the reporting period.
   b. Attachments to the Optimization Report including summaries, descriptions, reports and other information as required, or as applicable, to meet the requirements of this Permit during the reporting period, or as a required submittal. Refer to Appendix E for Optimization Report questions.
   c. Certification and signature pursuant to G2.D and notification of any changes to authorization pursuant to G2.C.

F. RECORDS RETENTION

The Permittee must retain records of all monitoring information (field notes, sampling results, etc.), optimization documents submitted with the annual or one-time report, and any other documentation of compliance with permit requirements for a minimum of five years following the termination of permit coverage. Such information must include all calibration and maintenance records, and records of all data used to complete the application for this permit. This period of retention must be extended during the course of any unresolved litigation regarding the discharge of pollutants by the Permittee or when requested by Ecology.

G. NONCOMPLIANCE NOTIFICATION

In the event the Permittee is unable to comply with any of the terms and conditions of this permit which may cause a threat to human health or the environment, including threats resulting from unanticipated ***bypass*** or upset, or does not comply with the narrative effluent requirements, the Permittee must:

1. Immediately, in no case more than 24 hours of becoming aware of the circumstances, notify Ecology of the failure to comply by calling the applicable regional office phone number (find at Ecology' Report a Spill webpage[16]).
2. Immediately take action to prevent the discharge/***pollution***, or otherwise stop or correct the noncompliance.
3. Submit a written report to Ecology using the WQWebPortal within five (5) days of the time the Permittee becomes aware of a reportable event. The report must contain:
    a. A description of the noncompliance and its cause
    b. The period of noncompliance including exact dates and times
    c. If the noncompliance has not been corrected, the anticipated time it is expected to continue
    d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance

Ecology may waive the written report on a case-by-case basis upon request if the Permittee has submitted a timely oral report.

Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with the terms and conditions of this permit or the resulting liability for failure to comply. Refer to Section G13 of this permit for specific information regarding non-compliance.

H. ACCESS TO PLANS AND RECORDS

1. The Permittee must retain the following permit documentation (reports and monitoring records) on site, or within reasonable access to the site, for use by the operator or for on-site review by Ecology:
    a. Permit Coverage Letter
    b. Puget Sound Nutrient General Permit
    c. Discharge Monitoring Reports
    d. Attachments to the Annual or Single Report as required in the Nitrogen Optimization Plan (NOP)
    e. Nutrient Reduction Evaluation for Permittees listed in Tables 5 and 8 or AKART Analysis for Permittees listed in Table 11

S10. PERMIT FEES

The Permittee must pay permit fees assessed by Ecology. Fees for wastewater discharges covered under this permit are established by Chapter 173-224 WAC.

[16] https://ecology.wa.gov/About-us/Get-involved/Report-an-environmental-issue/Report-a-spill

GENERAL CONDITIONS

G1. DISCHARGE VIOLATIONS

All discharges and activities authorized by this general permit must be consistent with the terms and conditions of this general permit. Failure to follow the corrective action requirement after discharge of TIN at a level that exceeds the action level identified and authorized by the general permit constitutes a violation of the terms and conditions of this permit.

G2. SIGNATORY REQUIREMENTS

A. All permit applications must bear a certification of correctness to be signed:

1. In the case of corporations, by a responsible corporate officer;
2. In the case of a partnership, by a general partner of a partnership;
3. In the case of sole proprietorship, by the proprietor; or
4. In the case of a municipal, state, or other public facility, by either a principal executive officer or ranking elected official.

B. All reports required by this permit and other information requested by Ecology must be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

1. The authorization is made in writing by a person described above and submitted to Ecology.
2. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters.

C. Changes to authorization. If an authorization under paragraph G2.B.2 above is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph G2.B.2 above must be submitted to Ecology prior to or together with any reports, information, or applications to be signed by an authorized representative.

D. Certification. Any person signing a document under this section must make the following certification:

E. "I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

G3. RIGHT OF INSPECTION AND ENTRY

The Permittee must allow an authorized representative of Ecology, upon the presentation of credentials and such other documents as may be required by law:

A. To enter upon the premises where a discharge is located or where any records are kept under the terms and conditions of this permit.

B. To have access to and copy – at reasonable times and at reasonable cost -- any records required to be kept under the terms and conditions of this permit.

C. To inspect – at reasonable times – any facilities, equipment (including monitoring and control equipment), practices, methods, or operations regulated or required under this permit.

D. To sample or monitor – at reasonable times – any substances or parameters at any location for purposes of assuring permit compliance or as otherwise authorized by the ***Clean Water Act***.

G4. GENERAL PERMIT MODIFICATION AND REVOCATION

This permit may be modified, revoked and reissued, or terminated in accordance with the provisions of Chapter 173-226 WAC. Grounds for modification, revocation and reissuance, or termination include, but are not limited to, the following:

A. When a change occurs in the technology or practices for control or abatement of pollutants applicable to the category of dischargers covered under this permit.

B. When effluent limitation guidelines or standards are promulgated pursuant to the CWA or Chapter 90.48 RCW, for the category of dischargers covered under this permit.

C. When a water quality management plan containing requirements applicable to the category of dischargers covered under this permit is approved, or

D. When information is obtained that indicates cumulative effects on the environment from dischargers covered under this permit are unacceptable.

G5. REVOCATION OF COVERAGE UNDER THE PERMIT

Pursuant to Chapter 43.21B RCW and Chapter 173-226 WAC, the ***Director*** may terminate coverage for any discharger under this permit for cause. Cases where coverage may be terminated include, but are not limited to, the following:

A. Violation of any term or condition of this permit.

B. Obtaining coverage under this permit by misrepresentation or failure to disclose fully all relevant facts.

C. A change in any condition that requires either a temporary or permanent reduction or elimination of the permitted discharge.

D. Failure or refusal of the Permittee to allow entry as required in RCW 90.48.090.

E. A determination that the permitted activity endangers human health or the environment, or contributes to water quality standards violations.

F. Nonpayment of permit fees or penalties assessed pursuant to RCW 90.48.465 and Chapter 173-224 WAC.

G. Failure of the Permittee to satisfy the public notice requirements of WAC 173-226-130(5), when applicable.

G6. COMPLIANCE WITH OTHER LAWS AND STATUTES

Nothing in this permit will be construed as excusing the Permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations.

G7. DUTY TO REAPPLY

The Permittee must apply for permit renewal at least 180 days prior to the specified expiration date of this permit.

G8. TRANSFER OF GENERAL PERMIT COVERAGE

In the event of any change in control or ownership of facilities from which the authorized discharge emanate, the Permittee must follow the procedures listed in their individual NPDES permit when notifying Ecology.

G9. REMOVED SUBSTANCES

The Permittee must not re-suspend or reintroduce collected screenings, grit, solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewater to the final effluent stream for discharge to state waters.

G10. DUTY TO PROVIDE INFORMATION

The Permittee must submit to Ecology, within a reasonable time, all information that Ecology may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee must also submit to Ecology, upon request, copies of records required to be kept by this permit [40 CFR 122.41(h)].

G11. OTHER REQUIREMENTS OF 40 CFR

All other requirements of 40 CFR 122.41 and 122.42 are incorporated in this permit by reference.

G12. ADDITIONAL MONITORING

Ecology may establish specific monitoring requirements in addition to those contained in this permit by administrative order or permit modification.

G13. PENALTIES FOR VIOLATING PERMIT CONDITIONS

Any person who is found guilty of willfully violating the terms and conditions of this permit shall be deemed guilty of a crime, and upon conviction thereof shall be punished by a fine of up to ten thousand dollars ($10,000) and costs of prosecution, and/or by imprisonment in the discretion of the court. Each day upon which a willful violation occurs may be deemed a separate and additional violation.

Any person who violates the terms and conditions of a waste discharge permit shall incur, in addition to any other penalty as provided by law, a civil penalty in the amount of up to ten thousand dollars ($10,000) for every such violation. Each and every such violation shall be a separate and distinct offense, and in case of a continuing violation, every day's continuance shall be deemed to be a separate and distinct violation.

G14. PROPERTY RIGHTS

This permit does not convey any property rights of any sort, or any exclusive privilege.

G15. DUTY TO COMPLY

The Permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

G16. TOXIC POLLUTANTS

The Permittee must comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if this permit has not yet been modified to incorporate the requirement.

G17. PENALTIES FOR TAMPERING

The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two years per violation, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this condition, punishment shall be a fine of not more than $20,000 per day of violation, or imprisonment of not more than four (4) years, or both.

G18. REPORTING PLANNED CHANGES

Report planned changes in a manner consistent with the individual permit.

G19. REPORTING OTHER INFORMATION

Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to Ecology, it must promptly submit such facts or information.

G20. REPORTING ANTICIPATED NON-COMPLIANCE

The Permittee must give advance notice to Ecology by submission of a new application or supplement thereto at least one hundred and eighty (180) days prior to commencement of such discharges, of any facility expansions, or other planned changes, such as process modifications, in the permitted facility which may result in noncompliance with permit limits or conditions. Any maintenance of facilities, which might necessitate unavoidable interruption of operation and degradation of effluent quality, must be scheduled during non-critical water quality periods and carried out in a manner approved by Ecology.

G21. APPEALS

A. The terms and conditions of this general permit, as they apply to the appropriate class of dischargers, are subject to appeal by any person within 30 days of issuance of this general permit, in accordance with Chapter 43.21B RCW, and Chapter 173-226 WAC.

B. The terms and conditions of this general permit, as they apply to an individual discharger, are appealable in accordance with Chapter 43.21B RCW within 30 days of the effective date of coverage of that discharger. Consideration of an appeal of general permit coverage of an individual discharger is limited to the general permit's applicability or nonapplicability to that individual discharger.

C. The appeal of general permit coverage of an individual discharger does not affect any other dischargers covered under this general permit. If the terms and conditions of this general permit are found to be inapplicable to any individual discharger(s), the matter shall be remanded to Ecology for consideration of issuance of an individual permit or permits.

G22. SEVERABILITY

The provisions of this permit are severable, and if any provision of this permit, or application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

G23. BYPASS PROHIBITED

This permit prohibits a bypass, which is the intentional diversion of waste streams from any portion of a treatment facility.

See bypass prohibitions included in each jurisdiction's individual NPDES permit.

APPENDIX A – DEFINITIONS

303(d) Listed Waters means waterbodies listed as Category 5 on Washington State's Water Quality Assessment.

Action Level means an indicator value used to determine the effectiveness of best management practices at a WWTPs. Action levels are not water quality criteria or effluent limits by themselves but indicators of treatment optimization.

Adaptive Management means the process of incorporating new information into optimization implementation to ensure effective attainment of documented goals or the facility specific action level.

AKART means acronym for "all known, available, and reasonable methods of prevention, control, and treatment." AKART represents the most current methodology that can be reasonably required for preventing, controlling, or abating the pollutants and controlling pollution associated with a discharge.

Alternative Restoration Plan means a near-term plan, or description of actions, with a schedule and milestones, that is more immediately beneficial or practicable to achieving water quality standards.

Applicant means an owner or **operator in responsible charge** seeking coverage under this permit**.**

Best Management Practices (BMPs) means schedules of activities, prohibitions of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce the pollution of waters of the State.

Bubbled action level means the sum of individual action levels for all WWTPs in the same discharger category under a single jurisdiction's ownership.

Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

Day means a period of 24 consecutive hours.

Clean Water Act (CWA) means the Federal Water Pollution Control Act enacted by Public Law 92-500, as amended by Public Laws 95-217, 95-576, 96-483, and 97-117; USC 1251 et seq.

Composite (also **Composite Sample)** means a mixture of grab samples collected at the same sampling point at different times, formed either by continuous sampling or by mixing discrete samples. May be "time-composite" (collected at constant time intervals) or "flow-proportional" (collected either as a constant sample volume at time intervals proportional to stream flow, or collected by increasing the volume of each aliquot as the flow increases while maintaining a constant time interval between the aliquots.

Director means the Director of the Washington Department of Ecology or his/her authorized representative.

Discharger means an owner or operator of any facility or activity subject to regulation under Chapter 90.48 RCW or the Federal Clean Water Act.

Domestic Wastewater means water carrying human wastes, including kitchen, bath, and laundry wastes from residences, buildings, industrial establishments, or other places, together with such ground water infiltration or surface waters as may be present.

Dominant loader means domestic WWTPs discharging more than 2,000 lbs/day TIN. Cumulatively, dominant loaders constitute > 80% of the domestic point source TIN load.

Ecology means the Washington State Department of Ecology.

Ground Water means water in a saturated zone or stratum beneath the land surface or a surface water body.

Greater Puget Sound Region means the marine area where human nutrient loads, from Washington Waters of the Salish Sea, contribute to waters not meeting marine DO standards. The GPS region include the Northern Bays (Bellingham, Samish, and Padilla Bays) as well as Puget Sound Proper, which are the marine waters south of the entrance of Admiralty Inlet (Whidbey Basin, Main Basin, South Sound, and Hood Canal).

Moderate loader means a domestic WWTP discharging between 100 and 2,000 lbs/day TIN. Cumulatively, moderate loaders constitute roughly 19 % of the domestic point source TIN load.

National Pollutant Discharge Elimination System (NPDES) means the national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the State from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington Department of Ecology.

Notice of Intent (NOI) means the application for, or a request for coverage under this general permit pursuant to WAC 173-226-200.

Operator means any individual who performs routine duties, onsite at a wastewater treatment plant that affect plant performance or effluent quality.

Operator in Responsible Charge means the individual who is designated by the owner as the person routinely onsite and in direct charge of the overall operation and maintenance of a wastewater treatment plant.

Optimization (also treatment optimization) means a best management practice (BMP) resulting in the refinement of WWTP operations that lead to improved effluent water quality and/or treatment efficiencies.

Outfall means the location where the site's wastewater discharges to surface water.

Overburdened community means a geographic area where vulnerable populations face combined, multiple environmental harms and health impacts, and includes, but is not limited to, highly impacted communities as defined in RCW 19.405.020.

Owner means a town or city, a county, a sewer district, board of public utilities, association, municipality or other public body.

Permittee means an entity that receives notice of coverage under this general permit.

Point source means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, and container from which pollutants are or may be discharged to surface waters of the State. This term does not include return flows from irrigated agriculture.

Pollutant means dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, domestic sewage sludge (biosolids), munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste.

Pollution means contamination or other alteration of the physical, chemical, or biological properties of waters of the State; including change in temperature, taste, color, turbidity, or odor of the waters; or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the State as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare; or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses; or to livestock, wild animals, birds, fish or other aquatic life.

Receiving water means the water body at the point of discharge. If the discharge is to a storm sewer system, either surface or subsurface, the receiving water is the water body to which the storm system discharges. Systems designed primarily for other purposes such as for ground water drainage, redirecting stream natural flows, or for conveyance of irrigation water/return flows that coincidentally convey stormwater are considered the receiving water.

Representative sample (also **representative sampling**) means a wastewater sample which represents the flow and characteristics of the discharge. Representative samples may be a grab sample, a time-proportionate **composite sample**, or a flow proportionate sample.

Salish Sea means Puget Sound, Strait of Georgia, and Strait of Juan de Fuca, including their connecting channels and adjoining waters.

SEPA (State Environmental Policy Act) means the Washington State Law, RCW 43.21C.020, intended to prevent or eliminate damage to the environment.

Septage means, for the purposes of this permit, any liquid or semisolid removed from a septic tank, cesspool, vault toilet or similar source which concentrates wastes or to which chemicals have been added.

Site means the land where any "facility" is physically located.

Small Loader means a domestic WWTP discharging less than 100 lbs/day TIN. Cumulatively, small loaders constitute < 1% of the domestic point source TIN load.

Surface Waters of the State includes lakes, rivers, ponds, streams, inland waters, salt waters, and all other surface waters and water courses within the jurisdiction of the state of Washington.

Total Inorganic Nitrogen (TIN) means the sum of ammonia, nitrate, and nitrite. It includes dissolved and particulate fractions.

Total Maximum Daily Load (TMDL) means a calculation of the maximum amount of a pollutant that a water body can receive and still meet state water quality standards. Percentages of the total maximum daily load are allocated to the various pollutant sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The TMDL calculations must include a "margin of safety" to ensure that the water body can be protected in case there are unforeseen events or unknown sources of the pollutant. The calculation must also account for seasonable variation in water quality.

Washington Waters of the Salish Sea means areas of the Salish Sea subject to Washington State's Water Pollution Control Act (Chapter 90.48 RCW)

Wasteload Allocation (WLA) means the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality based effluent limitation (40 CFR 130.2[h]).

Water quality means the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose.

Waters of the State includes those waters as defined as "waters of the United States" in 40 CFR Subpart 122.2 within the geographic boundaries of Washington State and "waters of the State" as defined in Chapter 90.48 RCW, which include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and water courses within the jurisdiction of the state of Washington.

Week (same as **Calendar Week**) means a period of seven consecutive days starting at 12:01 a.m. (0:01 hours) on Sunday.

APPENDIX B – ACRONYMS

AKART	All Known, Available, and Reasonable Methods of Prevention, Control, and Treatment
BMP	Best Management Practice
CFR	Code of Federal Regulations
CWA	Clean Water Act
DIN	Dissolved Inorganic Nitrogen
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
FR	Federal Register
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NRP	Nutrient Reduction Plan
PSNF	Puget Sound Nutrient Forum
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
TBEL	Technology Based Effluent Limit
TIN	Total Inorganic Nitrogen
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WAC	Washington Administrative Code
WQ	Water Quality
WQBEL	Water Quality Based Effluent Limit
WWTP	Wastewater Treatment Plant

APPENDIX C – ANNUAL REPORT QUESTIONS FOR DOMINANT LOADERS

Permittees are required to submit annual reports online, pursuant to Special Condition S9.C.

1. Did your facility stay below the Action Level in S4.b, Table 5 or Table 6 for the jurisdiction with a bubbled action level? (S4.C.2.b.i)
    a. Attach a document listing the contribution of each of your individual facilities to the total bubble allocation for the reporting period. (S4.C.2.b.i)
2. Did your facility stay below a 10 mg/L annual average TIN concentration? (S4.C.2.b.i) (**If Q1 =Y and Q2 = Y, then no further questions).**
3. **Attach** a document describing the assessment method applied to evaluate the existing treatment process. (S4.C.1.a)
4. What is your pre-optimization TIN removal rate, expressed as a percentage? (S4.c.1.a.i)
5. **Attach** a document explaining your initial approach for optimization. (S4.C.1.a)
6. Did you maintain and/or update your assessment approach after year 1?(S4.C.1.a.ii)
7. Do viable optimization strategies exist for your current treatment process? (S4.C.1.b)
8. Did all of the potential optimization strategies you identified and evaluated for S4.C.1.b have a reasonable implementation cost and timeframe? (S4.C.1.b)
9. ATTACH a document describing your preferred optimization strategy for implementation in 2022 (due July 1) (S4.C.1.c)
10. What is the expected performance for the selected optimization strategy? (S4.C.1.c**)**
11. **Attach** a document describing optimization plan implementation including start date, schedule for full implementation, initial costs, and challenges including impacts to other measures of treatment plant performance. (S4.C.2.a)
12. What TIN removal rate was observed during the reporting period? (S4.C.2.b.ii)
13. **Attach** a document describing your ongoing investigations to reduce influent TIN loads from septage handling practices, commercial, dense residential and industrial sources. (S4.C.3.a, S4.C.3.b)
14. **(If Q1=N and Q7 = Y) Attach** document including: factors causing the WWTP to not meet the optimization goal, whether modifications to the strategy could improve performance, and whether a different strategy or combination of strategies may be more appropriate. Also, document changes to the optimization strategy either through the selection of the new optimization strategy and new performance metric or existing implementation refinement. Revise the expected performance if electing to keep the existing strategy. Provide rationale for no changes if Permittee proposes no changes to the optimization strategy (S4.D.1.a and S4.D.1.b)
15. **(If Q1 = No and Q7 = No) Attach** abbreviated engineering report or technical memo (due 12 months after documenting action level exceedance or determination that no optimization strategies exist). (S4.D.2)

16. **(If Q1 = No in two prior years)** Did you implement the Engineering Report as planned, starting after Ecology's approval? (S4.D.2.a)
17. Did you submit the required Nutrient Reduction Evaluation on or before 12/31/2026? If no, **date** the document was or will be provided. (S4.E)
18. Did you submit discharge monitoring reports according to the required schedule? If no, **attach** a document describing/listing the missing records and corrective actions taken/or planned. (S7, S9.A)
19. Are you retaining all applicable records? If no, **attach** a document describing/listing the missing records and corrective actions taken and/or planned. (S9.F)
20. Did you follow non-compliance notification requirements? If no, **attach** a document describing the non-compliance and the corrective actions taken and/or planned. (S9.G)

APPENDIX D – ANNUAL REPORT QUESTIONS FOR MODERATE LOADERS

Permittees are required to submit annual reports online, pursuant to Special Condition S9.D.

1. Did your facility stay below the Action Level in S5.b, Table 8 or Table 9 for the jurisdiction with a bubbled action level? (S5.C.2.b.i)
    a. Attach a document listing the contribution of each of your individual facilities to the total bubble allocation for the reporting period. (S5.C.2.b.i)
2. Did your facility stay below a 10 mg/L annual average TIN concentration? (S5.C.2.b.i) (**If Q1 =Y and Q2 = Y, then no further questions).**
3. **Attach** a document describing the assessment method applied to evaluate the existing treatment process. (S5.C.1.a)
4. What is your pre-optimization TIN removal rate, expressed as a percentage? (S5.c.1.a.i)
5. **Attach** a document explaining your initial approach for optimization. (S5.C.1.a)
6. Did you maintain and/or update your assessment approach after year 1?(S5.C.1.a.ii)
7. Do viable optimization strategies exist for your current treatment process? (S5.C.1.b)
8. Did all of the potential optimization strategies you identified and evaluated for S5.C.1.b have a reasonable implementation cost and timeframe? (S5.C.1.b)
9. ATTACH a document describing your preferred optimization strategy for implementation in 2022 (selection due July 1) (S5.C.1.c)
10. What is the expected performance for the selected optimization strategy? (S5.C.1.c**)**
11. **Attach** a document describing optimization plan implementation including start date, schedule for full implementation, initial costs, and challenges including impacts to other measures of treatment plant performance. (S5.C.2.a)
12. What TIN removal rate was observed during the reporting period? (S5.C.2.b.ii)
13. **Attach** a document describing your ongoing investigations to reduce influent TIN loads from septage handling practices, commercial, dense residential and industrial sources. (S5.C.3.a, S5.C.3.b)
14. **(If Q1=N and Q7 = Y) Attach** document including: factors causing the WWTP to not meet the optimization goal, whether modifications to the strategy could improve performance, and whether a different strategy or combination of strategies may be more appropriate. Also, document changes to the optimization strategy either thorough the selection of the new optimization strategy and new performance metric or existing implementation refinement. Revise the expected performance if electing to keep the existing strategy. Provide rationale for no changes if Permittee proposes no changes to the optimization strategy (S5.D.1.a and S5.D.1.b)
15. **(If Q1 = No and Q7 = No) Attach** abbreviated engineering report or technical memo (due 12 months after documenting action level exceedance or determination that no optimization strategies exist). (S5.D.2)

16. **(If Q1 = No in two prior years)** Did you implement the Engineering Report as planned, starting after Ecology's approval? (S5.D.2.a)
17. Did you submit the required Nutrient Reduction Evaluation on or before 12/31/2026? If no, **date** the document was or will be provided. (S5.E)
18. Did you submit discharge monitoring reports according to the required schedule? If no, **attach** a document describing/listing the missing records and corrective actions taken/or planned. (S7, S9.A)
19. Are you retaining all applicable records? If no, **attach** a document describing/listing the missing records and corrective actions taken and/or planned. (S9.F)
20. Did you follow non-compliance notification requirements? If no, **attach** a document describing the non-compliance and the corrective actions taken and/or planned. (S9.G)

APPENDIX E – ONE TIME REPORT QUESTIONS FOR SMALL LOADERS

Permittees are required to submit the single report online, pursuant to Special Condition S9.E.

1. **Attach** a document describing your initial assessment process, your optimization goal, the list of prioritized optimization strategies identified, and the strategy implemented in 2022 (S6.B.1.b). If any optimization strategies were found to not have a reasonable implementation cost or timeframe (S6.B.2.a.iv), include description of the feasibility and cost analysis that led to exclusion of any approach(es). (S6.B.1.a, S6.B.1.b)
2. Did your plant meet or exceed the pre-optimization empirical TIN removal rate in each year of this permit and also maintain or reduce TIN loads? If no, **attach** a document describing how you revised your optimization strategy in response to the evaluation in each of the prior permit years, and document your adaptive management steps, your assessment process, and the new optimization strategy or strategies you identified, and your updated optimization goal(s) and performance metric(s). (S6.B.2.b.ii, S6.B.2.c)
3. Did your facility stay below a 10 mg/L annual average TIN concentration? (S6.B.2.b.i) (**If Q2 =Y and Q3 = Y, then no further questions)**
4. What is your pre-optimization empirical TIN removal rate? (S6.B.1.a.i)
5. Did you maintain you reassessment approach after year 1? If no, **attach** a document describing assessment revisions that occurred each year over the permit term. (S6.B.1.a.ii)
6. What is your expected TIN removal with the preferred optimization strategy? (S6.B.1.b)
7. **Attach** a document describing optimization implementation including costs, time for full implementation, start date, challenges, and impacts to treatment performance. (S6.B.2.a)
8. What was the TIN removal rate observed each year during the reporting period? (S6.B.2.b.ii)
9. **Attach** a document describing your ongoing investigations to reduce influent TIN loads from septage handling practices, commercial, dense residential and industrial sources. (S6.B.3)
10. Did you submit the required AKART analysis on or before 12/31/2025? If no, **date** document was or will be provided. (S6.C)
11. Did you submit discharge monitoring reports according to the required schedule? If no, **attach** a document describing the missed monitoring activities and the corrective action taken. (S7, S9.A)
12. Are you retaining all applicable records? If no, **attach** a document descripting the missing records and the corrective action taken and/or planned. (S9.F)
13. Did you follow non-compliance notification requirements? If no, **attach** a document describing the non-compliance and the corrective actions taken and/or planned. (S9.G)

Appendix B

Existing WWTP Design Criteria and Hydraulic Profile

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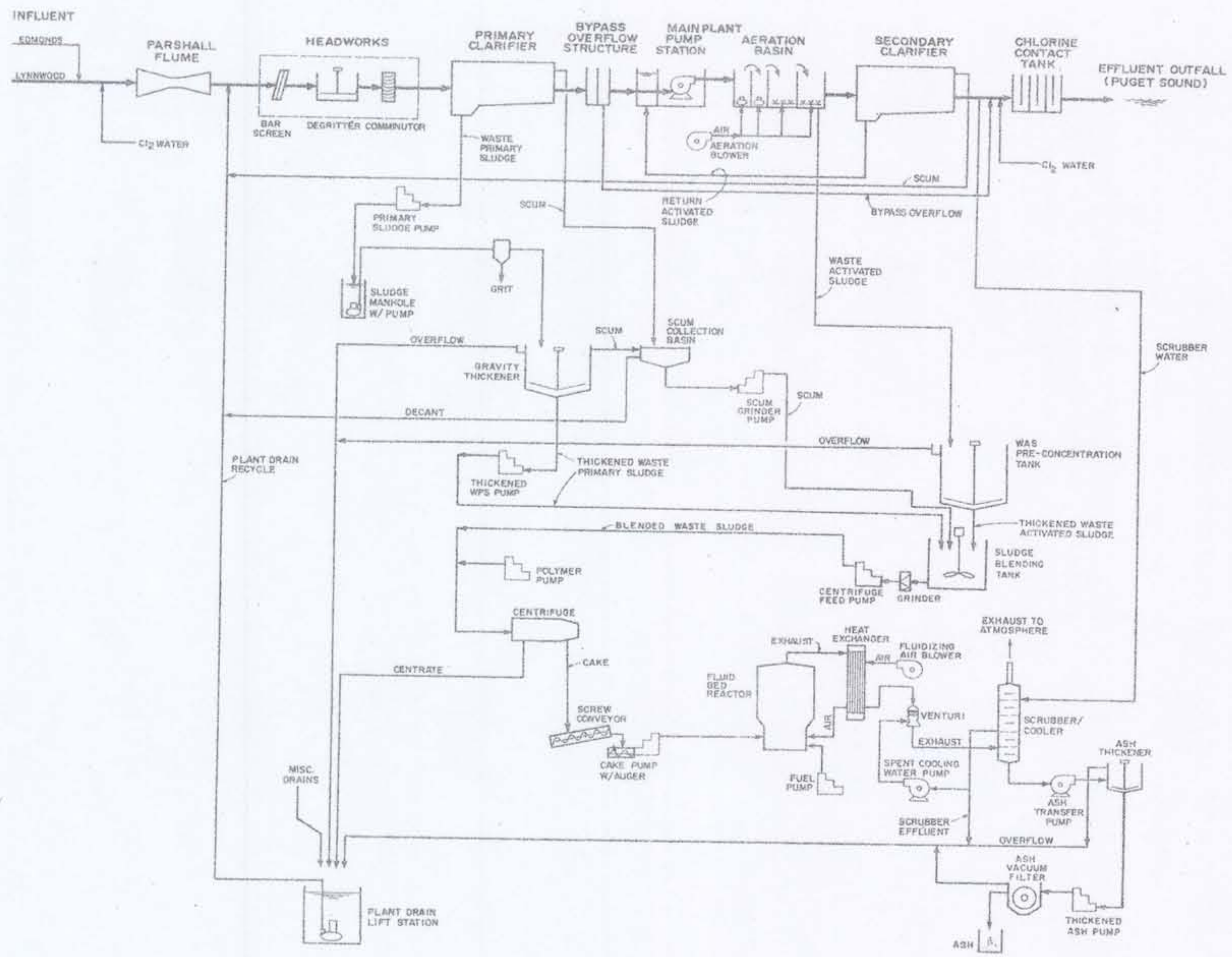
PROCESS SCHEMATIC



DESIGN CRITERIA & PLANT DATA

DESIGN YEAR	2010	DESIGN FLOW	7.4 MGD
STARTUP YEAR	1991	STARTUP FLOW	3.9 MGD

PLANT LOADINGS

	STARTUP YEAR	DESIGN YEAR
FLOW		
ANNUAL AVERAGE	3.9 MGD	5.4 MGD
MAXIMUM MONTH AVERAGE	5.4 MGD	7.4 MGD
PEAK	9.8 MGD	13.6 MGD
ORGANIC LOADING (MAX. MONTH AVERAGE)		
5-DAY BIOCHEMICAL OXYGEN DEMAND	9,458 LB/DAY	12,960 LB/DAY
TOTAL SUSPENDED SOLIDS	9,458 LB/DAY	12,960 LB/DAY

MECHANICAL BAR RAKE (EXISTING)

QUANTITY	1
GRID SIZE	48" W X 62" L X 36" H
GRID ANGLE	45 DEGREES
BAR SIZE	1/4" X 1-1/2" - 1" O.C.
CONVEYOR SIZE	48" W X 8' L

INFLUENT FLOW METER

QUANTITY	1
TYPE	PARSHALL FLUME
THROAT WIDTH	30"
CAPACITY, MGD	31

COMMINUTOR (EXISTING)

QUANTITY	1
TYPE	DRUM
DRUM DIA.	25"
SLOT WIDTH	3/8"

BYPASS BAR SCREEN (EXISTING)

QUANTITY	1
GRID SIZE	36" W X 42" L X 36" H
GRID ANGLE	60 DEGREES
BAR SIZE	1/2" DIA. - 2-1/2" O.C.

DEGRITTER (EXISTING)

QUANTITY	1
TYPE	PISTA GRIT
DIAMETER	12 FT.
DEPTH	12 FT.

EFFLUENT FLOW METER

QUANTITY	1
TYPE	SONIC
THROAT DIAMETER	30"
CAPACITY, MGD	25

DESIGN CRITERIA & PLANT DATA (CONT'D)

		STARTUP FLOW (3.9 MGD)	DESIGN ANNUAL AVERAGE FLOW (5.4 MGD)	DESIGN MAX. MONTH FLOW (7.4 MGD)	DESIGN PEAK FLOW (13.6 MGD)
RECTANGULAR PRIMARY CLARIFIER (EXISTING)					
QUANTITY	3				
SIZE	15' W X 105' L				
SETTLING AREA/UNIT	1,600 FT²				
SIDE WATER DEPTH	8.5 FT				
VOLUME/UNIT	107,000 GAL				
HYDRAULIC LOADING/UNIT, MGD		1.33*	1.37	1.88	3.45
SURFACE LOADING RATE/UNIT, GPD/FT²		790*	815	1,115	2,050
DETENTION TIME/UNIT, HR		1.9*	1.9	1.4	0.8
WEIR LENGTH/UNIT	179 FT				
WEIR LOADING RATE/UNIT, GPD/LF		7,410*	7,640	10,480	19,250
SLUDGE COLLECTOR SIZE	15'-6" W X 110' L	(*FOR TWO UNITS)			
SCREW CONVEYOR SIZE	10" DIA. X 15' L				
CIRCULAR PRIMARY CLARIFIER (MODIFIED EXISTING)					
QUANTITY	1				
SIZE	45 FT. DIA				
SETTLING AREA	1,590 FT²				
SIDE WATER DEPTH	12.5 FT				
VOLUME	149,000 GAL				
HYDRAULIC LOADING, MGD		1.25	1.30	1.78	3.27
SURFACE LOADING RATE, GPD/FT²		790	815	1,115	2,050
DETENTION TIME, HR		2.9	2.8	2.0	1.1
WEIR LENGTH	134 FT				
WEIR LOADING RATE, GPD/LF		9,310	9,670	13,250	24,370
SLUDGE COLLECTOR SIZE	45 FT DIA				
MAIN PLANT PUMP STATION					
QUANTITY OF PUMPS	4				
TYPE OF PUMP	DRY PIT, NON-CLOG, CENTRIFUGAL				
CAPACITY/PUMP @ TDH	4,600 GPM @ 48 FT.				
HORSEPOWER	75				
VOLUME OF WET WELL	20,000 GAL				
AERATION BASINS					
QUANTITY	3				
SIDE WATER DEPTH	24 FT				
VOLUME/UNIT	309,000 GAL				
DETENTION TIME, HR.		3.8*	4.1	3.0	2.2**
MLSS CONCENTRATION, MG/L		3,000	3,500	3,500	---
F:M RATIO		0.42*	0.26	0.36	---
SOLIDS RETENTION TIME, DAYS		4.5*	5.4	3.7	---
		(*FOR TWO BASINS)		(** @ 10 MGD)	
QUANTITY OF CELLS/BASIN	4				
VOLUME OF CELL NO. 1	19,500 GAL				
VOLUME OF CELL NO. 2	19,500 GAL				
VOLUME OF CELL NO. 3	212,500 GAL				
VOLUME OF CELL NO. 4	57,500 GAL				
OXYGEN REQ./CELL NO. 1, LB/HR		10*	10	11	13**
OXYGEN REQ./CELL NO. 2, LB/HR		10*	10	11	13**
OXYGEN REQ./CELL NO. 3, LB/HR		260*	250	330	400**
OXYGEN REQ./CELL NO. 4, LB/HR		50*	50	60	90**
		(* FOR TWO BASINS)		(** @ 10 MGD)	
AERATION BLOWERS					
QUANTITY	3				
TYPE	MULTI STAGE CENTRIFUGAL				
CAPACITY/UNIT	2,500 CFM				
DISCHARGE PRESSURE	12 PSIG				
STAGES	8				
HORSEPOWER	200				
SECONDARY CLARIFIERS					
QUANTITY	4				
SIZE	24' W X 120' L				
SETTLING AREA/UNIT	2,880 FT²				
SIDE WATER DEPTH	14 FT				
VOLUME/UNIT	302,000 GAL				
SURFACE LOADING RATE/UNIT, GPD/FT²		650*	625**	640	870***
DETENTION TIME/UNIT, HR		3.7	4.0	3.9	2.9***
WEIR LENGTH/UNIT	320 FT				
WEIR LOADING RATE/UNIT, GPD/LF		6,095*	5,625**	5,780	7,810***
SLUDGE COLLECTOR SIZE	23'-6" W X 120' L	(*FOR TWO UNITS, **FOR THREE UNITS, ***@ 10 MGD)			
SCREW CONVEYOR SIZE	10" DIA. X 24' L				
CHLORINE CONTACT TANK (MODIFIED EXISTING)					
OVERALL SIZE	42' W X 56' L				
SIDE WATER DEPTH	20 FT				
VOLUME	326,000 GAL				
QUANTITY OF CELLS	2				
DETENTION TIME (2 CELLS), MIN		120	87	63	34
AERATION	100 CFM @ 10 PSIG				
CHLORINATION SYSTEM (EXISTING)					
QUANTITY OF CHLORINATORS	2				
CAPACITY/UNIT	2,000 LB/DAY				
CHLORINE CONTAINER	6 @ 1-TON EA				
CHLORINE DOSAGE	5 MG/L				
CHLORINE FEED RATE, LB/DAY Cl_2		163	225	308	567
OUTFALL & DIFFUSER (EXTENDED EXISTING)					
PIPE DIA	36"				
DIFFUSER LENGTH	240 FT				
QUANTITY OF DIFFUSER PORTS	80				
DIA. OF DIFFUSER PORTS	3 - 4"				
DIFFUSER VELOCITY, FT/SEC		0.92	1.28	1.75	3.2
PLANT DRAIN LIFT STATION (MODIFIED EXISTING)					
QUANTITY OF PUMPS	2				
TYPE OF PUMP	SUBMERSIBLE				
CAPACITY/PUMP @ TDH	620 GPM @ 70' TDH				
HORSEPOWER	25				
VOLUME OF WET WELL	2,300 GAL				

		STARTUP FLOW (3.9 MGD)	DESIGN ANNUAL AVERAGE FLOW (5.4 MGD)	DESIGN MAX. MONTH FLOW (7.4 MGD)	DESIGN PEAK FLOW (13.6 MGD)
PRIMARY SLUDGE PUMPS (EXISTING)					
QUANTITY	4				
TYPE	AIR-OPERATED DIAPHRAGM				
CAPACITY/UNIT @ TDH	50 GPM @ 45' TDH				
AIR REQUIREMENTS	35 CFM @ 40 PSIG				
GRAVITY THICKENER (EXISTING)					
QUANTITY	1				
SETTLING AREA	450 FT²				
SIDE WATER DEPTH	11 FT				
VOLUME	37,000 GAL				
SURFACE LOADING RATE, GPD/FT²		245	340	440	---
SOLIDS LOADING RATE, PPD/FT²		10	14	18	---
DETENTION TIME, HR		8.1	5.8	4.4	---
UNDERFLOW SOLIDS CONC.	8%				
THICKENED WPS PUMPS (EXISTING)					
QUANTITY	2				
TYPE	PROGRESSING CAVITY				
CAPACITY/UNIT @ TDH	35 GPM @ 25 FT				
HORSEPOWER	2				
WAS PRE-CONCENTRATION TANK					
QUANTITY	1				
SIZE	20 FT. SQ.				
SETTLING AREA	400 FT²				
SIDE WATER DEPTH	15 FT				
VOLUME	45,000 GAL				
SURFACE LOADING RATE, GPD/FT²		275	415	515	---
SOLIDS LOADING RATE, GPD/FT²		7	10	15	---
DETENTION TIME, HR		9.8	6.5	5.2	---
UNDERFLOW SOLIDS CONC.	1.5%				
CENTRIFUGE FEED PUMPS					
QUANTITY	2				
TYPE	PROGRESSING CAVITY				
CAPACITY/PUMP @ TDH	65 GPM @ 5' TDH				
HORSEPOWER	5				
SLUDGE HANDLING MANHOLE (EXISTING)					
QUANTITY OF PUMPS	2				
TYPE OF PUMP	SUBMERSIBLE				
CAPACITY/PUMP @ TDH	206 GPM @ 30 FT				
HORSEPOWER	5				
VOLUME OF WET WELL	1,000 GAL				
SCUM COLLECTION BASIN					
QUANTITY OF PUMPS	1				
TYPE OF PUMP	CENTRIFUGAL CHOPPER				
CAPACITY/PUMP @ TDH	100 GPM @ 30' TDH				
HORSEPOWER	5				
VOLUME OF SCUM TANK	1,100 GAL				
CENTRIFUGE					
QUANTITY	2				
CAPACITY/UNIT	940 LB/HR				
HYDRAULIC LOADING, GPM (24-HR BASIS)		19	29	41	---
SOLIDS LOADING, LB/HR (24-HR BASIS)		300	430	585	---
SOLIDS FEED CONC., % D.S.		3.2	3.0	2.85	---
POLYMER DOSAGE	12 LB/TON D.S.				
MAIN DRIVE HORSEPOWER	100				
BACK DRIVE HORSEPOWER	40				
BOWL SIZE	24" DIA X 72" L				
BOWL SPEED, RPM	2,500				
DISCHARGE SCREW CONVEYOR	12" DIA X 30' L				
POLYMER SYSTEM					
QUANTITY OF TANKS	2				
SIZE/TANK	6' DIA X 6' H				
VOLUME/TANK	1,200 GAL				
AGING CONCENTRATION	0.5%				
FEED CONCENTRATION	0.25%				
POLYMER USAGE, LB/DAY	84	43	62	84	---
DRY POLYMER FEEDER CAPACITY	200 LB/HR				
POLYMER METERING PUMP RATING	3 GPM @ 25 FT TDH				
SLUDGE CAKE PUMPS					
QUANTITY	2				
TYPE	PISTON				
CAPACITY/UNIT @ TDH	10 GPM @ TDH				
HORSEPOWER/PUMP	30				
FLUID BED INCINERATION SYSTEM					
QUANTITY OF REACTORS	1				
CAPACITY/REACTOR	860 LB/HR D.S.				
REACTOR SIZE	9.5 FT. DIA				
SOLIDS LOADING, LB/DAY		6,650	9,560	13,050	---
FEED SOLIDS CONC.	28% T.S.				
FEED VOLATILE SOLIDS CONTENT	10,000 BTU/LB V.S.				
FEED SLUDGE FUEL VALUE 10^6 BTU/DAY		49.9	71.7	97.9	---
FLUIDIZING AIR BLOWER RATING	1500 SCFM @ 5 PSIG				
ATOMIZING BLOWER RATING	700 SCFM @ 1.5 PSIG				
REHEAT BLOWER RATING	8,000 SCFM				
PREHEATER (HEAT EXCHANGER) SIZE	1.0×10^6 BTU/HR				
PREHEATER TEMPERATURE	1,000 °F				
VENTURI PRESSURE DROP	30 IN. H_2O				
COOLING SCRUBBER SIZE	4 TRAY				
ASH THICKENER SIZE	10 FT. DIA				
ASH VACUUM FILTER SIZE	3 FT. DIA				
SLUDGE BLENDING TANK					
QUANTITY	1				
SIZE	10 FT. SQ.				
SIDE WATER DEPTH	10.5 FT				
VOLUME	7,850 GAL				
DETENTION TIME, HR		2.3	2.1	2.0	---
BLENDED SOLIDS CONC.	2.5 - 3%				
MIXER HP	2				

Gray & Osborne, Inc., P.S.
CONSULTING ENGINEERS
YAKIMA — SEATTLE — TACOMA
WASHINGTON

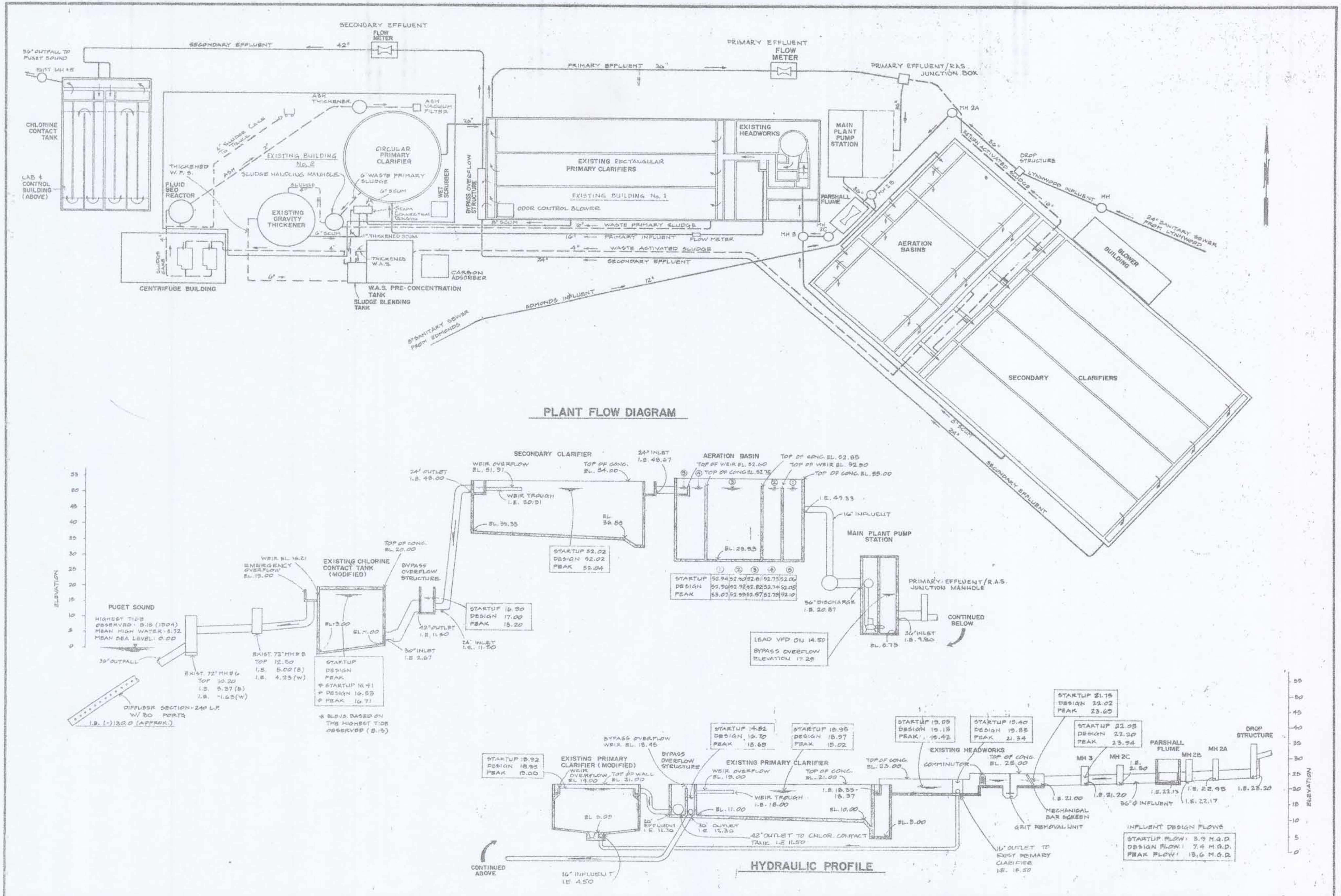
DATE DEC. 1988
SCALE NONE
DRAWN V.K.
CHECKED J.P.W.
APPROVED A.R.V.

No	REVISION	DATE	APPD

ANTHONY R. VIVOLO — REGISTERED PROFESSIONAL ENGINEER, STATE OF WASHINGTON
JOHN P. WILSON — PROFESSIONAL ENGINEER

CITY OF LYNNWOOD
SNOHOMISH COUNTY — WASHINGTON
Wastewater Treatment Facility
PROCESS SCHEMATIC & DESIGN CRITERIA

SHEET G-4
OF 30
FILE No
JOB No



Gray & Osborne, Inc., P.S.
CONSULTING ENGINEERS
YAKIMA — SEATTLE — TACOMA, WASHINGTON

DATE DEC. 1988

CITY OF LYNNWOOD
SNOHOMISH COUNTY, WASHINGTON
Wastewater Treatment Facility
FLOW DIAGRAM AND HYDRAULIC PROFILE

SHEET G-5
OF 30

Appendix C

Exhibits

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EXHIBIT C-1: EXISTING SITE AERIAL

FACILITY PLAN FOR LYNNWOOD WWTP

RH2

LYNNWOOD
WASHINGTON

SCALE:NTS

0" 1" 2"

DRAWING IS FULL SCALE WHEN BAR MEASURES 1"

PLOT DATE: 3/4/2022

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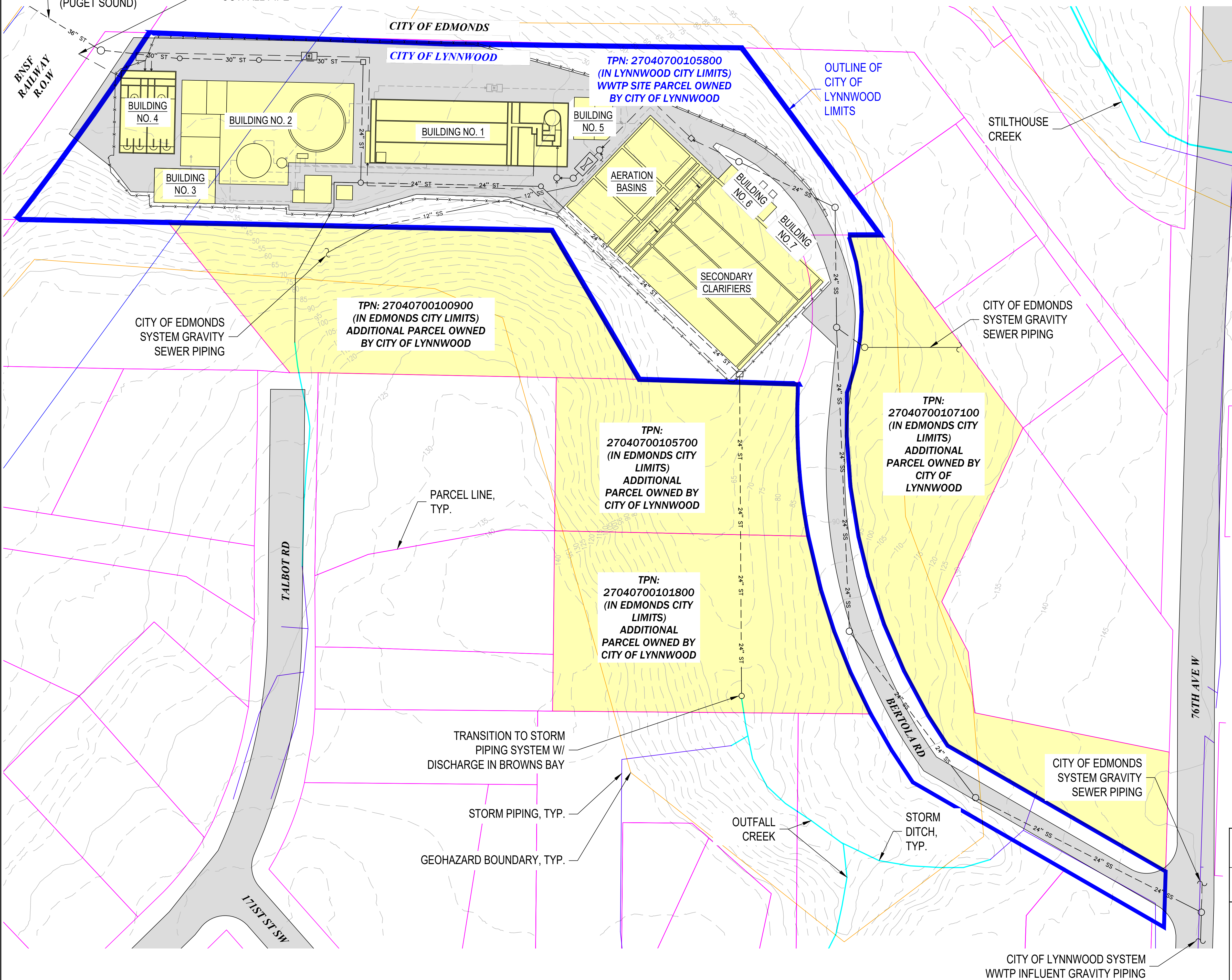


NOTES

1. YELLOW HATCHED PARCELS ARE IN THE CITY OF EDMONDS BUT OWNED BY THE CITY OF LYNNWOOD.
2. ROAD BOUNDARY OUTLINES AND HATCHING ARE ESTIMATED AND NOT SURVEYED.
3. CONTOURS ARE BASED ON THE WESTERN WASHINGTON 3DEP LIDAR PROJECT (2016-2017) DATA EXPORTED FROM DNR'S WA. LIDAR PORTAL.
4. PARCEL LINES ARE FROM SNOHOMISH COUNTY GIS DATA.
5. WWTP INFRASTRUCTURE IS FROM FIGURE 7-1 EXISTING SITE PLAN FROM THE CITY OF LYNNWOOD 2012 WW COMPREHENSIVE PLAN UPDATE.
6. GEOHAZARD BOUNDARIES ARE BASED ON THE CITY OF LYNNWOOD GEOLOGICALLY HAZARDOUS AREAS MAP (DRAFT).
7. CREEKS, STORM DITCHES, AND STORM PIPING ARE FROM CITY OF EDMONDS GIS DATA.

EXISTING BUILDING KEY

BUILDING NO. 1
- HEADWORKS
- 3 RECTANGULAR PRIMARY CLARIFIERS

BUILDING NO. 2
- CIRCULAR PRIMARY CLARIFIER
- GRAVITY THICKENER
- INCINERATOR AND ASSOCIATED EQUIPMENT
- CHLORINE GAS SYSTEM
- NON-POTABLE WATER SYSTEM
- PRIMARY TREATMENT AND SOLIDS HANDLING SYSTEM ELECTRICAL SERVICE AND GENERATOR

BUILDING NO. 3 - SOLIDS HANDLING BUILDING
- DEWATERING EQUIPMENT

BUILDING NO. 4 - CONTROL BUILDING
- OFFICES AND LABORATORY
- CHLORINE CONTACT TANK BELOW

BUILDING NO. 5 - MAIN PLANT PUMP STATION (MPPS) BUILDING

BUILDING NO. 6 - BLOWER BUILDING
- AERATION BLOWERS
- SECONDARY TREATMENT SYSTEM ELECTRICAL SERVICE AND EQUIPMENT (UPPER LEVEL)

BUILDING NO. 7 - GENERATOR BUILDING
- SECONDARY TREATMENT SYSTEM ELECTRICAL SERVICE BACK-UP GENERATOR

EXHIBIT C-2: EXISTING SITE OVERVIEW

FACILITY PLAN FOR LYNNWOOD WWTP

RH2 LYNNWOOD WASHINGTON

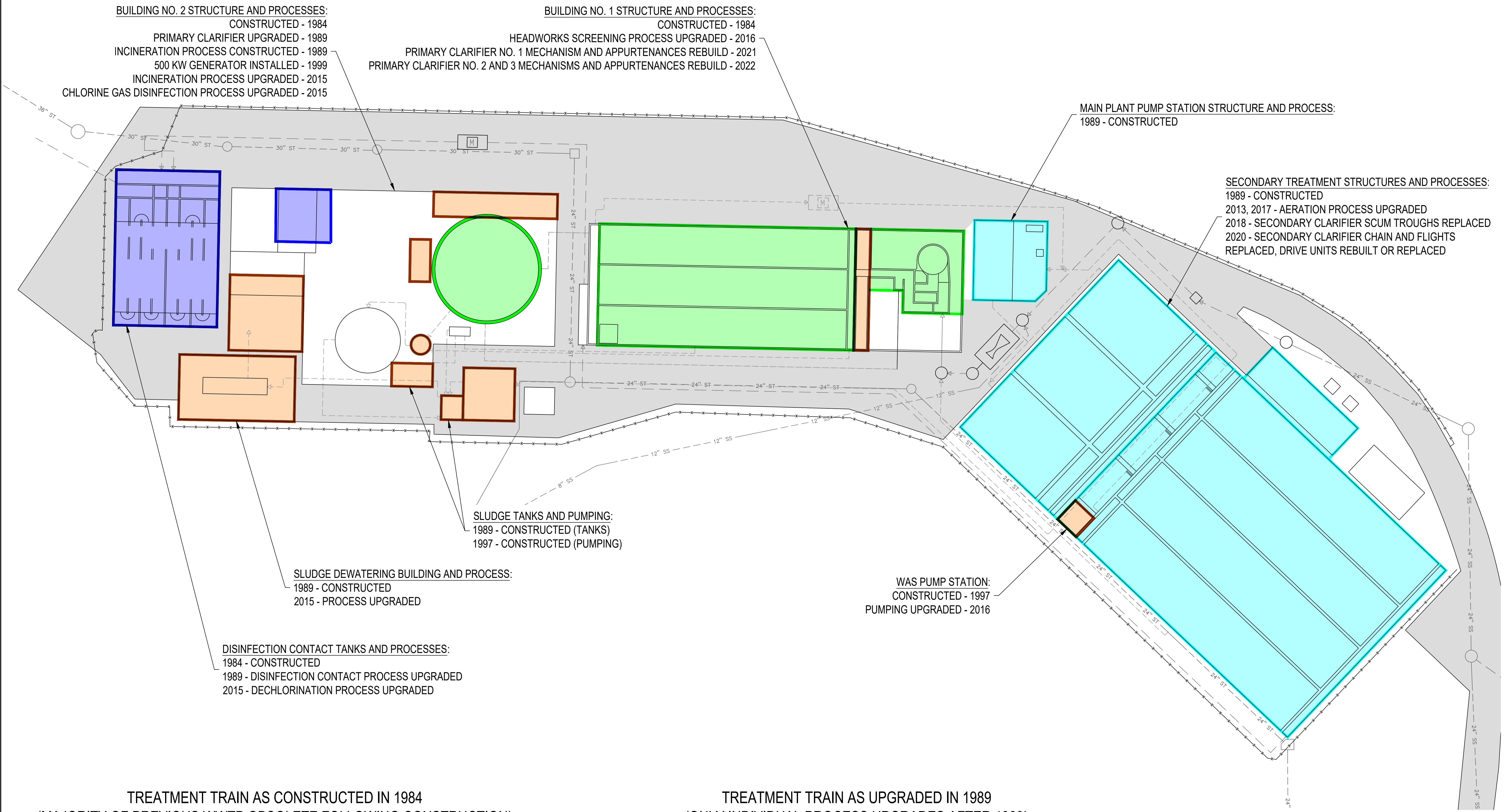
SCALE: 1" = 40'

0" 1" 2"

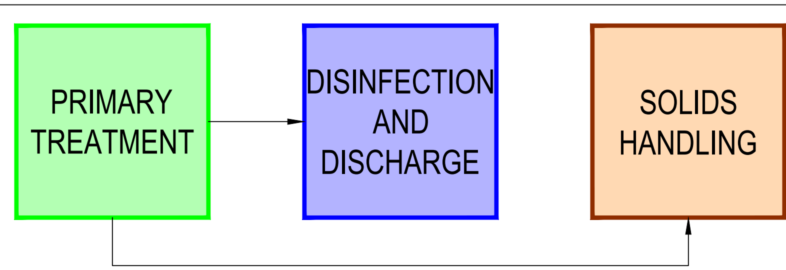
DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 3/4/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_ex-site-plan.dwg



TREATMENT TRAIN AS CONSTRUCTED IN 1984
(MAJORITY OF PREVIOUS WWTP OBSOLETE FOLLOWING CONSTRUCTION)



TREATMENT TRAIN AS UPGRADED IN 1989
(ONLY INDIVIDUAL PROCESS UPGRADES AFTER 1989)

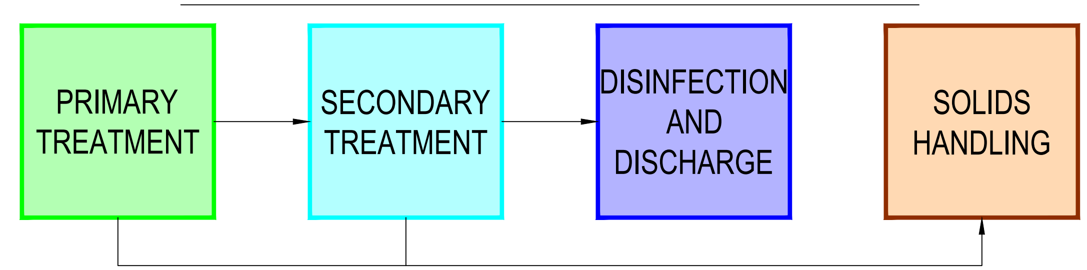


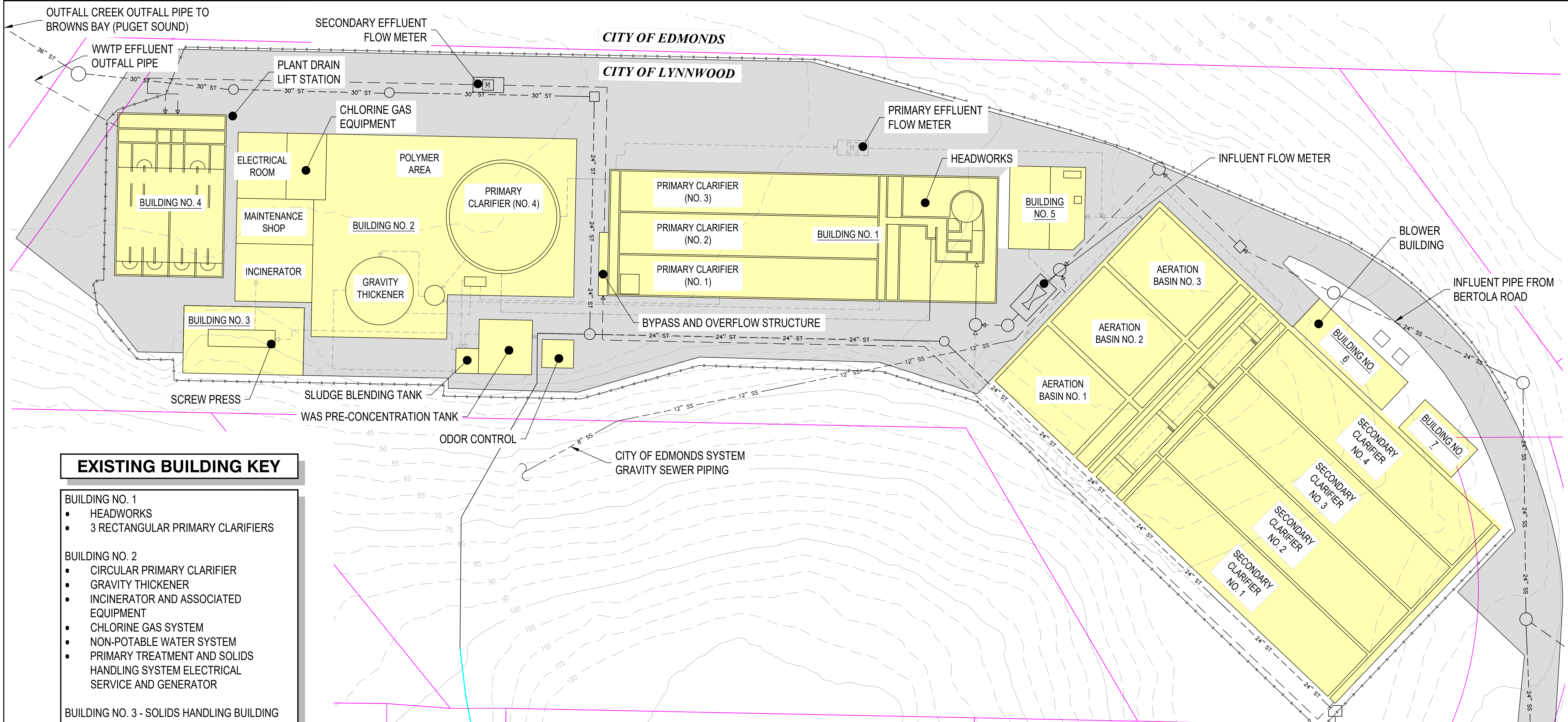
EXHIBIT C-3: WWTP IMPROVEMENTS HISTORY

FACILITY PLAN FOR LYNNWOOD WWTP

RH2 LYNNWOOD WASHINGTON

SCALE: 1" = 20'
DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 4/5/2022



EXISTING BUILDING KEY

BUILDING NO. 1
- HEADWORKS
- 3 RECTANGULAR PRIMARY CLARIFIERS

BUILDING NO. 2
- CIRCULAR PRIMARY CLARIFIER
- GRAVITY THICKENER
- INCINERATOR AND ASSOCIATED EQUIPMENT
- CHLORINE GAS SYSTEM
- NON-POTABLE WATER SYSTEM
- PRIMARY TREATMENT AND SOLIDS HANDLING SYSTEM ELECTRICAL SERVICE AND GENERATOR

BUILDING NO. 3 - SOLIDS HANDLING BUILDING
- DEWATERING EQUIPMENT

BUILDING NO. 4 - CONTROL BUILDING
- OFFICES AND LABORATORY
- CHLORINE CONTACT TANK BELOW

BUILDING NO. 5 - MAIN PLANT PUMP STATION (MPPS) BUILDING

BUILDING NO. 6 - BLOWER BUILDING
- AERATION BLOWERS
- SECONDARY TREATMENT SYSTEM ELECTRICAL SERVICE AND EQUIPMENT (UPPER LEVEL)

BUILDING NO. 7 - GENERATOR BUILDING
- SECONDARY TREATMENT SYSTEM ELECTRICAL SERVICE BACK-UP GENERATOR

EXHIBIT C-4: EXISTING LOWER SITE PLAN

FACILITY PLAN FOR LYNNWOOD WWTP

RH2 LYNNWOOD WASHINGTON

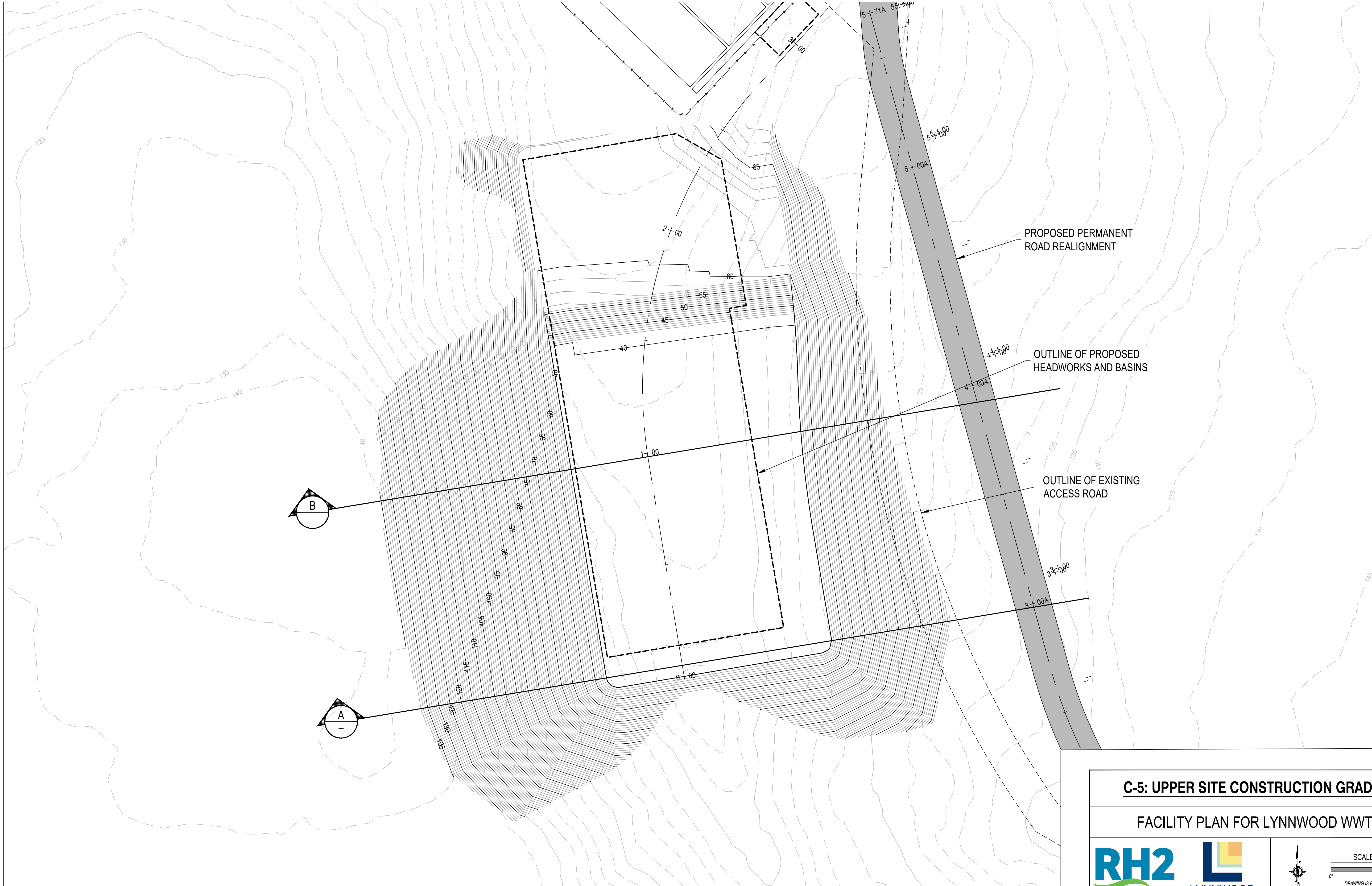
SCALE: 1" = 20'

0" 1" 2"

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_ex-lower-site-plan.dwg



C-5: UPPER SITE CONSTRUCTION GRADING

FACILITY PLAN FOR LYNNWOOD WWTP

RH2

LYNNWOOD
WASHINGTON

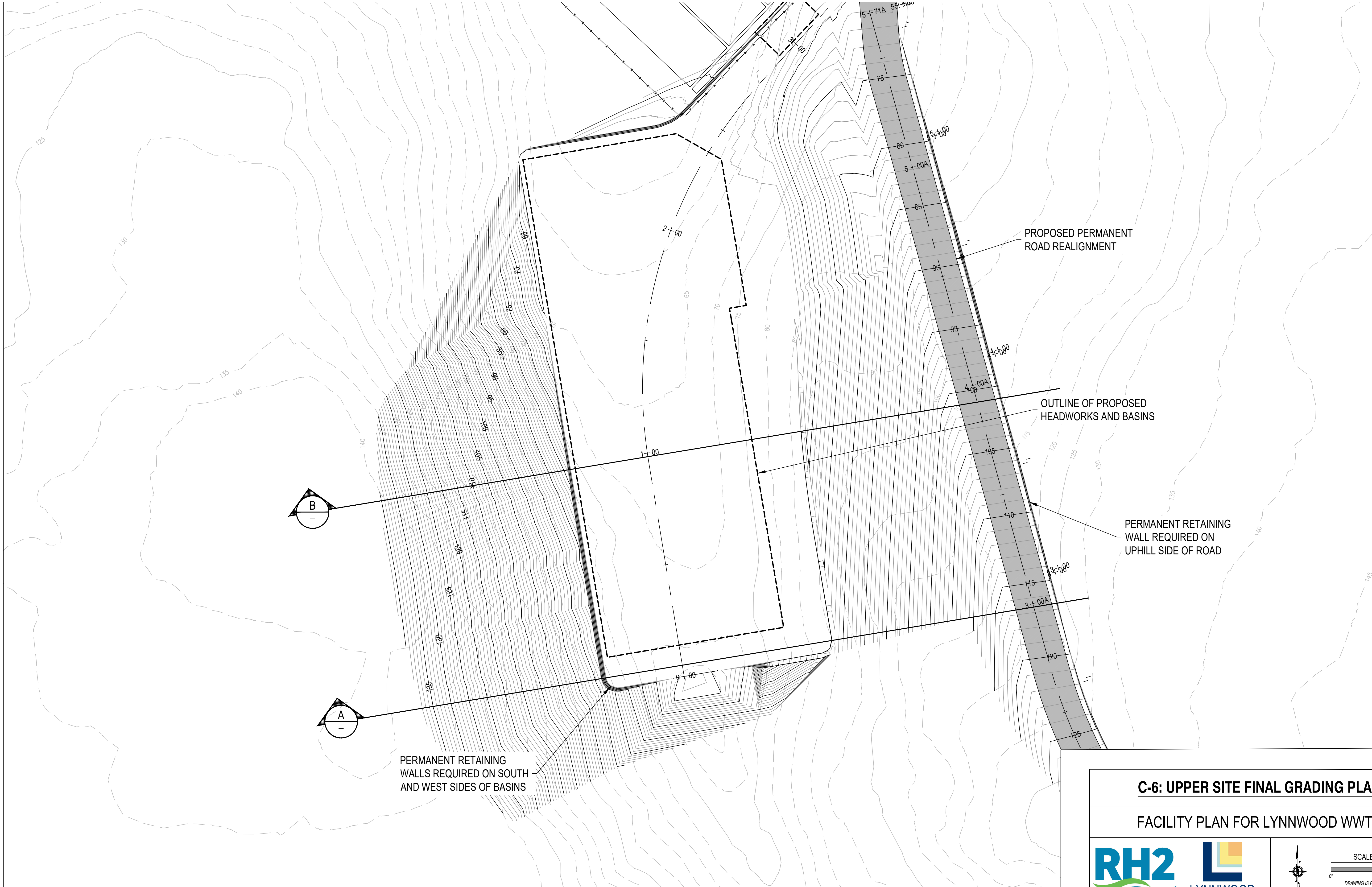
SCALE: 1" = 20'

0" 1" 2"

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_c3d-sections.dwg



C-6: UPPER SITE FINAL GRADING PLAN

FACILITY PLAN FOR LYNNWOOD WWTP

RH2

LYNNWOOD
WASHINGTON

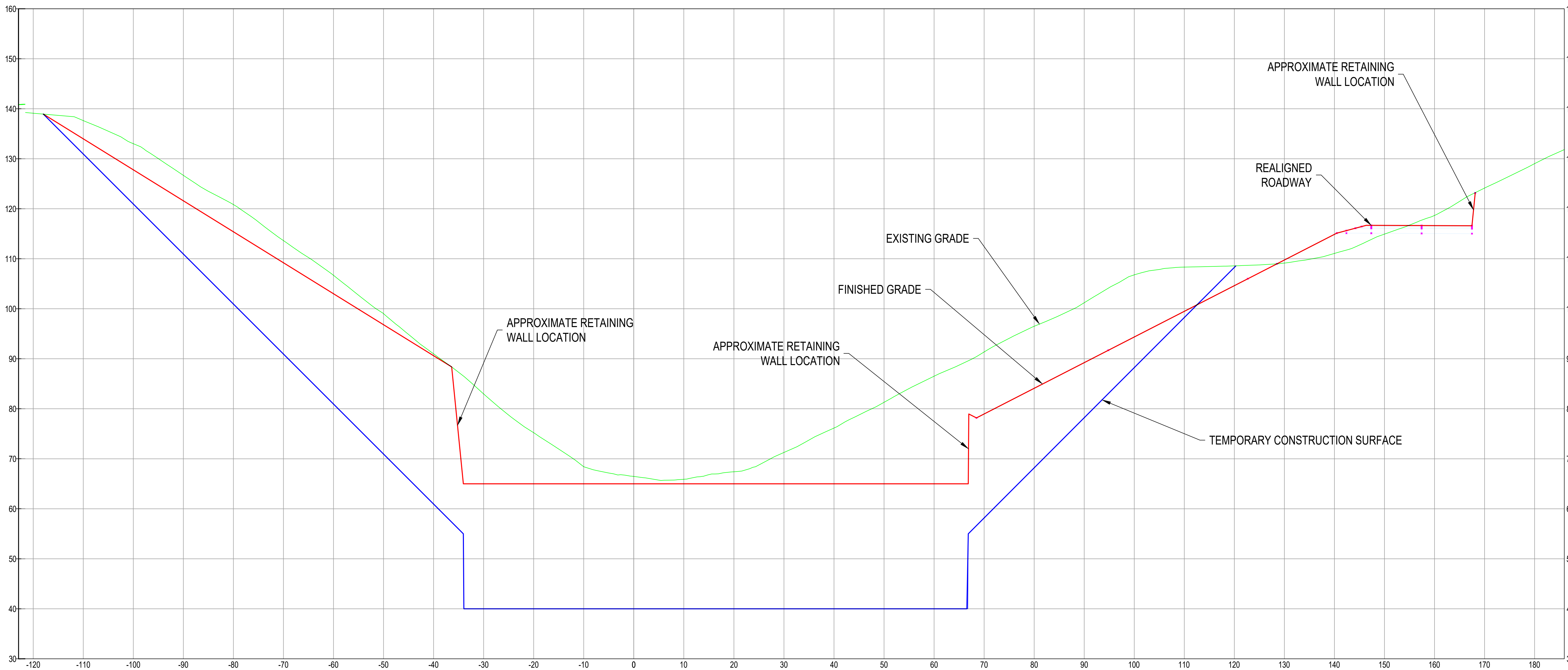
SCALE: 1" = 20'

0" 1" 2"

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_c3d-sections.dwg



C-7: UPPER SITE GRADING CROSS SECTION A

FACILITY PLAN FOR LYNNWOOD WWTP

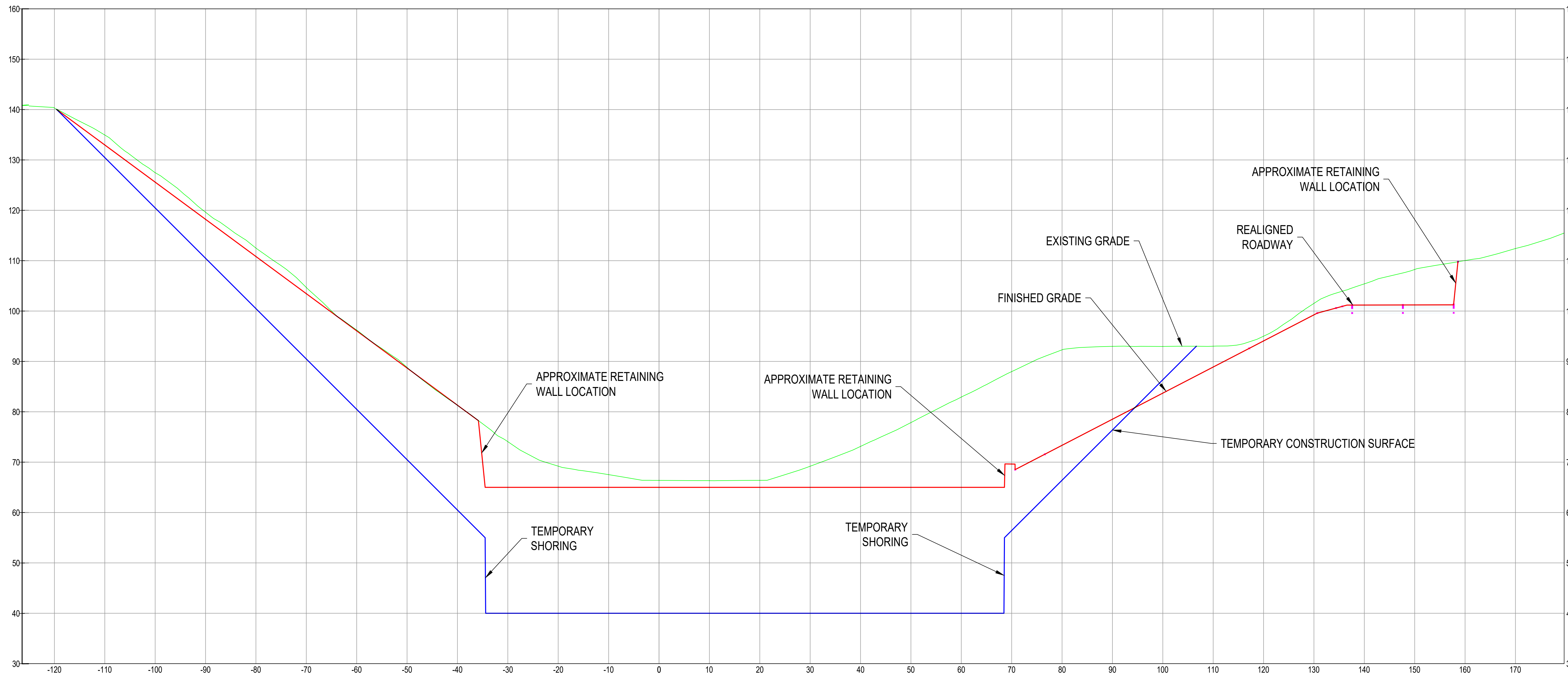
SCALE: NTS

0" 1" 2"

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_c3d-sections.dwg



C-8: UPPER SITE GRADING CROSS SECTION B

FACILITY PLAN FOR LYNNWOOD WWTP

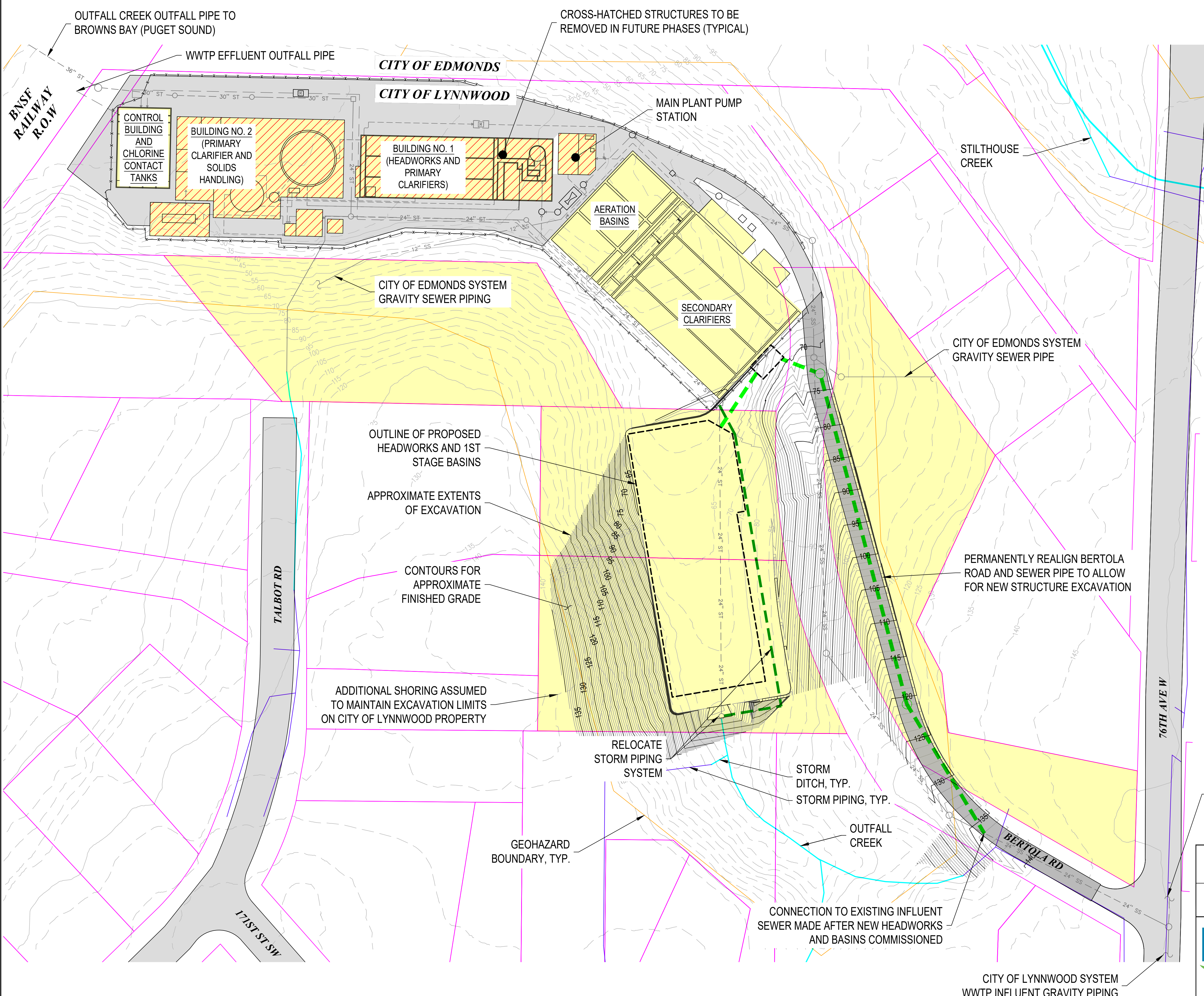
SCALE: NTS

0" 1" 2"

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_c3d-sections.dwg



NOTES

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6. GEOHAZARD BOUNDARIES ARE BASED ON THE CITY OF LYNNWOOD GEOLOGICALLY HAZARDOUS AREAS MAP (DRAFT).
7. CREEKS, STORM DITCHES, AND STORM PIPING ARE FROM CITY OF EDMONDS GIS DATA.
8. EXCAVATION AND GRADING CONTOURS SHOWN ARE PRELIMINARY FOR THE PURPOSES OF APPROXIMATING THE DISTURBED AREA. EXTENTS CAN BE REDUCED OR ADJUSTED DURING DESIGN WITH ADDITIONAL SHORING OR OTHER MEASURES.

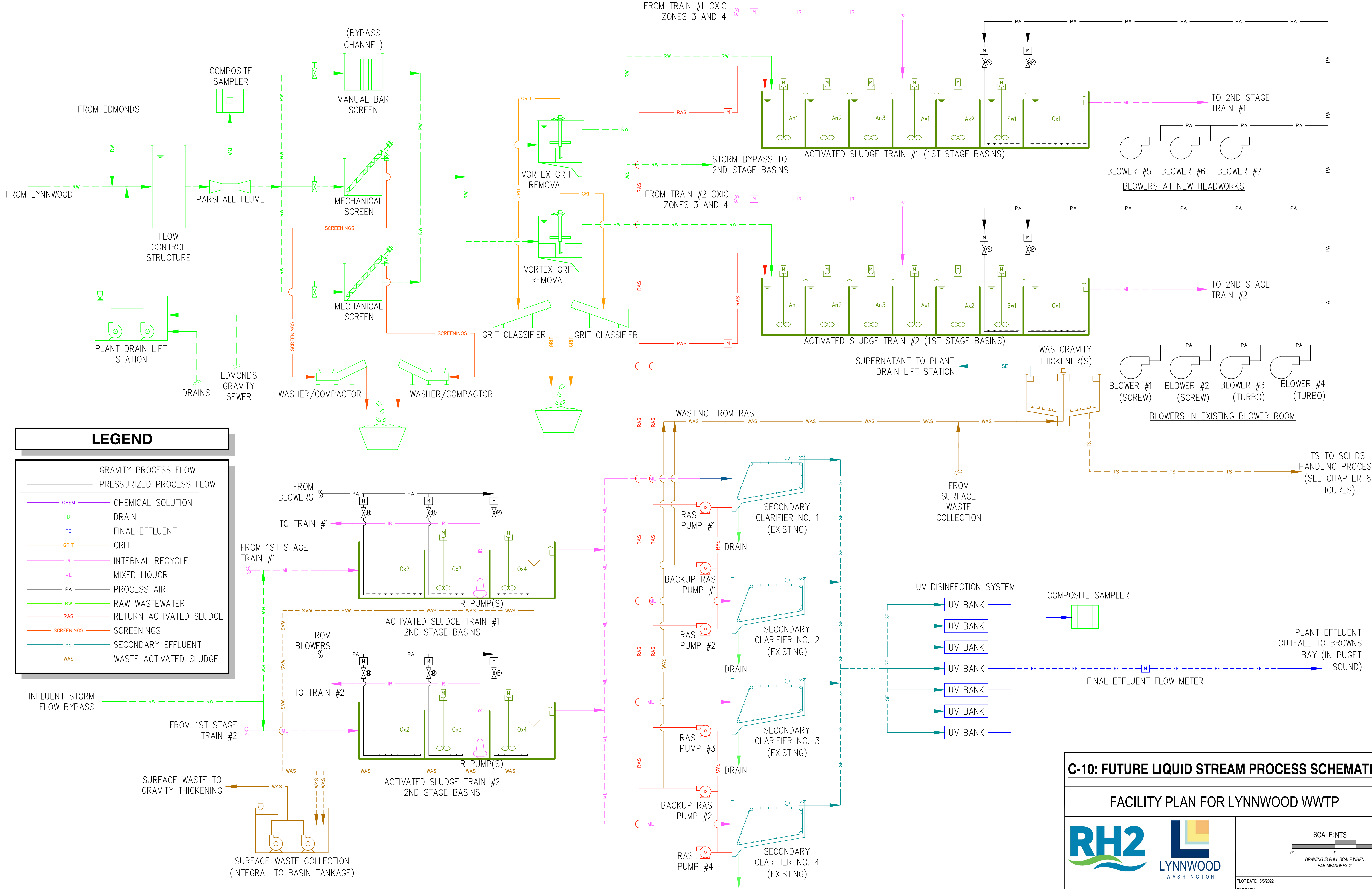
C-9: UPPER SITE PREPARATION PLAN

FACILITY PLAN FOR LYNNWOOD WWTP

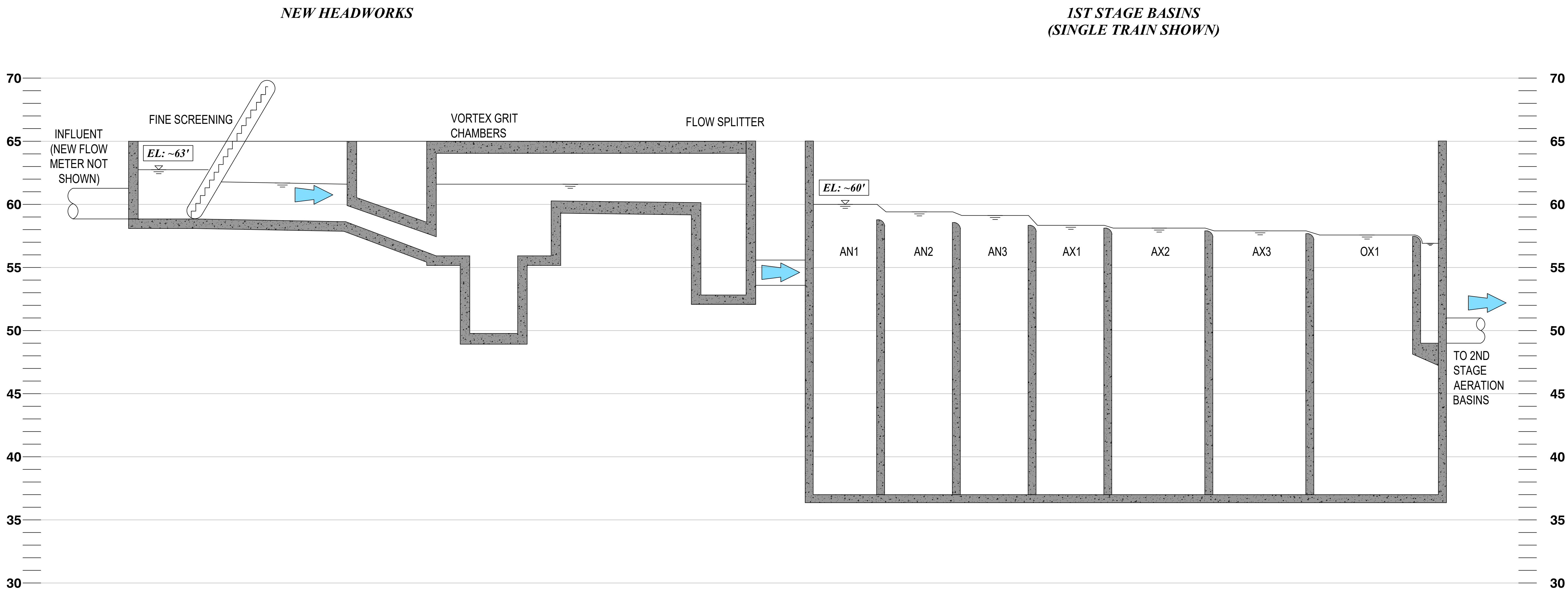
SCALE: 1" = 40'

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022



C-10: FUTURE LIQUID STREAM PROCESS SCHEMATIC



HYDRAULIC PROFILE PART 1

H: NTS; V: 1" = 4'

NOTE: ELEVATIONS ON HYDRAULIC PROFILE ARE PRELIMINARY ESTIMATES AND WILL CONFIRMED WITH HYDRAULIC MODELING DURING FINAL DESIGN.

C-11: PROPOSED HYDRAULIC PROFILE - UPPER SITE

FACILITY PLAN FOR LYNNWOOD WWTP

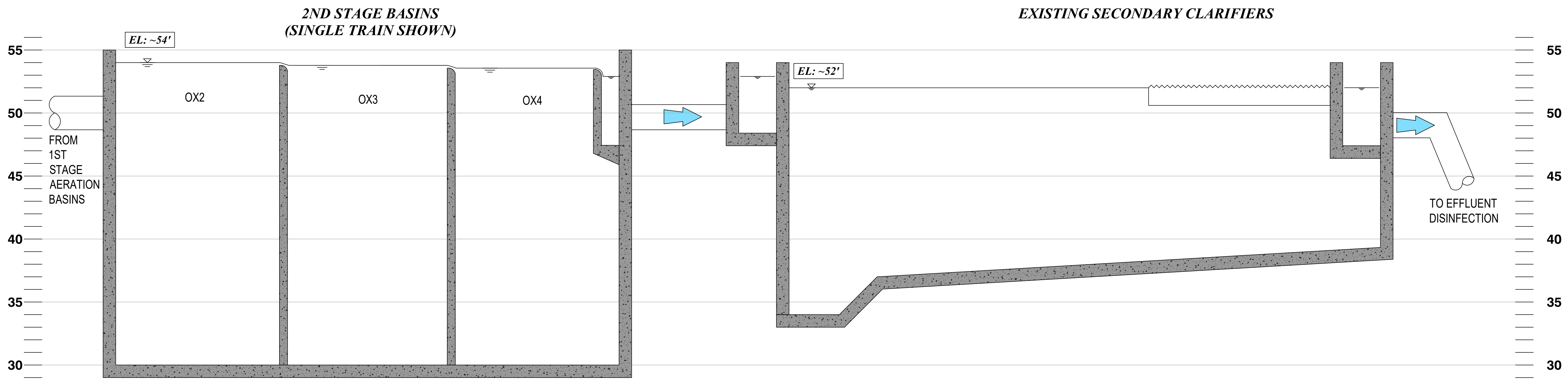
SCALE: AS SHOWN

0" 1/2" 1"

DRAWING IS FULL SCALE WHEN BAR MEASURES 1"

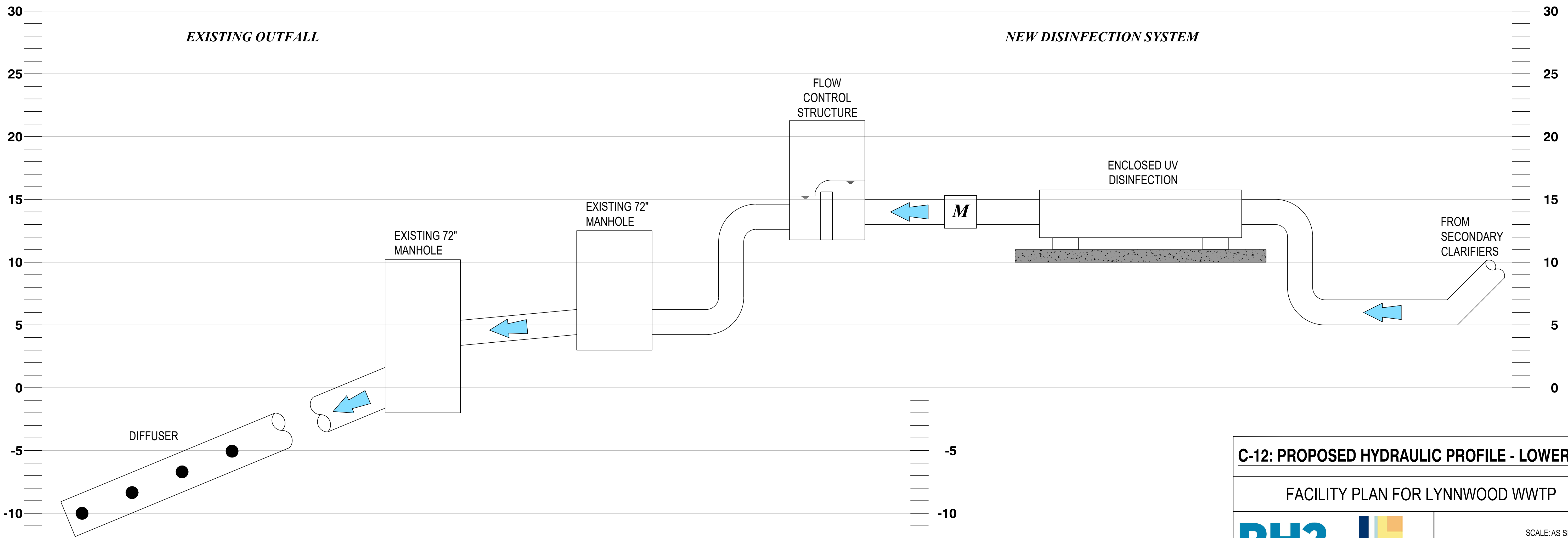
PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_hydrprof.dwg



HYDRAULIC PROFILE PART 2

H: NTS; V: 1" = 4'



HYDRAULIC PROFILE PART 3

H: NTS; V: 1" = 4'

NOTE: ELEVATIONS ON HYDRAULIC PROFILES ARE PRELIMINARY ESTIMATES AND WILL CONFIRMED WITH HYDRAULIC MODELING DURING FINAL DESIGN.

C-12: PROPOSED HYDRAULIC PROFILE - LOWER SITE

FACILITY PLAN FOR LYNNWOOD WWTP

RH2

LYNNWOOD
WASHINGTON

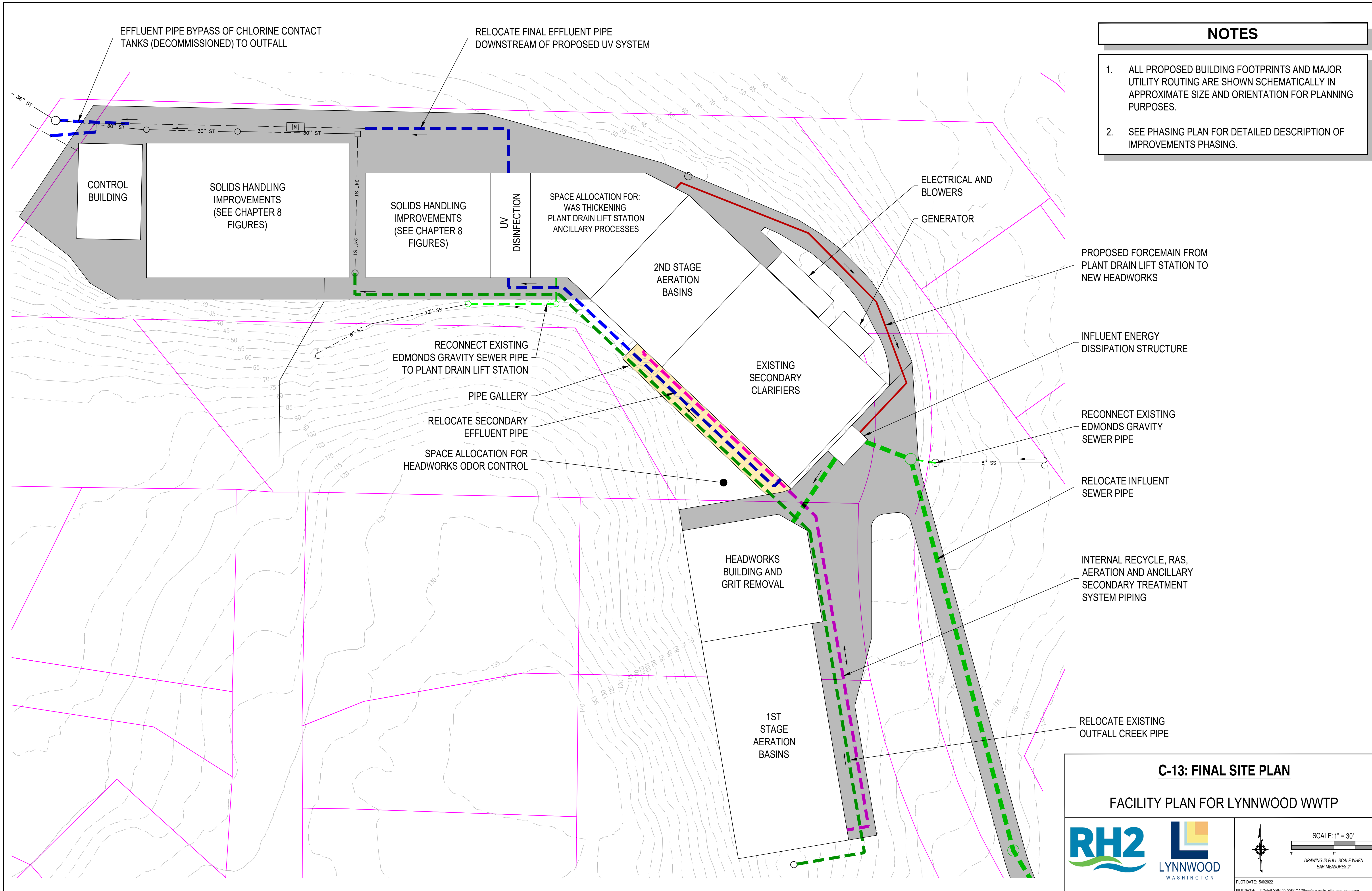
SCALE: AS SHOWN

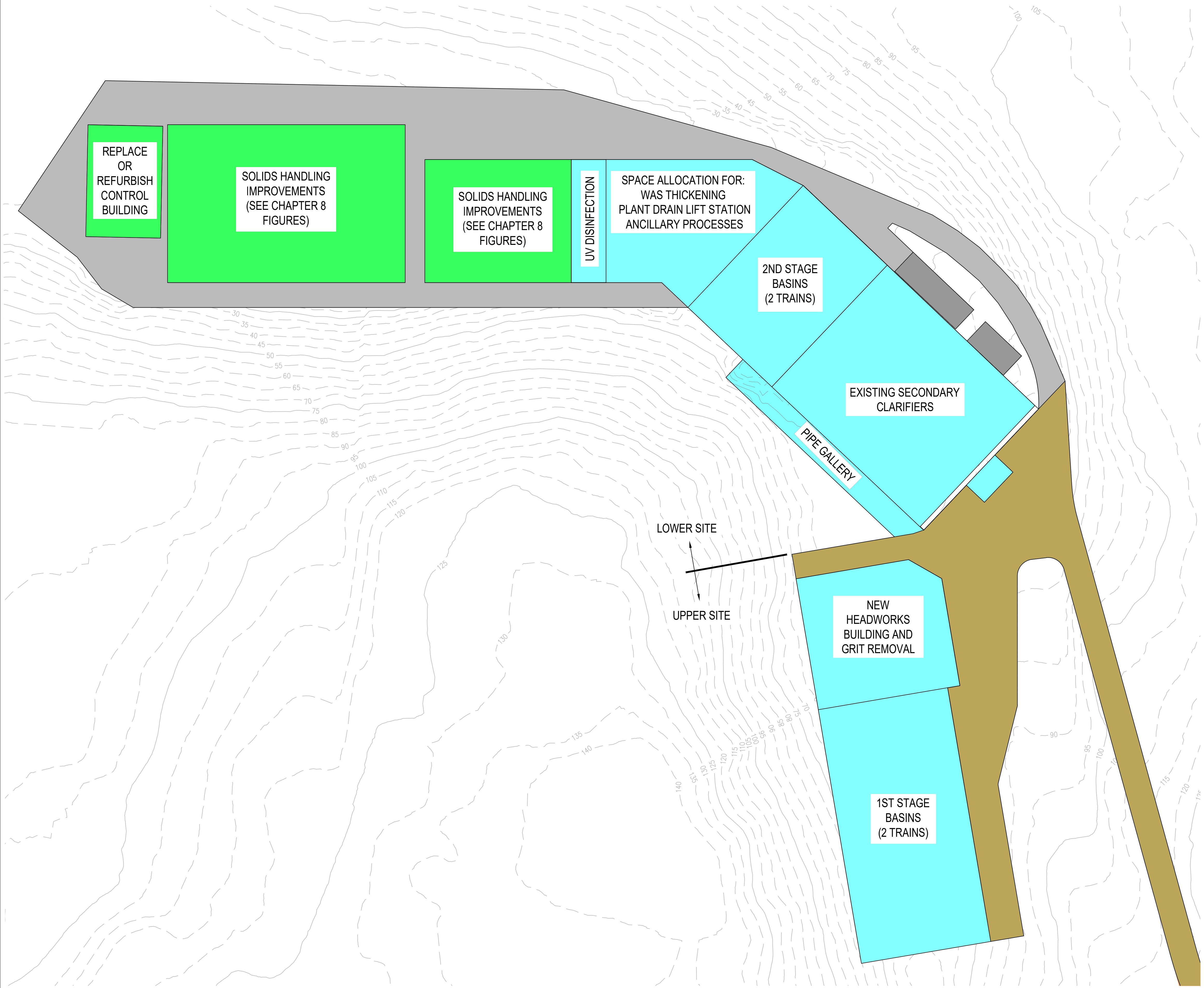
0" 1/2" 1"

DRAWING IS FULL SCALE WHEN BAR MEASURES 1"

PLOT DATE: 5/6/2022

FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_hydrprof.dwg


EFFLUENT PIPE BYPASS OF CHLORINE CONTACT TANKS (DECOMMISSIONED) TO OUTFALL
RELOCATE FINAL EFFLUENT PIPE DOWNSTREAM OF PROPOSED UV SYSTEM
NOTES
1. ALL PROPOSED BUILDING FOOTPRINTS AND MAJOR UTILITY ROUTING ARE SHOWN SCHEMATICALLY IN APPROXIMATE SIZE AND ORIENTATION FOR PLANNING PURPOSES.
2. SEE PHASING PLAN FOR DETAILED DESCRIPTION OF IMPROVEMENTS PHASING.
36" ST
30" ST
24" ST
CONTROL BUILDING
SOLIDS HANDLING IMPROVEMENTS (SEE CHAPTER 8 FIGURES)
SOLIDS HANDLING IMPROVEMENTS (SEE CHAPTER 8 FIGURES)
UV DISINFECTION
SPACE ALLOCATION FOR: WAS THICKENING PLANT DRAIN LIFT STATION ANCILLARY PROCESSES
2ND STAGE AERATION BASINS
ELECTRICAL AND BLOWERS
GENERATOR
PROPOSED FORCEMAIN FROM PLANT DRAIN LIFT STATION TO NEW HEADWORKS
12" SS
8" SS
RECONNECT EXISTING EDMONDS GRAVITY SEWER PIPE TO PLANT DRAIN LIFT STATION
EXISTING SECONDARY CLARIFIERS
INFLUENT ENERGY DISSIPATION STRUCTURE
PIPE GALLERY
RELOCATE SECONDARY EFFLUENT PIPE
SPACE ALLOCATION FOR HEADWORKS ODOR CONTROL
RECONNECT EXISTING EDMONDS GRAVITY SEWER PIPE
8" SS
RELOCATE INFLUENT SEWER PIPE
HEADWORKS BUILDING AND GRIT REMOVAL
INTERNAL RECYCLE, RAS, AERATION AND ANCILLARY SECONDARY TREATMENT SYSTEM PIPING
1ST STAGE AERATION BASINS
RELOCATE EXISTING OUTFALL CREEK PIPE
C-13: FINAL SITE PLAN
FACILITY PLAN FOR LYNNWOOD WWTP
RH2
LYNNWOOD WASHINGTON
SCALE: 1" = 30'
DRAWING IS FULL SCALE WHEN BAR MEASURES 2"
PLOT DATE: 5/6/2022



PHASING PLAN

1. PHASE 1 – UPPER SITE PREPARATION
   - RELOCATE ACCESS ROAD AND INFLUENT SEWER PIPE
   - CLEARING OF THE SITE
   - RELOCATE OUTFALL CREEK PIPE SYSTEM
   - MAJOR EXCAVATION
   - FINAL STABILIZATION

2. PHASE 2 – LIQUID STREAM IMPROVEMENTS
   CONSTRUCT NEW HEADWORKS AND ADDITIONAL BASINS
   - CONSTRUCT HEADWORKS AND 2ND/ STAND AERATION BASINS
   - TEST HEADWORKS AND 2ND/ STAGE BASINS
   - CONSTRUCT PIPE GALLERY
   - COMMISSION HEADWORKS AND 2ND/ STAGE BASINS
   - CONSTRUCT 1ST STAGE BASINS AND MAKE SECONDARY CLARIFIER IMPROVEMENTS
   - DEMOLISH EXISTING HEADWORKS, PRIMARY CLARIFIERS AND MPPS
   - CONSTRUCT ANCILLARY SECONDARY TREATMENT SYSTEMS
   - INSTALL UV DISINFECTION SYSTEM

3. PHASE 3 – SOLIDS HANDLING IMPROVEMENTS
   - DEMOLISH BUILDING NO. 2
   - CONSTRUCT SOLIDS HANDLING BUILDING
   - DEMOLISH REMAINING UNUSED INFRASTRUCTURE

C-14: RECOMMENDED IMPROVEMENTS PHASING

FACILITY PLAN FOR LYNNWOOD WWTP

RH2

LYNNWOOD
WASHINGTON

SCALE: 1" = 30'
0" 1" 2"
DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

PLOT DATE: 5/6/2022
FILE PATH: J:\Data\LYNN\20-0054\CAD\lynnfp-e-wwtp_impmts-phasing.dwg

Appendix D

BHC Population and Flow Projections Technical Memorandum

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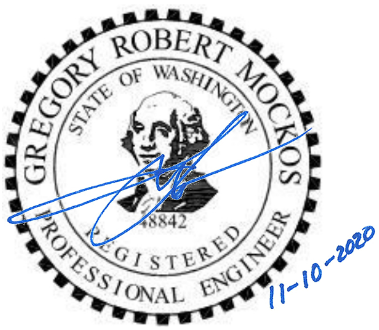
TECHNICAL MEMORANDUM

Date: November 10, 2020

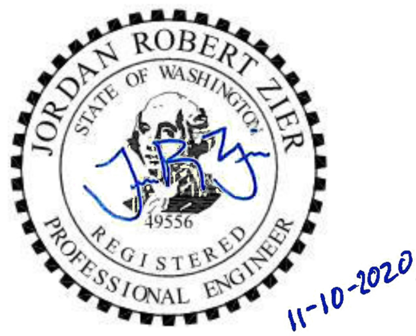
To: Dan Mahlum, P.E., RH2 Engineering

From: Greg Mockos, P.E., Jordan Zier, P.E., Talia Tittelfitz, Lauren Moore, BHC Consultants

Subject: Population and Flow Projections



Gregory Robert Mockos, P.E.
BHC Consultants, LLC



Jordan Robert Zier, P.E.
BHC Consultants, LLC

1. Introduction

The City of Lynnwood (City) is updating its Wastewater Treatment Plant (WWTP) Facility Plan to plan for future growth and address aging infrastructure needs, increasingly stringent sewage sludge incineration (SSI) emission standards and changing effluent discharge limits. This technical memorandum discusses population and employment flow projections for the City sanitary sewer service area for the following years: 2019 (baseline), 2026 (6-year), 2030 (10-year), 2040 (20-year) and 2050 (30-year). Flows herein were estimated for average day, average day of max month, peak day, and peak hour flow categories.

2. Residential Population Baseline

2.1 Datasets

Population and employment data were collected from the Office of Financial Management (OFM) and Puget Sound Regional Council (PSRC). To establish the boundaries where data was collected, a GIS shapefile was submitted to OFM and PSRC containing four geographies[1] labeled as shown in Figure 2-1.

- A: Service area provided within the City of Lynnwood (excluding City Center and Alderwood Mall)
- B: Service area provided within the City of Edmonds
- C: Service provided to the Alderwood Mall Area
- D: Service provided to Lynnwood City Center

[1] Note that Lynnwood sewer service area encapsulated by geographies A, C, and D is not identical to the City of Lynnwood boundary, as some parts of the City are served by other providers.

Combined, these four geographies represent the area served by the City's sanitary sewer system. The Alderwood Mall Area and Lynnwood City Center were set apart for analysis due to their higher development potential compared to the City as a whole. Both areas are commercial centers with the Lynnwood City Center being the focal point for a wide range of current and forthcoming projects "intended to significantly upgrade the City's transportation network, add new public spaces and parks, build housing, improve cultural attractions, create a pedestrian-friendly environment, and enhance livability."[2]

Finally, it is assumed that the Snohomish County Buildable Lands Report (BLR) Land Use Capacity analysis and methodology may be available by the end of the year; if so, the results of the Land Use Capacity analysis can supplement the OFM Small Area Estimates Program (SAEP) estimate and PSRC's Total Employment estimates discussed in this memo. Results from the Land Use Capacity analysis can also be compared to the future population forecasted by PSRC.

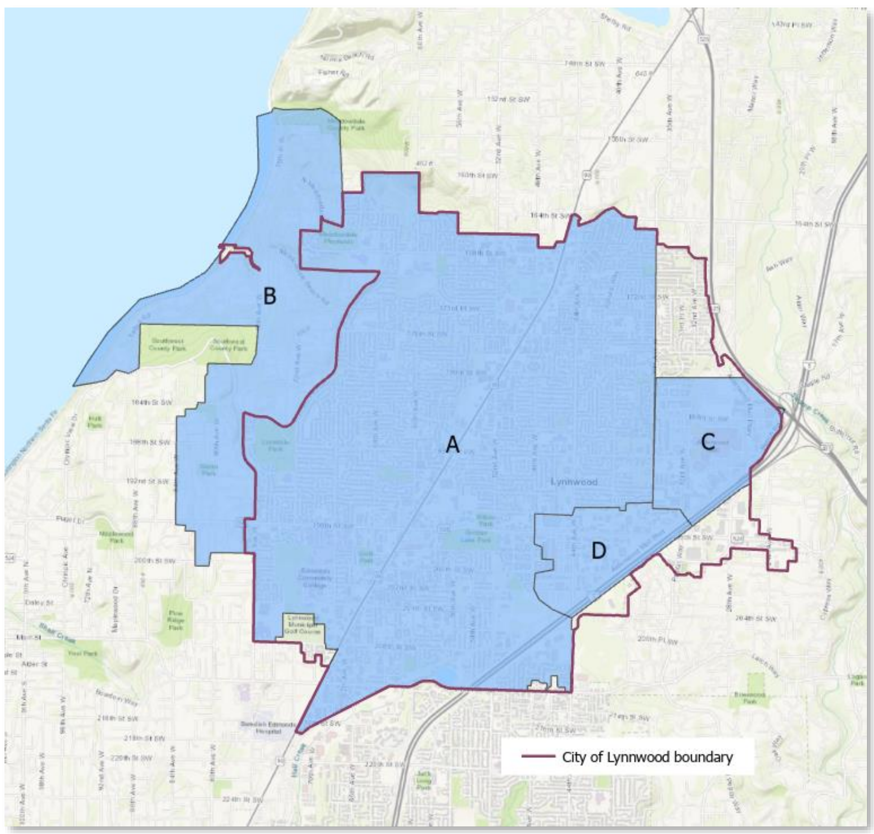


Figure 2-1 – Geographies Used to Compile Population and Employment Estimates

[2] City of Lynnwood: City Center, https://www.lynnwoodwa.gov/Government/Departments/Economic-Development/City-Center.

2.2 *Population Baseline*

The residential population baseline year was 2019. The OFM Small Area Estimates Program (SAEP) prepares custom population estimates upon request. OFM provided a 2019 population estimate for the requested geographies, recorded in Table 2-1. This estimate provides the population baseline against which forecasted growth can be compared.

Table 2-1
Baseline Population Estimates

Geography	Area (ac.)	2019 Population Estimate
Service area provided within the City of Lynnwood [A]	3,970.34	34,528
Service area provided within the City of Edmonds [B]	1,177.78	6,455
Alderwood Mall Area [C]	362.88	743
Lynnwood City Center [D]	280.22	981
Total Service Area [A+B+C+D]	**5,791.22**	**42,707**

The total City baseline population is 42,707. OFM notes that an accuracy evaluation for this program is still in progress. Errors in accuracy may arise because OFM's estimates are developed year-by-year based on the last Census. New Census data will be available in the spring of 2021. Until then, OFM's estimates are the best available.

3. Employment Baseline

The employment baseline year was 2019. Employment population projections were collected from 2019 Covered Employment data provided by PSRC and are summarized in Table 3-1.

Table 3-1
Baseline Employment Estimates

Geography	2019 Employment Estimate
Service area provided within the City of Lynnwood [A]	15,825 employees
Service area provided within the City of Edmonds [B]	767 employees
Alderwood Mall Area [C]	8,316 employees
Lynnwood City Center [D]	4,325 employees
Total Service Area [A+B+C+D]	**29,233** employees

The total City baseline employment is 29,233 employees. The total employment number captures employees covered by the Washington Unemployment Insurance Act (the Act) as well as those who are self-employed. Because the Alderwood Mall Area and Lynnwood City Center are major commercial areas, they contain employment estimates that greatly exceed their population, as recorded in Table 2-1.

4. Forecast Datasets

Population forecasts were estimated for 2019, 2026, 2030, 2040, and 2050. Residential population and employment projections for 2020, 2025, 2030, 2035, and 2040 were obtained from PSRC to forecast population. PRSC provided a population estimate for each requested geography using the Land Use Vision (LUV) regional model. According to PSRC's Growth Projection Users Guide, "The Land Use Vision (LUV) is a policy-directed growth projection out to 2040 for jurisdictions and other geographies. It represents the urban-focused growth pattern the region is planning for under VISION 2040 and local comprehensive plans and supports PSRC's long-range planning analyses and modeling. The current Land Use Vision was released in October 2017 and utilizes the 2015 macroeconomic forecast."

The population of residents living in group quarters[3] was estimated using spatial data provided by PSRC. The group quarters population was added to the household population to generate total population. BHC then estimated residential population and employment forecasts for each forecast year by calculating a straight-line interpolation between baseline data and the projection years provided by PSRC. The LUV, while the most current forecasting tool available at PSRC, may return improbable forecasts for small geographies. For example, LUV-modeled employment forecasts showed unlikely declines in employment in the City of Edmonds service area. Adjustments were made to the projections based on professional judgement and local knowledge to rectify this discrepancy. The results of the population forecast analysis are summarized in Table 4-1.

Table 4-1
Initial Population Forecast Compiled by PSRC

Geography	2019	2026	2030	2040	2050
Service area provided within the City of Lynnwood [A]	34,528	39,606	43,549	53,330	61,770
Service area provided within the City of Edmonds [B]	6,455	7,010	7,139	7,423	8,040
Alderwood Mall Area [C]	743	1,489	1,530	2,143	2,535
Lynnwood City Center [D]	981	1,591	1,733	1,875	2,086
Total Service Area [A+B+C+D]	**42,707**	**49,696**	**53,951**	**64,771**	**74,431**

[3] A Census category that includes hospitals, nursing facilities, college dormitories, and other places where people stay or live in a group living arrangement.

Following conversations with City of Lynnwood Planners, PSRC's projected population in Geographies C and D was adjusted in order to align with future planned development, which is considerably higher than what was initially forecasted in Table 4-1. For example, while the LUV model returned a 2040 population of around 2,000 people in the Alderwood Mall area (Geography C), City planning efforts generally assume a future population target that may be much higher. According to current City permitting data, over 800 residential units are currently under construction in this area. Northline Village, a proposed redevelopment of Lynnwood Square connected to the Link extension in Geography D, could add as many as 3,000 people to the area alone.

The most plausible explanation for this inconsistency is that PSRC's LUV model did not fully integrate planned infrastructure improvements. The current version of the LUV model was largely developed between 2016 and 2017, meaning that some newer pipeline developments would not have been factored in. This is the most likely reason for the diminished forecasts, because the zoning and land use inputs applied to the LUV model appear to be otherwise appropriate for high-density areas.

Accordingly, discussion with the City supported transferring some of the population projected for Geography A into Geographies C and D. This approach ensures that the total forecasted growth remains consistent with the LUV model's outcome, but the relative distribution of the population within Lynnwood better corresponds with expectations for development. PSRC's Vision 2050 includes a goal for regional growth centers and areas within walking distance of high-capacity transit to take on 65% of the region's population growth (MPP-RGS-8). Given this, it was deemed justifiable to transfer 65% of population growth within Lynnwood city boundaries to the Alderwood Mall and City Center areas (Geographies C and D, respectively). With this modification, final adjusted population projections are given in Table 4-2 below.

Table 4-2
Final Adjusted Population Forecast

Geography	2019	2026	2030	2040	2050
Service area provided within the City of Lynnwood [A]	34,528	36,780	38,224	41,912	45,077
Service area provided within the City of Edmonds [B]	6,455	7,010	7,139	7,423	8,040
Alderwood Mall Area [C]	743	2,834	4,175	7,599	10,538
Lynnwood City Center [D]	981	3,072	4,413	7,837	10,776
Total Service Area [A+B+C+D]	**42,707**	**49,696**	**53,951**	**64,771**	**74,431**

More so than population growth, employment projections generated by the model do appear to be consistent with anticipated development. The results of the employment forecast analysis are summarized in Table 4-3, and provide the basis for BHC's flow estimates.

Table 4-3
Employment Forecast

Geography	2019	2026	2030	2040	2050
Service area provided within the City of Lynnwood [A]	15,825	17,748	18,816	23,907	26,828
Service area provided within the City of Edmonds [B]	767	780	792	805	816
Alderwood Mall Area [C]	8,316	9,157	10,599	12,908	14,377
Lynnwood City Center [D]	4,325	4,632	5,062	7,622	7,861
Total service area [A+B+C+D]	**29,233**	**32,317**	**32,257**	**45,242**	**49,882**

As with population growth, the Lynnwood service area (Geography A) accounts for the largest share of total growth over time. However, there is less divergence among the four regions in these forecasts, indicating that jobs may be spread more evenly across the service area than residential population. As commercial centers, the Alderwood Mall Area and the Lynnwood City Center (Geographies C and D, respectively) are forecasted to increase in employment totals over time. As with population, it is likely that the rate of employment growth is projected to increase after the year 2030 due to forthcoming infrastructure development and associated increases in density to accommodate a growing population. The City of Edmonds service area is projected to grow at a much smaller rate, increasing in employment capacity only by approximately fifty jobs through the 2050 planning horizon.

Unlike population growth, the employment growth will be more evenly distributed among Geographies A, B, and C. The City of Lynnwood service area (Geography A) is projected to account for approximately 50 percent of total employment, giving this geography the largest share. This is followed by the Lynnwood City Center (Geography D), the Alderwood Mall Area (Geography C), and the City of Edmonds service area (Geography B).

5. Baseline Flow

The City's Wastewater Comprehensive Plan Update (CPU) used the methodology of projecting average day flow from population, employment, and service area. Per capita flows of 50 gallons per day (gpd) and 31 gpd were previously estimated for residential population and employees, respectively. Moreover, an average Inflow and Infiltration (I&I) of 300 gallons per acre day (gpad) was estimated for the service area. The average day flow was multiplied by peaking factors to calculate the average day of max month, peak day, and peak hour flows. An assessment of the previously used planning numbers against more recent flow data from the WWTP is provided in Section 5.2.

5.1 Baseline Flow Estimate

Baseline flows were estimated by applying the per capita flow above to the population and employment baseline values in Sections 2 and 3. The resulting baseline flows for the four geographies are provided in Table 5-1.

Table 5-1
Flow Estimates Using Per Capita and Population

Geography	2019 Population Estimate	2019 Employment Estimate	Area (acres)[1]	Average Day Flow (MGD)[2]
Service area provided within the City of Lynnwood [A]	34,528	15,825	3,970.34	3.41
Service area provided within the City of Edmonds [B]	6,455	767	1,177.78	0.70
Service area provided to the Alderwood Mall area [C]	743	8,316	362.89	0.40
Service area provided to Lynnwood City Center [D]	981	4,325	280.22	0.27
Total [A+B+C+D]	**42,707**	**29,233**	**5,791.23**	**4.78**

Notes:
1) Values based on ArcGIS shapefile data.
2) Flow Assumptions per 2012 CPU: 50 gallons per day (gpd) per resident, 31 gpd per employee, 300 gallons per acre day I&I

Per Table 5-1, the total average day flow to the WWTP is 4.78 MGD. However, the population and areas shown in Table 5-1 above do not account for unsewered areas or properties served by on-site sewage, or septic systems. There are approximately 237 residences served by septic and approximately 124 acres of parks or open space. Adjustments in population and service area to account for these reductions in service area are provided in Table 5-2. The adjusted values result in a predicted 2019 average day flow 4.69 MGD.

Table 5-2
Flow Estimates Using per Capita and Population, Adjusted for Parks and Septic

Geography	2019 Population Estimate[3]	2019 Employment Estimate	Area (acres)[1]	Average Day Flow (MGD)[2]
Service area provided within the City of Lynnwood [A]	33,925	15,825	3,820.85	3.33
Service area provided within the City of Edmonds [B]	6,455	767	1,149.78	0.69
Service area provided to the Alderwood Mall area [C]	735	8,316	362.20	0.40
Service area provided to Lynnwood City Center [D]	978	4,325	279.99	0.27
Total [A+B+C+D]	**42,093**	**29,233**	**5,612.8**	**4.69**

Notes:
1) Values based on ArcGIS shapefile data. Adjusted to remove areas from parks and septic parcels that are not expected to contribute to I&I.
2) Flow Assumptions per 2012 CPU: 50 gallons per day (gpd) per resident, 31 gpd per employee, 300 gallons per acre day I&I
3) Sewered population adjusted to account for properties on septic, assumed 2.59 residents per septic residence (per Census).

5.2 Comparison to Historic Flows

To validate the accuracy of the baseline flow estimate in Section 5.1, it was compared to recent flows seen at the WWTP from 2017 to 2019. These flows are summarized in Table 5-3.

Table 5-3
Recorded WWTP Flows

	2017	2018	2019	$Avg_{2017-2019}$	2017-2019 Peaking Factor[3]	CPU Peaking Factor[4]
Average Day Flow[1] (MGD)	4.60	4.32	4.04	**4.32**	1.00	1.00
Max Month Flow[1] (MGD)	6.24	6.14	5.01	5.80	1.34	1.28
Peak Day Flow[2] (MGD)	11.95	9.82	16.53	12.77	2.95	3.03
Peak Hour Flow[2] (MGD)	20.46	13.24	20.13	17.94	4.15	4.28

Notes:
1) Source: City of Lynnwood Department of Ecology Discharge Monitoring Reports
2) Source: City of Lynnwood Meter at WWTP effluent. Flow attenuation occurs through the plant between WWTP influent and effluent so the effluent peak flows indicated above do not reflect influent peak flows.
3) Peaking factors calculated from 2017 to 2019 average WWTP flows.
4) Peaking factors used in CPU, November 2012

Average day and average day of max month flow was estimated from Discharge Monitoring Reports (DMRs); peak day flow and peak hour flow were estimated from a City flow meter on the WWTP effluent. Peaking factors from the 2017-2019 WWTP flow data and the CPU are also provided in Table 5-3. The current WWTP National Pollution Discharge Elimination System (NPDES) permit states a permitted max month flow of 7.4 MGD. Typically, planning is triggered when a WWTP experiences 85% of the permitted flow, or 6.29 MGD, for three consecutive months.

Flows derived from the calculations based on the per capita and I&I rates from the CPU are approximately 8.5% higher than the measured 2017-2019 WWTP effluent flow (4.69 MGD versus 4.32 MGD). The slightly conservative numbers derived from the population and employment projections are appropriate for planning and do not warrant the need to change projection methodology or values. The per capita and I&I numbers will be used for future flow projections.

Comparing peaking factors from recent record data to peaking factors used in the CPU there is less than 5% difference across all flow categories. Furthermore, the lower recorded peaking factors seen in the peak day flow and peak hour flow categories may be a result of flow attenuation through the WWTP given the flow is measured on the WWTP effluent. A change in peaking factors from previous planning efforts is not recommended based on the analysis herein. The peaking factors used in the CPU will be used to project future flow.

5.3 Flow Projections

The baseline flow estimate for average day flow was then applied to the future population and employment values for the 2026, 2030, 2040, and 2050 planning horizons. The I&I rate is applied to the service area. The average day flow projections for future years for individual geographies (A thru D) and at the WWTP (Total) are shown in Table 5-4 below.

Table 5-4
Average Day Flow Projections

Geography	2026 ADF (MGD)	2030 ADF (MGD)	2040 ADF (MGD)	2050 ADF (MGD)
Service area provided within the City of Lynnwood [A]	3.55	3.66	4.00	4.25
Service area provided within the City of Edmonds [B]	0.72	0.73	0.74	0.77
Service area provided to the Alderwood Mall Area [C]	0.53	0.65	0.89	1.08
Service area provided to Lynnwood City Center [D]	0.38	0.46	0.71	0.87
Total [A+B+C+D]	**5.19**	**5.49**	**6.34**	**6.97**

The flow estimates in Table 5-4 are based on the assumption that all residents will be connected to the sanitary sewer system and removed from on-site sewage (septic) systems by 2026. Parks and open spaces are assumed to remain indefinitely.

CPU peaking factors were then applied to the average flow to estimate max month, peak day, and peak hour flows at the WWTP for each of the planning horizons. The total flow projections for the City are provided in Table 5-5.

Table 5-5
Flow Projections at WWTP

	2026	2030	2040	2050
Average Day Flow (MGD)	5.19	5.49	6.34	6.97
Max Month Flow (MGD)	6.64	7.03	8.12	8.92
Peak Day Effluent Flow (MGD)	15.72	16.64	19.21	21.11
Peak Hour Effluent Flow (MGD)	22.20	23.50	27.14	29.82

Appendix E

CBE Incinerator Report

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Lynnwood WWTP Incinerator Report

for

RH2

Bothell, WA

Presented by: Chavond-Barry Engineering Corp.

Prepared By: John Yu
Checked By: LB, AH, KC Revision 2 Nov. 28, 2021

Table of Contents

OBJECTIVE

With the passing of the Clean Air Act in 1972, wastewater treatment plants started to utilize sewage sludge incinerators (SSI) as final treatment process for the sewage sludge. Most of the initial incinerators built in the 1970's were Multiple Hearth Incinerators (MHI). Lynnwood facility had the first Fluidized Bed Incinerator (FBI) for sludge incineration built in 1964, although initially incinerator had no air pollution control (APC) system, which was added later. The original incinerator was replaced in 1989 by Joy Energy. Both the incinerator and APC had several upgrades since that time to improve performance and meet new emission regulations. FBI has largely supplanted MHI for sewage sludge incineration after 1990 due to ease of operation and cleaner combustion, with many providing very long service life. Although aging, the Lynnwood incinerator has provided good service over the years. However, with the expected population growth in Lynnwood over the next 20 years, the incinerator system's condition and capacity needs to be reviewed to determine whether it is capable of meeting the future demand.

CAPACITY DETERMINATION

To determine the maximum operational capacity of the Lynnwood incinerator, we first determine their current operational status. To do so we first need to define their current sludge cake quality. Monthly operation data sheets were provided by Lynnwood and following monthly average values are extracted from those data sheets.

2019 Monthly Sludge Cake Data

	%TS (Solid% in wet sludge)	%VS (volatile% in solid)	Sludge Feed (Dry lb/hr)	Sludge Total Heat (mbtu/hr)	Sludge Solid HHV (btu/lb)	Sludge volatile HHV (btu/lb)
2019 Jan	21.9	84.5	408	3.44	8,431	9,978
2019 Feb	25.5	80.4	404	3.24	8,020	9,975
2019 Mar	23.8	82.1	371	3.05	8,221	10,013
2019 Apr	23.5	82.3	386	3.18	8,238	10,010
2019 May	22.2	84.6	368	3.11	8,451	9,989
2019 Jun	21.1	84.4	335	2.83	8,448	10,009
2019 Jul	19.8	84.4	355	3.00	8,451	10,013
2019 Aug	19.8	87.5	325	2.84	8,738	9,987
2019 Sep	18.8	85.5	329	2.82	8,571	10,025
2019 Oct	20.3	83.6	356	2.98	8,371	10,013
2019 Nov	21.9	82.0	389	3.19	8,201	10,001
2019 Dec	22.9	83.9	385	3.23	8,390	10,000
2019 AVG	21.8	83.8	368	3.08	8,378	10,001

2020 Monthly Sludge Cake Data

	%TS (Solid% in wet sludge)	%VS (volatile% in solid)	Sludge Feed (Dry lb/hr)	Sludge Total Heat (mbtu/hr)	Sludge Solid HHV (btu/lb)	Sludge volatile HHV (btu/lb)
2020 Jan	21.2	86.2	365	3.15	8,630	10,012
2020 Feb	22.5	85.4	387	3.30	8,527	9,985
2020 Mar	20.7	84.2	379	3.20	8,443	10,028
2020 Apr	21.9	84.5	391	3.30	8,440	9,988
2020 May	22.4	83.5	378	3.16	8,360	10,012
2020 Jun	21.6	84.6	386	3.26	8,446	9,983
2020 Jul	19.5	84.4	383	3.23	8,433	9,992
2020 Aug	16.4	86.7	275	2.39	8,691	10,024
2020 Sep	18.5	85.6	267	2.54	9,513	11,113
2020 Oct	20.4	86.1	282	2.42	8,582	9,967
2020 Nov	18.8	85.7	272	2.33	8,566	9,996
2020 AVG	20.4	85.2	342	2.93	8,603	10,100

From the data, it can be seen that, with few exceptions, typical sludge cake's solid percentage varies from 18% to 24% while typical volatile in sludge cake solid varies from 82% to 87%. Therefore, for calculation purposes, we selected 21% solid and 84% volatile as starting points as the typical Lynnwood sludge cake. Based on the operational sheet, the sludge volatile's heating value is around 10,000 btu/lb. This is consistent with typical US municipal waste water sludge. As the facility doesn't have any ultimate analysis of the sludge, we used a typical WWTP sludge cake composition that matches up to 10,000 btu/lb heating value using modified Dulong formula. Therefore, the sludge properties for our baseline calculation are as follow:

Assumed Lynnwood Sludge Properties:

Cake's Solid% = 21%
Solid's Volatile% = 84%
Volatile's HHV = 10,000 btu/lb
Volatile's Ultimate Analysis:

Carbon	55%
Hydrogen	7%
Oxygen	27%
Nitrogen	10%
Sulfur	0.5%
Chlorine	0.5%

Based on the monthly data, it appears Lynnwood typically feeds between 300 to 400 dry lb/hr of sludge cake to the incinerator. Therefore, using 350 dry lb/hr, Lynnwood's current typical operation heat and mass balance is calculated as follows:

H&M Balance 1: Typical Incinerator Operation

				LB/HR
Materials In:	Waste Feed (dry)			350
	Water In Waste Feed			1,317
	Combustion Air (dry) (1516 scfm)			6,957
	Water In Waste Combustion Air			64
	Fuel (Oil)			47
	Purge Air			0
	Spray Water			0
			TOTAL:	8,735
Materials Out:				LB/HR
(To PHE)	O_2			937
	N_2			5,379
	CO_2			741
	SO_2			3
	HCL			0
	HF			0
	ASH			56
	H_2O			1,616
			TOTAL:	8,733
Heat In:		LB/HR	BTU/LB	BTU/HR
Waste Feed (dry)		350	0	0
Water In Waste Feed		1,317	0	0
Combustion Air (dry)		6,957	262	1,823,317
Water In Combustion Air		64	1,537	98,835
Fuel (Oil)		47	0	0
Purge Air		0		0
SprayWater		0		0
Combustion of Combustibles in Waste		294	10,000	2,940,000
Combustion of Fuel		47	18,993	883,575
			TOTAL:	5,745,727
Heat Out:		LB/HR	BTU/LB	BTU/HR
	N_2	5,379	383	2,057,923
	CO_2	741	368	272,750
	SO_2	3	265	781
	HCL	0		435
	ASH	56	360	20,160
	H_2O	1,616	1,774	2,866,313
	R&C (3.5%)			201,100
			TOTAL:	5,745,727

There are a few items of note in the above calculation. The exhaust gas from the incinerator is assumed to be 1500°F. This is on the low range of typical FBI exhaust temperature. However, due to the slagging issue the facility has been experiencing, the operators believe running at a lower temperature reduces the slag build up and requires less downtime for slag clean out. The incinerator is also operating at approximately 140% excess air. This is much higher than typical and an indication that the incinerator has more sludge burning capacity. Running the incinerator at minimal amount of excess air required, the feed rate to the incinerator can be increased to as shown in the following heat and mass balance:

[Table in following page]

Heat and Mass Balance 2: Max Feed Condition

				LB/HR
Materials In:	Waste Feed (dry)			620
	Water In Waste Feed			2,331
	Combustion Air (dry) (1505 scfm)			6,908
	Water In Waste Combustion Air			72
	Fuel (Oil)			41
	Purge Air			0
	Spray Water			0
			TOTAL:	9,972

Materials Out:			LB/HR
(To PHE)	O_2		546
	N_2		5,365
	CO_2		1,181
	SO_2		5
	HCL		0
	HF		0
	ASH		99
	H_2O		2,774
		TOTAL:	9,969

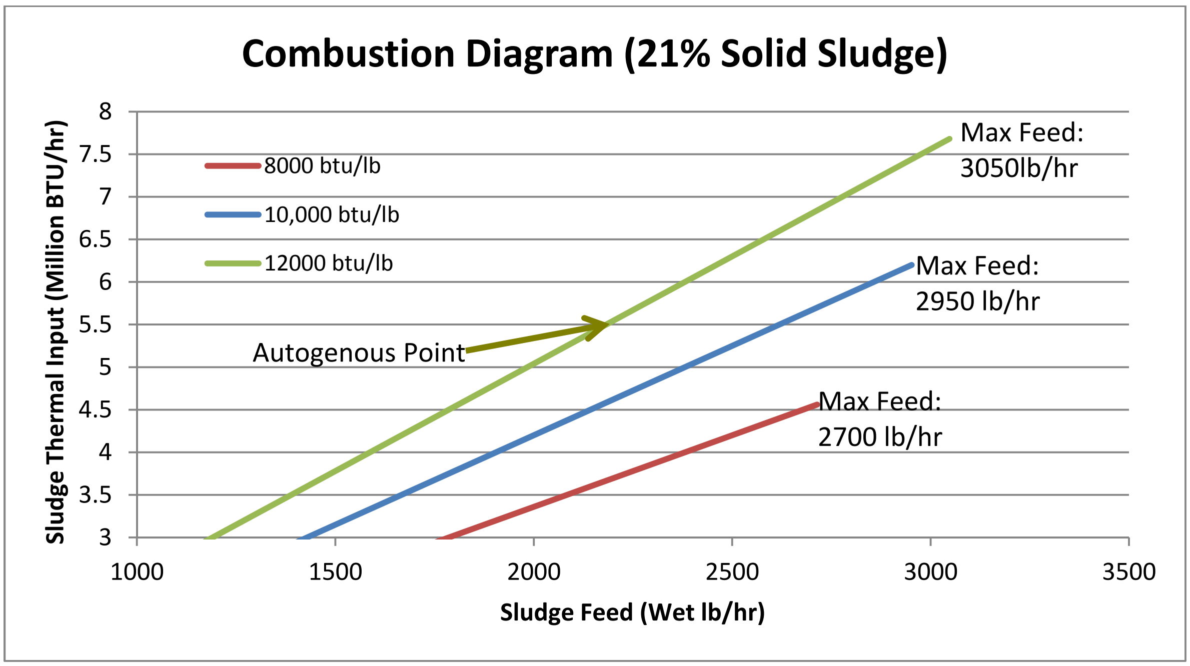
Heat In:	LB/HR	BTU/LB	BTU/HR
Waste Feed (dry)	620	0	0
Water In Waste Feed	2,331	0	0
Combustion Air (dry)	6,908	262	1,810,529
Water In Combustion Air	72	1,537	110,794
Fuel (Oil)	41	0	0
Purge Air	0		0
SprayWater	0		0
Combustion of Combustibles in Waste	520	10,000	5,203,800
Combustion of Fuel	41	18,993	785,728
		TOTAL:	7,910,851

Heat Out:			LB/HR	BTU/LB	BTU/HR
1,500	^oF	O_2	546	348	190,001
		N_2	5,365	383	2,052,223
		CO_2	1,181	368	434,524
		SO_2	5	265	1,383
		HCL	0		770
		ASH	99	360	35,683
		H_2O	2,774	1,774	4,919,387
		R&C (3.5%)			276,880
			TOTAL:		7,910,851

Based on the above, the max feed rate is about 620 dry lb/hr, which is nearly 80% over facility's current typical capacity. However, running at incinerator's maximum feed rate is difficult, when every parameter needs to be closely monitored and finely tuned. Therefore, most facilities' maximum feed rate for FBI is about 85% of FBI's theoretical design max feed rate, which about be about 527 dry lb/hr. From the operational data sheets, the highest daily average rate over the past few years was on Feb. 16, 2019 at 508 dry lb/hr, which is right around this operational maximum. Feed rate over the past year has been lower.

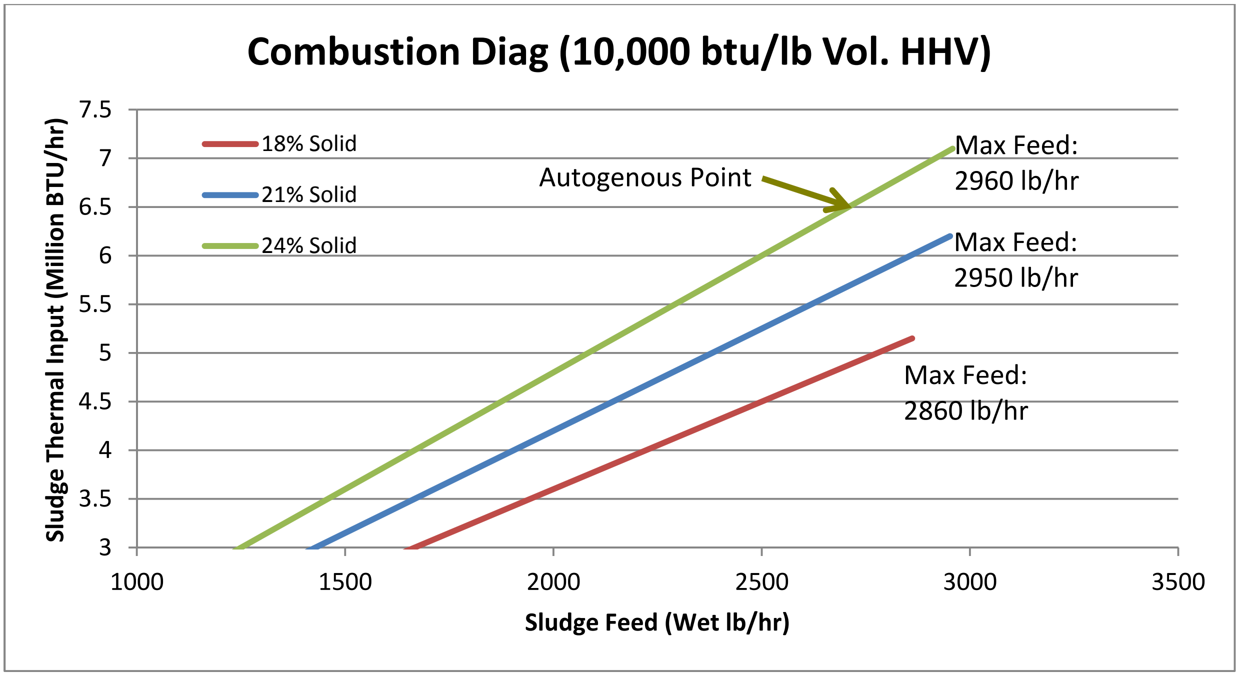
FUTURE CHANGES

With respect to possible future changes, combustion diagrams can be used to help visualize how changes of various sludge properties, such as its heating value, dryness, and other factors affect the capacity of the incinerator. The following two charts show how changes in heating value and dryness affects the combustion range of the incinerator.



In this chart, it can be seen that changing the heating value affects the maximum amount of sludge that can be burnt. With higher heating value sludge, less fuel is required so more of the incinerator's thermal capacity can be used to process sludge. In fact, at a high enough heating value, the incinerator can be operated autogenously, without any supplemental fuel oil. For sludge with volatile HHV at 12,000 btu/lb, it can be incinerated autogenously at feed rate above 2,200 wet lb/hr.

This next chart shows the how different sludge dryness affects the combustion**.**



From this chart, one can see if we hold the heating value constant and change the sludge cake's dryness, it doesn't seem to affect the wet feed rate as much. However, the higher dryness sludge cake contains much more solid, so for the 24% solid sludge cake, the max feed in dry lb/hr is 710 dry lb/hr, over 10% more than 21% solid sludge cake's feed rate of 620 dry lb/hr. So improved drying is also advantageous in improving the overall sludge handling capacity of the incinerator. Also note, at a higher dryness, the incinerator could potentially operate autogenously too. With 24% sludge, the incinerator could operate autogenously at approximately 2,710 wet lb/hr feed rate.

However, please note that the above are process condition based calculations. The incinerator also has physical limitations which we try best to model but it is difficult to tell whether it will actually allow it to be operated at the theoretical capacity. Especially since this incinerator is an older design, with some design parameters such as air distribution, ratio of freeboard vs bed, etc. might not be as optimized when compared to an incinerator of later design. This might provide a limitation on capacity that's not fully captured in the calculations above.

Some other adjustments might also able to increase the FBI's capacity. The above calculations are based 1100°F hot air from Primary Heat Exchanger to Windbox. If that can be increased to 1200°F, the design capacity can be increased slightly to approximately 640 lb/hr. Advantageously, with greater heat recovery, the incinerator can operate with less fuel oil.

POSSIBLE UPGRADES

There are some potentials of increasing capacity with physical modifications to the incinerator. However, due to the limitation of the space within the Lynnwood facility, type and magnitude of physical modification is limited. Some minor changes, which could improve the capacity, are to rebuild the incinerator with pipe tuyeres for air distribution at the bottom of the current windbox; this converts the current windbox to combustion zone and provides more volume for combustion. Adding an over-bed blower to increase the amount of combustion air available in freeboard could also potentially increase the capacity by about 10%.

Within the current space confine it might be possible to increase the incinerator bed diameter slightly. Below is a table showing the theoretical capacity and typical operational max capacity at various bed diameters.

Bed Diameter	Max Capacity (lb/hr)	Operational Max (lb/hr)
5.5’ (Current)	620	527
6’	740	630
7’	1030	875
8’	1350	1145

Therefore, a fairly small increase in diameter could provide significant increase in capacity. However, if the incinerator’s size is increased, all equipment in the system would need to be reviewed whether it could handle the extra capacity. The current EnviroCare scrubber is oversized; therefore it is able to take on a certain amount of extra capacity. But the sludge feeding system and heat exchangers would likely also need to be replaced, adding significant capital cost. Furthermore, rebuilding of the incinerator would likely require the incinerator to comply with the federal emission regulation for new SSI, which might require additional air pollution control equipment. As such, the capital cost for such an endeavor would be quite significant.

CEMS OXYGEN ISSUE

During the December 2020 stack test, Steve Nelson of Coal Creek Environmental noted the location of the CEMS oxygen port could be interfered by the heated air from the plume suppression blower and has likely been reading much higher than the actual flue gas oxygen level. Strong evidence supporting this is that, during the stack test, the stack flue gas is measured at 848 dscfm, which would indicate only about 850 scfm of combustion air, much less than the 1500 scfm reading by the fluidizing air blower flowmeter. If that level of combustion air is correct, that would only be about 6% of excess air, which is much less than minimal 30% excess air typically required for good combustion in a fluidized bed incinerator. Properly fluidizing a FBI of this size would also require at least 1000 scfm of fluidizing air. This issue could also be part of the reason why the facility has not been burning well since 2020, with high CO emission and limited burning capacity. Uncertainty of the combustion air flow and CEM oxygen reading would also make process modeling difficult.

Steve Nelson and John Yu of CBE visited Lynnwood on July 27th, 2021 to investigate this issue. With the difference between the stack flue gas reading and fluidizing air blower flowmeter not correlating, several different methods were utilized to check the FAB air flow.

Throughout the day, the FAB's flow, as indicated by the flowmeter, was kept closely at 1500 scfm. A multipoint pitot tube/manometer test was first utilized at the FAB inlet duct to determine the flow. The FAB air flow, as determined by this method, was approximately 1160 scfm.

FAB power consumption was checked next. The local meter at the FAB showed 6.7 psig at FAB outlet and -7" wc at FAB inlet for total fan pressure of 193" wc. The MCC showed about 36 kw power draw (48.3 HP). Assuming 72% fan efficiency, which is typical for FAB, this works out to about 1145 cfm of air flow.

As the bed tuyeres are essentially an orifice plate, the pressure drop across the tuyeres can be used for air flow calculation. Unfortunately, the facility's bed pressure transmitter was not working properly, so the tuyere pressure drop cannot be determined. However, it was noted that the total pressure drop of the bed tuyere and the sand bed is nearly 120" wc. This is much higher than the typical FBI operation with tuyere pressure drop of between 18" to 25" wc and sand bed pressure drop of around 60" to 70" wc, for a total pressure drop of about 85" wc between bed tuyere and sand bed. The facility has been using approximately 5' of static sand bed, which when fluidized, would likely be over 90" wc differential pressure. This matches the total pressure drop observed. Such high sand bed could cause potential bed fluidization issue, which leads to some of the operational issues the facility has observed.

Oxygen level of flue gas at outlet of the incinerator and at outlet of the secondary heat exchanger are checked and compared to the CEMS value. If there is no additional air to the flue gas, the flue gas oxygen level in dry basis at the three points (Primary Heat Exchanger Inlet, Secondary Heat Exchanger Outlet, and Stack) should be the same. With the CEMS O2 reading at range of 14.0 to 14.5%, Primary Heat Exchanger inlet's O2 reading was 12.3% and was 13.3% at secondary heat exchanger outlet. This indicates there might be a slight air leak on the heat exchangers. However, since the measurements were not taken simultaneously, it is possible there were some process changes during the time causing the reading to be different at the incinerator outlet and SHE outlet. Using the feed rate of 32.3 gpm and thickened sludge at 2.04% solid (process value during the time of the test), the feed rate was calculated to be 332 dry lb/hr (32.3 gpm * 8.4 lb/gal *0.0204 * 60 min). Heat and mass balance was performed using 18.9% sludge cake solid, 83% volatile in dry solid and typical sludge ultimate analysis with heating value of 10,000 btu/lb volatile, various possible oxygen values were calculated and presented in the following table. The 24 hour fuel oil usage on July 22nd was 180 gallons total, leaving the hourly average to be about 7.5 gallons.

O2 (% dry basis)	FAB (SCFM)	Excess Air (%)	Fuel Oil (GPH)
10.0	1170	90	7.2
12.0	1500	130	8.8
12.3	1570	138	9.1
14.5	2400	220	13.0

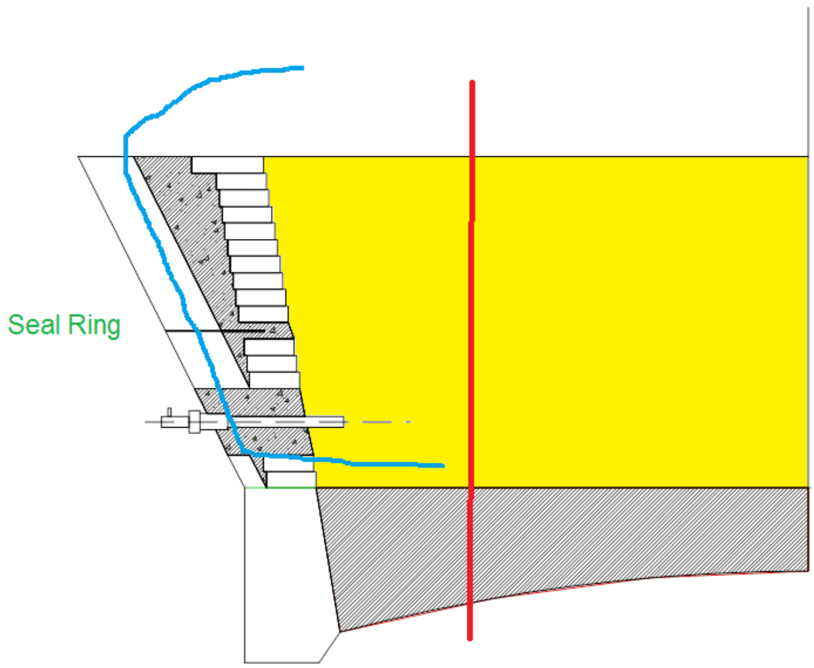
The various heat and mass balance scenarios don't seem to match other observations very well. It is possible the sludge analysis assumption is off or the portable analyzer measurement was not measuring correctly (due to leak in the temporary piping, interference from purge air, etc.). But it seems to indicate that the CEMS O2 reading is indeed too high.

For proper fluidization of this incinerator, the fluidizing air should be in 1100 to 1650 scfm range. We have arrived at several fluidizing air values based on various methods.

Method	FAB Flow (SCFM)	Note
Stack test flue gas flow	850	Based on calculation from stack flue gas flow.
FAB power calculation	1145	Assume 72% fan efficiency
Pitot Tube at FAB inlet	1160	
H&M Calculation (low)	1170	Matching fuel usage
FAB Flow Meter	1500	
H&M Calculation (high)	1570	Matching O2 value

Based on the various values above, it seems most likely the actual FAB flow is between 1150 to 1200 scfm when the FAB flowmeter is reading 1500 scfm. At this fluidizing air range, proper fluidization can be achieved, even if the FAB flow meter and the CEMS O2 are not reading correctly. Therefore, while the low fluidizing air might be part of the cause of poor fluidization and combustion issues the facility is seeing, it doesn't completely explain the poor incinerator performance.

One possibility that could explain the issues the facility is seeing might be air short circuiting the bed through the back of the refractory as shown in the graphic below. The air, instead of going through the sand bed, finds a lower pressure resistance path behind the refractory. This is more likely to occur here given the higher sand bed induces a greater pressure drop through the sand bed. This could explain why the oxygen at the incinerator outlet seems to be sufficiently high, but, due to a portion of air, was not utilized in fluidizing the sand bed and led to poor combustion. All of the fluidized bed reactors CBE knows of, built since the 90's, have a gas seal ring in the bed area to prevent this type of air short circuit. But given Lynnwood has one of the earliest fluidized bed sludge incinerators, it is not known whether this design feature is incorporated. It is also possible that the seal ring weld could have failed. More potential evidence supporting this theory is that Lynnwood reports during their annual shutdown, they still see most of the gravel at the tuyere level. The gravel is placed at the bottom of the bed covering the tuyere holes prior to the loading of sand to minimize sand shifting through the tuyere holes. However, other facilities that utilize gravel reports that the gravel wears away after a few months of operation of the incinerator; due to the air jets from the tuyere essentially sand blasting the gravel; eroding them away quickly. As gravel remains in the Lynnwood incinerator, it is an indication that there is not as much air passing through the tuyere holes. To conclusively diagnose this issue, a thermal image of the shell would show a hot zone going from bed level elevation to the top of the fluidized bed elevation. Unfortunately with the external cladding on the reactor, this would be difficult to see. However, with a properly set-up thermal camera, it should still be possible to spot the temperature difference.



OTHER ISSUES

During the past year of investigation of the Lynnwood incinerator, there have been other issues noted that prevent it from functioning optimally. Additional issues the Lynnwood incinerator is having are as follows:

1. Slagging: The Lynnwood incinerator often has slagging issue. With slag forming on the incinerator outlet cross-over duct, this greatly reduces the effective diameter of the duct and increases the pressure drop of the flue gas flow, preventing proper operation. Based on an earlier study, it was determined the sludge chemistry has high potential of slagging formation due to high amounts of sodium and potassium. CBE has designed a chemical additive system for Lynnwood that will dose proper amounts of kaolin clay and lime into the sludge to balance the chemistry, which should minimize slag formation. Currently the facility controls the slag formation by limiting freeboard temperature to less than 1500^{o}F and has limited success. However, as limiting the freeboard temperature will limit the amount of sludge can be burned; an additive treatment system would allow the incinerator to perform at its maximum capacity.
2. During the inspection, the scrubber showed signs of corrosion, which is very unusual. Envirocare, the scrubber supplier believed the wash down timer was not properly set. By having more frequent and longer wash downs it should limit acid laden water buildup at various crevices in the scrubber that cause corrosion. It has been reported with the change of wash

frequency, the scrubber corrosion seems to be reduced, but small amounts of corrosion were still found during the latest inspection in September of 2021. Basic analysis of the corroded material taken in the 2020 inspection shown high levels of iron, chromium, some nickel, and chloride. As such, the corrosion should be due to the HCl attack on the stainless steel shell.

3. Corrosion of Ductworks: The duct work, especially the crossover duct at outlet of the incinerator and top plenum of the heat exchanger have seen heavy corrosion and require frequent replacement. Shell corrosion is typically caused by condensation of acid gas on the interior of the shell. The amount of corrosion could be potentially reduced by externally insulating the duct work to maintain the shell temperature above 300^{o}F, above the acid dew points. The cross-over duct and top plenum are also under the roof hatch which seems to have a large gap. Cold air drafting in through the gap could exacerbate the corrosion by dropping the shell temperature. This is supported by the duct corrosion that seems to be worse on the top half (closer to the roof hatch) of the duct.
4. The CEMS filter also has an unusual amount of greenish material on the filter. Performing basic analysis, it shows high levels of iron, chromium, nickel and chloride. As such, it seems likely the material is from corrosion of the scrubber's or the duct work's stainless steel and it got entrained in the flue gas flow. Improvement of the scrubber corrosion should reduce the filter plugging. If not, checking of the duct corrosion is needed.
5. Sludge not pumping properly: After switching the sludge feed pump from Schwing piston pump to Seepex progressive cavity pump, the facility has been experiencing feed issues. The Seepex pump cannot properly split the sludge evenly to feed the two feed ports. As such, one port is currently blocked with all the feed to just a single port on the incinerator. However, this should not cause any operational issue. Given the size of the Lynnwood incinerator, the sludge should still be properly dispersed and combusted in the bed even with one feed port. It has been observed that fluidized bed incinerators up to 12 feet in diameter can operate adequately with a single feed port, while Lynnwood's incinerator has a 5.5 feet diameter bed. However, the sludge pump also has problems pumping to capacity when sludge dryness is above 22%. This does cause a process issue as not enough feed can be supplied into the incinerator. And with the sludge being so wet, it also greatly increases operation cost when a high amount of auxiliary fuel is needed. Possible improvements for this include: increasing the size of the sludge pipe, adding polymer lubrication to the sludge pipe, or switching the sludge pump back to a Schwing piston pump.

6. CEM Oxygen analyzer: As previously discussed, the CEMS oxygen analyzer is not located properly and is likely to be interfered by the heated plume suppression air. This invalidates the CEMS oxygen monitor's reading and makes process calculation unreliable. It is highly recommended to either relocate the CEMS port placement to one where it wouldn't be interfered by the plume suppression air or redirect the plume suppression air upward so the highly turbulent mixing of the plume air and the flue gas happens entirely downstream of the CEMS.

SUGGESTED ACTION ITEMS:

1. Given the possible air short circuit issue, that potential problem needs to be properly identified. Use an IR camera to check potential air short circuiting the sand bed. If a hot spot is noted, then the bed level refractory needs to be removed and reworked. It is recommended to add a gas seal ring if one is not currently installed. If no hot spot is found, check closely upon maintenance shutdown to see any indication of potential cracks where the air could leak and patch those.
2. Upon restart, add sand to a static height of 3' above the bed instead of 5'. However, this was tried by the facility during the restart after the September 2021 shutdown and the facility reports that they could not establish stable running with the lower sand bed and was forced to add more sand to stabilize the system.
3. Perform sludge ultimate analysis and heat value so the heat and mass balance can be better performed.
4. At the next stack test, check FAB air flow along with the flue gas flow.
5. Consider adding external cladding on hot duct work to reduce corrosion.
6. Proper seal off the air leak point around the building to reduce ingress of cold air into the building. This will also reduce acid gas condensation on the duct shells.

7. Consider rework sludge piping and/or add lubrication to improve sludge feed delivery.
8. Relocate the CEMS port to minimize interference from the heated plume suppression air.
9. CBE has provided full specification of a kaolin clay and lime addition system which, when implemented, should greatly reduce slagging issues.

Appendix F

MSA Hauling Analyses

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Preliminary Design Report - Draft

Date: February 9, 2022

Project: Lynnwood WWTP Interim Sludge Disposal

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1. Introduction

This preliminary design report discusses the scope, design criteria, equipment selection and sizing, preliminary equipment and mechanical layout related to the work for City of Lynnwood's (City's) Wastewater Treatment Plant (WWTP) Interim Sludge Disposal Design.

2. Background

The City's WWTP has been incinerating the blended thickened primary sludge and Thickened Wasted Activated Sludge (TWAS) over the last 30 years. There are many challenges associated with the operation and maintenance of the existing incinerator. The challenges compounded in 2016 when the Federal Sewage Sludge Incinerator (SSI) Regulation came into effect. The regulation required additional treatment, monitoring, and testing of the incinerator and its exhaust scrubber. The City intends to pursue alternative treatment methods for beneficial reuse as a long-term solution, but they would like to implement landfill disposal of solids until a long-term solution is implemented.

In 2021 Murraysmith conducted a feasibility study, which investigated hauling un-stabilized and dewatered sludge from the City's WWTP for landfill disposal. The feasibility study evaluated the regulatory requirements, the logistics of sludge trucking, the requirement from the potential landfill, the equipment for the sludge treatment, conveyance, loading and odor control, and costs.

The study confirmed the feasibility of constructing a sludge loading system and hauling dewatered sludge for landfill disposal.

In October 2021 the City elected to retain Murraysmith to continue providing engineering services for performing the preliminary design, final design, and construction support of the selected alternative consisting of screw conveyors, a sludge distribution system with two loading bays, a temporary sludge loadout enclosure, and an odor control system to allow the City to implement the selected disposal option at the WWTP. The scope of the design include:

- Screw conveyor and sludge distribution system
- Sludge loadout enclosure
- Odor control for the sludge loadout enclosure
- Chemical dosing system for sludge odor control

In addition to design development of the items summarized above, Murraysmith will also assist the City as they apply for and obtain all the required permits for the project. This includes a shoreline permit, substantial development permit, landfill disposal approval, mechanical, electrical, building permit, and air permit.

3. Basis of Design

3.1 Sludge Quantity and Hauling Logistics

Analysis and discussion of the sludge quantity and hauling logistics can be found in the technical memorandum entitled *Lynnwood WWTP Interim Sludge Disposal Feasibility Study* (Murraysmith August 2021). An overview of the information discussed in that memorandum can be found in Table 1 below.

Table 1 – Sludge Hauling Quantity

Sludge Quantity Details	Design Data
Daily Sludge Production (Dry)	4.5 tons/day
Minimum Percent Total Solids	20%
Maximum Percent Total Solids	30%
Range of Sludge Production (Wet)	15-23 tons/day

3.2 Permitting

Sludge Disposal Permit

As discovered in the feasibility study, Lynnwood's interim sludge landfill disposal practice will require three levels of approval, each of which is dependent on the previous approval(s).

1. Approval from the disposal company and its landfill:

   Waste Management provided specific requirement to accept the sludge at its Columbia Ridge Landfill.

   - Biosolids waste profile – the City is in the process of setting up.
   - Biosolids lab data of following - the City has the testing conducted and will upload to the waste profile once completed.
     - Eight Resource Recovery and Conservation Act (RCRA) regulated metals plus copper and zinc
     - Toxicity Characteristic Leaching Procedure (TCLP) test for the eight RCRA metals
     - Isotopic testing for Radium, Uranium and Thorium
   - Pathogen control using a chemical recommended by Waste Management – Murraysmith is including a chemical dosing system in the design. The City will plan to purchase the use the chemical Biologic SR2 recommended by Waste Management.

2. Approval from the local health department which has jurisdictional oversite of the landfill site:

   For Columbia Ridge landfill, North Central Public Health District is the authority having jurisdiction (AHJ). They have provided the approval letter to the similar case for City of Edmonds. Once the disposal company and its landfill provide the acceptance letter to Lynnwood, Murraysmith will contact North Central Public Health District to get the process moving.

3. Approval from Washington state Department of Ecology:

   Ecology has indicated they will provide written approval for disposal on a temporary basis once the following documentation is obtained:

   - Notification letter from the City providing notice of intent to implement a temporary sludge disposal program. The interim program is anticipated to last five years while onsite improvements are made to process biosolids for beneficial reuse. The City should submit this letter with assistance from Murraysmith.

   - Approval letter from North Central Public Health District – to be obtained in step 2 above.

Shoreline Permit

The City's WWTP is adjacent to the City's Puget Sound shoreline and is part of current shoreline jurisdiction defined by the Shoreline Management Act (SMA). The City of Lynnwood has a Shoreline Master Program (SMP) that complies with SMA. Per Lynnwood SMP Section 5, shoreline use for Wastewater Treatment Facilities (WTF) in the High-Intensity Environment Designation requires a Shoreline Substantial Development Permit (SSDP). The High-Intensity Environment Designation applies within 200-ft and east of the Puget Sound ordinary high-water mark (OHWM), which encompasses the area of planned improvements, therefore, a SSDP is required for this project. The applicant shall submit a complete Shoreline Permit application including a site plan, the required fees, and a SEPA Checklist to the Lynnwood Community Development Director. Confluence Environmental Company on the Murraysmith team will prepare a SEPA checklist and SSDP application at the end of 60 percent design.

Air Permit

Puget Sound Clean Air Agency (PSCAA) is the AHJ of air quality related issues for the City of Lynnwood. An initial inquiry has been sent to PSCAA regarding the permit requirement for this project. According to PSCAA, a Notice of Construction Permit is required of any new or modified air pollution source prior to construction or making modifications (including equipment, process, or design changes) that affect the level of air contaminants emitted. Although this interim sludge disposal project will not involve sewage sludge incinerator, anaerobic digesters or chlorine sterilization, and will likely receive the exempt according to PSCAA *Regulation I-6, New Source Review, Section 6.03 (C),* the City is still required to submit a complete Notice of Construction application and explain on the reason of exemption. To submit the application, the applicant is required to submit General Information Form, Environmental Checklist with signatures (unless other government agency has already requested one, in which case a copy of the checklist is required) and Source-specific application.

The Murraysmith team will lead the air permitting effort at the end of 60 percent design.

Building Permit

According to the City of Lynnwood Municipal Code, any owner or owner's authorized agent who intends to construct, enlarge, alter, repair, move, demolish, or change the occupancy of a building or structure, or to cause any such work to be performed, shall first make Building Permit application to the City of Lynnwood and obtain the permit. The applicant needs to fill out the General Building Permit Application form and email it with an electronic set of plans and other submittal requirements.

The Murraysmith team will coordinate with the City's Development & Business Services (DBS) on any required electrical, mechanical, and plumbing permits at the end of 90 percent design.

4. Site Civil Design

4.1 Site Layout and Grading

The sludge loadout enclosure will be located on the west side of the plant along the right-of-way of Burlington Northern Railroad. There is a mild slope starting from the Solids Handling Building running downward towards the western fence line. The yard is paved asphalt, and it is assumed to be designed for standard transitory loading.

The constant high point-load from the sludge loadout trailers will likely cause damage to the existing asphalt, such as rutting and cracking. This damage will increase over time inhibiting container movement and potentially creating safety issues. Surface treatment of the asphalt would likely prove insufficient. To mitigate the above issues, the existing site will need to be improved. The primary means to do so involves installing a concrete pad in the location of the sludge loadout area. This concrete pad will likely encompass the entire footprint of the sludge loadout enclosure. The pad will then be integrated into rest of the asphalt yard to prevent any drop offs between the concrete and the asphalt. In addition to the above slab, concrete footings will need to be installed along the full alignment of the conveyor at the locations of the conveyor supports. These concrete footings will ensure proper anchorage for the conveyor.

As stated above, the area surrounding the sludge loadout area has a mild cross slope. This slope is concerning as plant staff will likely be moving the containers between load in and load out. An excessive cross slope may cause a fully loaded container to tip. To address the issue Murraysmith contacted the manufacturer of a common trailer mover, Trailer Caddy. According to manufacturer guidelines, the maximum acceptable cross slope for a fully loaded container is approximately 3 percent. According to as-built drawings, the cross slope over the area in question is less than 3 percent. Regrading beyond the immediate vicinity of the sludge loadout enclosure is not expected.

Preliminary Layout

The following drawing (in Attachment 1) is developed related to the civil site design.

- Drawing C-1 Overall Site Plan

5. Mechanical Design

5.1 Screw Conveyor and Sludge Distribution System

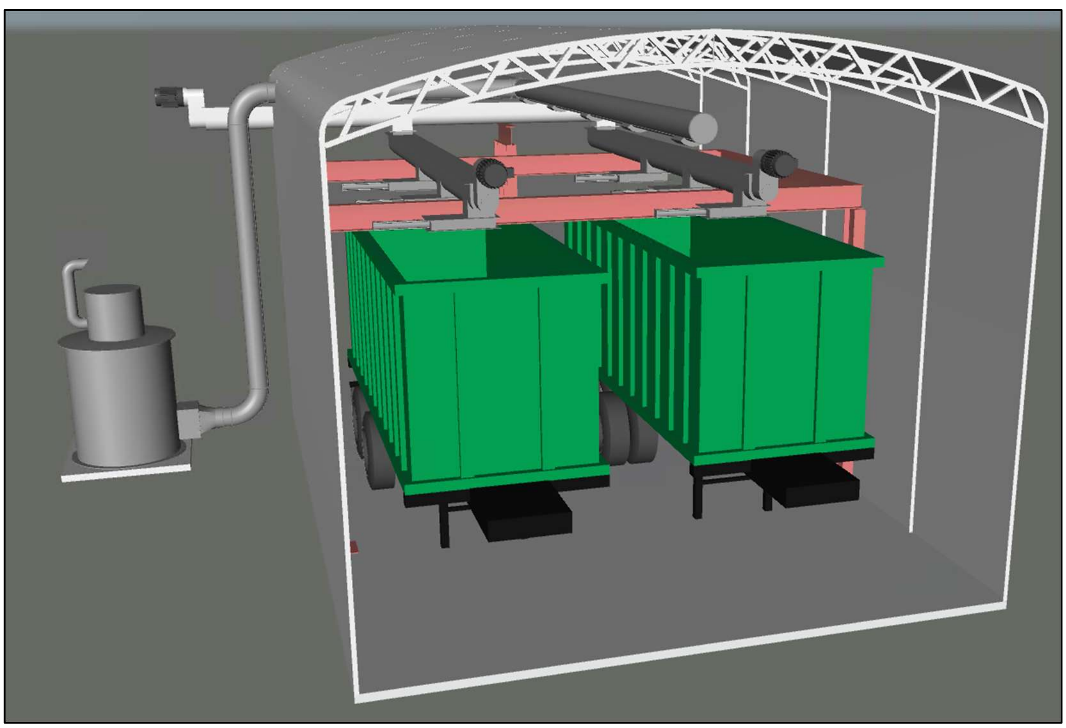
The sludge conveyance system begins within the Solids Handling Building located in the southwest corner of the plant. The conveyor exists the building heading westward across the plant site to the sludge loadout area. The following section details the screw conveyor system.

Description

The Solids Handling Building houses the plant's screw press assembly, which comprises of a screw press, a reversing screw conveyor cake distributor, and two cake pumps. Cake Pump No. 2, installed to the south of the conveyor, will be removed, and the proposed screw conveyor will be installed in its place. The conveyor then travels west out of the building under the roll-up door. No modifications to the door are anticipated for this project. A small piece of plywood may be constructed around the conveyor in the lower portion of the roll-up door opening to allow the roll-up door to be partially lowered onto the plywood to enclose the room and minimize drafts and odor problems.

Once in the plant yard, the conveyor transitions from horizontal to an incline lifting the sludge approximately 15-ft above grade. The sludge is then distributed between one of two distribution conveyors, which are installed directly over each loadout container. The distribution conveyors evenly discharge the sludge within the loadout containers. The following Figure 1 illustrated the concept for the sludge loadout area.

Figure 1
Lynnwood WWTP Sludge Loadout Concept



The conveyor assembly consists of three discrete conveyor sections. All are shaftless screw conveyors 9-inch diameter with a 9-inch pitch. The first portion of the conveyor will be placed horizontally running approximately 30 feet west from the Solids Handling Building. It will then connect to a second conveyor inclined at approximately 22-degree running for approximately 40 feet. The inclined conveyor will discharge the dewatered sludge to a third, horizontally mounted conveyor with two pneumatically actuated gates. This third conveyor will run into the sludge loadout enclosure, and the pneumatic gates will allow the sludge to be distributed between one of two discharge conveyors.

The discharge conveyors will be horizontally mounted above the sludge loadout containers, and they each have three pneumatically actuated slide gates mounted to their underside. This layout will allow distribution of the sludge to the rear, middle, and front of the loadout containers.

The pneumatically actuated gates will be plumbed into the plant's existing high pressure air system. A separate air compressor is not anticipated for this project. The pneumatic slide gates will be operated by the plant staff from the conveyors' control panel. Automated actuation of the gates built into the plant SCADA system is not anticipated for this project.

The conveyor sections will transition from one to another using standard Conveyor Equipment Manufacturers Association (CEMA) conveyor connections. Figure 2 illustrates an example connection between horizontal and inclined conveyors. See Attachment 2 for conveyor system cutsheets.

Figure 2
Transition between Horizontal and Inclined Conveyor

Design Criteria

Conveyor assembly design criteria can be found below in Table 2.

Table 2 – Conveyor Assembly Design Criteria

Conveyor Design Parameters	Design Data
Conveyor Sections	3
Design Incline	22 degrees
Minimum Capacity (Dry)	4.5 tons/day
Minimum Capacity (Wet)	23 tons/day
Sludge Percent Solids	20% -30%
Pneumatic Gate Quantity	8
Minimum Pneumatic Gate Air Pressure	80 pounds per square inch (psi)
Motor Data (total power)	20 HP
Motor Data (voltage/phase)	480v 3 phase

Preliminary Layout

The following drawings (in Attachment 1) are developed related to the screw conveyor.

- Drawing M-2 Sludge Handling Building Demolition Plan and Section
- Drawing M-3 Sludge Handling Building Screw Conveyor Plan and Section
- Drawing M-4 Sludge Loadout Plan and Section

5.2 Odor Control for the Sludge Loadout Enclosure

Odor control will be included in the design of the sludge loadout enclosure as a precautionary measure to mitigate foul odors leaving the plant. The preliminary design of the odor control system follows.

Description

The odor control system consists of a cylindrical vessel loaded with granular activated carbon. It will be connected to a single PVC duct which will be suspended from the roof structure of the sludge loadout enclosure. The unit has a top mounted fan, which will draw foul air from within the enclosure pulling it through the carbon media. Odor causing chemicals bind to this media, and the scrubbed air will be discharged to the atmosphere. No supply air ductwork is anticipated for this system as there will be enough air intrusion through the openings of the enclosure. See Attachment 2 for odor control cutsheets.

Design Criteria

The enclosure is approximated at 900 square feet with a maximum height of 18 feet. The odor control system will be designed to provide ventilation at a minimum of 4 air changes per hour (ACH), which will require a system of approximately 1,000 standard cubic feet per minute (scfm). Further design criteria can be found below in Table 3.

Table 3 – Odor Control Package Design Criteria

Odor Control Design Parameters	Design Data
Odor Control Package Capacity	1,000 scfm
Vessel Diameter	5.5 ft
Bed Face Velocity	51 ft/min
Empty Bed Residence Time	3.5 seconds
Carbon Capacity	59 cu. ft
Fan Motor Data	5 HP, 480V 3 phase
Noise Level (with attenuation)	55 decibels (dB)
Design H_2S Concentration (Peak)	10 parts per million (ppm)

Preliminary Layout

The following drawing (in Attachment 1) is developed related to the odor control package.

- Drawing M-5 Odor Control Plan and Sections

5.3 Chemical Dosing System for Sludge Odor Control

A chemical feed system is an optional addition to the project if dosing with Biologic SR2 becomes necessary. The preliminary design of the chemical feed system follows.

Description

Waste Management requires Biologic SR2 to be added to the sludge as a condition of disposal. The City may also elect to add the chemical to help with odor control if Republic Services provides disposal, although it is not required. The chemical feed system will include two peristaltic metering pumps with associated calibration columns, pulsation dampeners, and pressure release valves. The pumps and accoutrements will all be mounted onto an FRP backing panel to create a combined package system.

The design will provide two dosing locations to allow discharge either into the sludge hopper directly prior to the proposed screw conveyor or into the conveyor just prior to distribution into the containers. See Attachment 2 for chemical feed system cutsheets.

Design Criteria

Waste Management requires approximately one gallon of Biologic SR2 for each 2,000 wet tons of sludge. This equates to approximately 7 gallons of chemical per day based on the expected sludge loading. Based on this application rate, the chemical feed system will need to pump 0.3 gallons per hour (gph). Additional design criteria can be found in Table 4 below.

Table 4 – Chemical Feed System Design Criteria

Chemical Feed Design Parameters	Design Data
Pump Quantity	2
Pump Type	Peristaltic Metering Pump
Pump Capacity	0.04 – 0.4 gph
Motor Data	50W 120V or 240V 1 phase
VFD	Yes, Integrated in pump housing
Discharge Location	Sludge hopper, prior to conveyance -or- Screw conveyor prior to discharge

6. Structural Design

6.1 Sludge Loadout Enclosure

The sludge loadout enclosure is a temporary structure intended to contain odors and prevent rain intrusion to the dewatered sludge. The following section provides a description of the system.

Description

The proposed container loading area consists of a single 25-ft by 35-ft pre-engineered structure located approximately 2 feet from the property line at the southwest corner of the project site. The site coordinates are 47.84647, -122.33965. This fully enclosed building will house the two 20-ft long loading containers, sludge conveyor equipment, and structural support of the conveyor. The skeleton structure shall be approximately 18-ft tall providing a 16-ft minimum vertical clearance. Sludge disposal containers are trucked in and out through a door with the opening up to 12-ft wide x 16-ft high, located on the north end of the building. The structure is fully enclosed and sealed to allow for the installation and operation of an odor control system with negative pressure system. For selection of structure type, both pre-engineered fabric-lined structure and pre-fabricated steel building will be considered as alternative options.

For either alternative, the building will be supported by a monolithic concrete footing/slab on grade. This slab will also support sludge conveyor equipment and the containers themselves. See Figures 3 and 4 for examples of the pre-engineered fabric-lined structure and pre-fabricated steel structure alternatives, respectively, which may be used for this project.

Figure 3
Alternative 1 - Pre-engineered Fabric Structure

Figure 4
Alternative 2 - Pre-engineered Steel Structure

The loading containers are approximately 20-ft long by 8.5-ft wide by 8-ft tall and sit on chassis-style wheel beds. These containers are used to collect the sludge material and transport it to an off-site disposal area. See Figure 5 for a photo example of the equipment that is used to transport the containers.

Figure 5
Example Chassie-style Bed for Transportation of Loading Containers

Within the sludge loadout enclosure, a screw conveyor manufacturer designed steel structure will be installed to support the conveyors above the loading containers. It is anticipated that the frame will consist of structural steel wide flange frames. The entire enclosure will be supported on a monolithic concrete slab-on-grade and contain a central drain located within the building footprint. Location of the drain will be coordinated as to not interfere with the steel support structure. The slab is designed to support wheel loads from a fully loaded container (30-ton total) as well as any loading demands from the screw conveyor support frame (to be provided by the supplier). See Section 6.2 for additional information on the screw conveyor support.

A 6-ft by 6-ft concrete equipment pad will be installed adjacent to the enclosure to support a 5.5-ft diameter odor control carbon vessel. Duct for the odor control system will extend from the carbon vessel into the enclosure. The duct will be suspended from the enclosure structure.

6.2 Equipment and Pipe Support

Description

Structural design of the screw conveyor equipment between the Solids Handling Building and the sludge loadout enclosure includes the vertical support and anchorage of the conveyors as well as spread footings spaced at regular intervals (assumed to be 20-ft maximum) along the conveyor alignment per the supplier's design. Spread footings shall be designed to maintain soil bearing pressures equal to or less than 1,500 pounds per square foot (psf) (Table 1806.2 from 2018 Washington Building Code). The sludge conveyor equipment manufacturer shall provide support reactions to facilitate foundation and anchorage design. These reactions will include lateral load effects from wind and seismic.

6.3 Design Criteria

Loading criteria for the design of the various components of the sludge loadout enclosure, concrete slab, screw conveyor support, and odor control system anchorage are summarized below. Loads are generated for the enclosure based on the *2018 International Building Code (IBC)* and ASCE 7-16. Due to the light weight of the enclosure and the high wind speeds specific to the site, the enclosure lateral design will likely be governed by wind loading but seismic checks are included. The full enclosure design will be completed by the pre-engineered building manufacturer, following a performance specification generated by the design team. The design team will coordinate with the manufacturer as well as complete anchorage and foundation design. All loads required for the foundation and anchorage design is provided to the manufacturer. The structure is anticipated to be in place to a maximum of five years but is not considered a temporary structure under the definitions prescribed in ASCE 37, thus no reductions in short-term loading (wind or seismic) is permitted. The building and all associated structures on this project shall meet design requirements per the IBC/ASCE 7.

The wind loads on the enclosure are determined using the Directional Procedure prescribed in ASCE 7-16 Chapter 27, seismic design is generated per ASCE 7-16 Chapter 12. The screw conveyor and odor control equipment anchorage are designed as non-structural components. These are designed to satisfy both wind and seismic lateral loading requirements prescribed in ASCE 7-16 Chapter 29 and ASCE 7-16 Chapter 13, respectively. See Table 5 below for a summary of the design parameters.

Table 5 – Loading Design Criteria per 2018 IBC

Load Generation Criteria	
Risk Category	III
Ultimate Basic Design Wind Speed	105 miles per hour (mph)
Wind Exposure Category	D
Ground Snow Load	25 psf
Short-period spectral acceleration	1.461 g
1-second spectral acceleration	0.566 g
Site Classification	Class D (per Geotechnical report)
Roof Live Load	5 psf (fabric construction supported by skeleton structure)
Superimposed Dead Load	10 psf (includes allowance for ductwork, lighting, etc.)
Superimposed Concentrated Load	300 lbs. (concentrated load at roof structure)
Design Vehicle Wheel Load	8,000 lbs.
Design Total Container Load	30 tons

Additional loads not provided in the table above include anchorage and foundation loads for the screw conveyor and the odor control vessel, which are provided by the respective manufacturers and included in the design phase of this project.

6.4 Other Structural Considerations

The odor control system includes duct that will run along the roof ridge on the interior of the enclosure and shall be suspended from the enclosure structure. These loads are assumed as a 10-psf superimposed dead load and includes an allowance for lighting and other piping. A 300-lb point load to truss bottom chords to support temporary suspended loads is also included.

7. Electrical and Instrumentation & Control Design

7.1 Existing Power Supply

The screw conveyance system will require 3-phase 480 VAC power. The nearest power available for this is Motor Control Center – D (MCC-D) located in Area 3 on the upper floor of the Solids Handling Building. It has spare capacity, including a spare 100A circuit breaker. The new system will only require around 30 Amps at 480 VAC.

There is spare power from MCC-D to also feed the odor control system, and the chemical dosing pump skid. 120VAC power will either be sourced from the existing FKC Panelboard, or a new low voltage transformer will be added.

7.2 Design Criteria

The control panel for the conveyors is provided by the conveyor system supplier. It will include all the motor starters, relays, indicator lights, push buttons, and miscellaneous items required for complete local control of the system. The conveyors are provided with e-stop pull cords and zero speed switches. The slide gates will have open and closed limit switches, connected to the supplier provided control panel. The control panel will have all controls to operate the system in manual or automatic mode. It is integrated with the plant control system to allow for SCADA control.

This conveyor control panel will be integrated with the plant SCADA. An Ethernet communication link will allow for SCADA to read/write most signals needed. There is an ethernet switch with a spare port in the SHCP control panel, located on the lower floor. In addition to Ethernet communications, some hardwired I/O are included for enabling the system and for general fault indication. There are two nearby control panels in the Solids Handling area that could accommodate this. The existing Screw Press Control Panel (CP1) has a Micrologix 1400 PLC that has some spare I/O, and the SHCP panel on the lower floor has spare 24VDC I/O.

The odor control system will require around 5 HP of 480VAC power. It will be fed from the same 100A feed to the conveyor system control panel, or another spare bucket may be available in MCC-D. It will have a standalone panel, either provided by the supplier or included in the design. It will be able to run in manual, or from the SCADA system. It will be integrated with the SCADA system for basic control and monitoring.

The chemical dosing pump skid will require minimal power at 120 VAC. Similar to the odor control and conveyors, it will also be integrated into SCADA for basic control. It will be provided with a run command, and a feedback signal that shows it is running.

Above ground electrical conduits are rigid galvanized steel (RGS). All wiring is copper and sized per the NEC. Type THWN wire insulation is used for most branch circuits. Shielded cables is used for signal wiring and analog devices.

The Wonderware SCADA system will require screen additions to allow for control and monitoring of the conveyors, odor control, and chemical dosing. There is one computer in the control room, and one in the MCC/switchgear room that will require changes. The existing screen for the incinerator will be removed from SCADA.

7.3 Other Electrical and Instrumentation & Control Considerations

The electrical design will comply with NFPA 70 – National Electrical Code (NEC), along with any local or state codes.

8. Engineer's Opinion of Preliminary Construction Cost (OPCC)

Engineer's Opinion of Preliminary Construction Costs (OPCC) are estimated and summarized in Table 6 below, including:

- Screw conveyor and sludge distribution system
- Sludge loadout enclosure
- Odor control for the sludge loadout enclosure
- Chemical dosing system for sludge odor and pathogen control

Table 6 – OPCC of Lynnwood Sludge Disposal System

Items	Construction Cost	Capital Cost
Sludge Disposal System	$1,700,000	$2,100,000

Cost estimates were prepared to American Association of Cost Engineers (ACCE) Class 5 estimate standards for planning-level evaluations with a range of -50 percent to +100 percent. The estimate is in 2022 dollars. The construction cost estimate is an opinion of cost based on information available at the time of the estimate. Final costs will depend on several factors including actual field conditions, actual material and labor costs, market conditions for construction, regulatory factors, schedule, and other variables.

This estimate reflects Murraysmith's professional opinion of accurate costs currently and is subject to change as the project design matures. Murraysmith has no control over variances in the cost of labor, materials, equipment; nor services provided by others, Contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices, or bidding strategies. Murraysmith cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown. See Attachment 3 for the detailed cost estimates.

The following markups have been applied to the cost estimate.

- Contractor mobilization, general conditions, overhead, and profit of 30%
- Local sales tax of 10.4%
- Contingency of 30%
- Engineering, legal, and administration of 25%

Attachments

Attachment 1 – Preliminary Design Drawings

Attachment 2 – Equipment Cutsheets

Attachment 3 – Preliminary Construction Cost Estimate murraysmith

ATTACHMENT 1

LYNNWOOD
WASHINGTON

LYNNWOOD WWTP INTERIM SLUDGE DISPOSAL DESIGN AND SDC

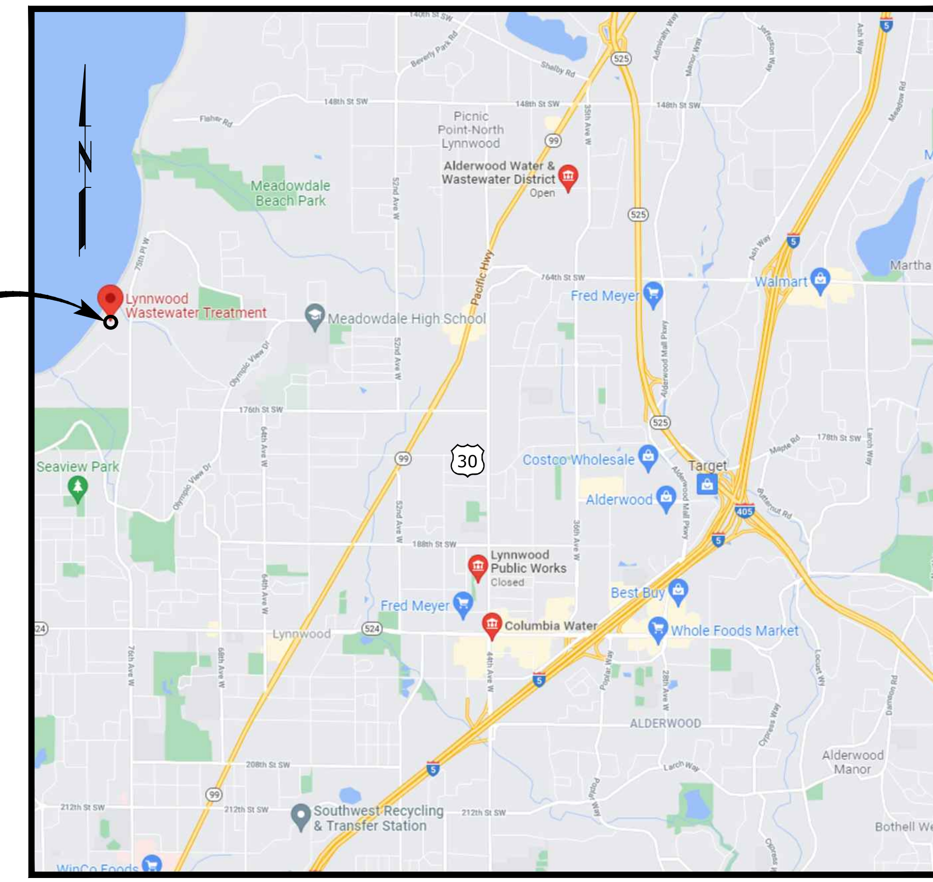
FEBRUARY 2022

30% SCHEMATIC DESIGN

DRAWING INDEX

GENERAL			
1	G-	1	Title Sheet, Vicinity Map, and Index of Drawings
2	G-	2	Abbreviations, Symbols, Legend, and General Notes
CIVIL			
3	C-	1	Overall Site Plan
4	C-	2	Temporary Erosion and Sediment Control Plan
5	C-	3	Civil Details
STRUCTURAL			
6	S-	1	Structural General Notes and Abbreviations
7	S-	2	Sludge Loading Enclosure Structural Plan
8	S-	3	Sludge Loading Enclosure Sections
9	S-	4	Structural Details
MECHANICAL			
10	M-	1	Mechanical Legend and Standard Details
11	M-	2	Sludge Handling Building Demolition Plan and Section
12	M-	3	Sludge Handling Building Screw Conveyor Plan and Sections
13	M-	4	Sludge Loadout Plan and Sections
14	M-	5	Odor Control Plan and Sections
15	M-	6	Mechanical Sections and Details
ELECTRICAL			
16	E-	1	Electrical General Notes and Abbreviations
17	E-	2	Electrical Symbols and Legend and Standard Details
18	E-	3	Electrical One Line Diagram
19	E-	4	Building Power and Instrumentation Plan
20	E-	5	Electrical Panel Schedule
21	E-	6	Electrical Schematic Wiring Diagrams
22	E-	7	Electrical & Grounding Details

PROJECT LOCATION



VICINITY MAP
SCALE: NTS

PROJECT ADDRESS: 17000 76th AVE W
EDMONDS, WA 98026

murraysmith
888 SW 5TH AVENUE, SUITE 1170
PORTLAND, OREGON 97204
P 503.225.9010

21-3310

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GENERAL NOTES

1. CONTRACTOR SHALL OBTAIN ALL NECESSARY LOCAL, COUNTY, STATE, AND UTILITY CONSTRUCTION PERMITS, AND SHALL CONTACT EACH PERMITTING AGENCY AT LEAST TWO (2) BUSINESS DAYS PRIOR TO STARTING WORK. CONTRACTOR SHALL OBTAIN ALL REQUIRED LICENSES BEFORE STARTING CONSTRUCTION.

2. THIS WORK TO TAKE PLACE DURING NORMAL TREATMENT PLANT OPERATIONS. CONNECTIONS TO EXISTING STRUCTURES WILL REQUIRE TEMPORARY SHUTDOWNS OF UNIT PROCESSES. COORDINATE WITH CITY OPERATIONS STAFF TO IDENTIFY CONSTRUCTION WINDOWS TO PERFORM THE WORK WITH MINIMAL PROCESS SHUTDOWNS.

3.THE LOCATIONS OF ALL EXISTING UNDERGROUND FACILITIES SHOWN ON THE PLANS ARE BASED ON INFORMATION SUPPLIED BY UTILITY COMPANIES. LOCATIONS ARE NOT GUARANTEED TO BE COMPLETE OR ACCURATE. NO SURVEY WAS COMPLETED FOR THIS PROJECT. THE CONTRACTOR SHALL VERIFY LOCATIONS, ELEVATIONS, TYPE AND SIZES OF ALL EXISTING UTILITIES PRIOR TO CONSTRUCTING NEW PIPING/CONDUITS AND SHALL ADJUST NEW PIPING/CONDUITS AS REQUIRED. CONTRACTOR SHALL NOTIFY ENGINEER IMMEDIATELY OF ANY CONFLICTS NOT SHOWN ON THE PLANS AND SHALL KEEP EXISTING UTILITIES IN SERVICE AND PROTECT THEM DURING CONSTRUCTION. WHERE INTERRUPTION OF EXISTING FACILITIES IS REQUIRED, CONTRACTOR SHALL PROVIDE 7 DAYS NOTICE TO ENGINEER AND THE AFFECTED UTILITY. CONTRACTOR SHALL ARRANGE FOR THE RELOCATION OF ANY IN CONFLICT WITH THE PROPOSED CONSTRUCTION.

4. CONTRACTOR SHALL INSTALL AND MAINTAIN EROSION AND SEDIMENTATION CONTROL DURING CONSTRUCTION (ANY TIME OF YEAR) PER THE REQUIREMENTS OF THE CITY OF SCAPPOOSE, COLUMBIA COUNTY, AND THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY (DEQ).

5. CONTRACTOR SHALL KEEP AND MAINTAIN A CURRENT SET OF DRAWINGS ON SITE. CONTRACTOR TO KEEP ACCURATE "AS-BUILT" RECORD COPY OF PLANS. "AS-BUILT" PLANS TO BE RETURNED TO ENGINEER AT COMPLETION OF PROJECT.

6. ANY ALTERATION OR VARIANCE FROM THESE PLANS, EXCEPT MINOR FIELD ADJUSTMENT NEEDED TO MEET EXISTING FIELD CONDITIONS, SHALL FIRST BE APPROVED BY THE ENGINEER. ANY ALTERATIONS OR VARIANCE FROM THESE PLANS SHALL BE DOCUMENTED ON CONSTRUCTION FIELD PRINTS AND TRANSMITTED TO THE ENGINEER. ANY PROPOSED CHANGES IN CONSTRUCTION PLANS MUST BE SUBMITTED IN WRITING AND APPROVED BY ENGINEER PRIOR TO COMMENCING WORK.

7. THE CONTRACTOR SHALL DISPOSE OF ALL REMOVED OR REPLACED MATERIAL AND EQUIPMENT IN ACCORDANCE WITH ALL APPLICABLE REGULATIONS, EXCEPT THOSE ITEMS DESIGNATED BY THE OWNER FOR SALVAGING. SALVAGED ITEMS SHALL REMAIN THE PROPERTY OF THE OWNER, AND SHALL BE CAREFULLY REMOVED AND STORED AS DIRECTED.

8. ALL STRUCTURES, LOTS, SWALES, DITCHES, CURBS, SPEED BUMPS, FENCES, WALLS, MAILBOXES, SIGNS, POLES, GUY WIRES, PIPING, AND UTILITIES DISTURBED DURING CONSTRUCTION TO BE RESTORED TO EXISTING CONDITION UNLESS OTHERWISE SPECIFIED. SUCH REPAIR SHALL BE CONSIDERED INCIDENTAL.

9. ALL FLANGE CONNECTIONS TO BE PROVIDED WITH FULL-FACE GASKETS.

10. PROVIDE "AS CONSTRUCTED" DRAWINGS INDICATING ALL CHANGES IN GRADE, ALIGNMENT, FITTINGS AND MATERIALS INSTALLED AND ANY OTHER UTILITIES OR OBSTACLES NOT SO INDICATED ON THESE PLANS.

11. AT THE END OF EACH WORK DAY ALL OPEN TRENCHES SHALL BE BACKFILLED AND ALL TRENCHES WITHIN STREETS SHALL BE TEMPORARILY PAVED OR COVERED TO THE SATISFACTION OF THE OWNER.

12. CONNECTIONS TO EXISTING STRUCTURES WILL REQUIRE TEMPORARY SHUTDOWNS OF EXISTING FACILITIES. THE CONTRACTOR SHALL COORDINATE THIS WORK WITH CITY OPERATIONS STAFF AND PROVIDE A MINIMUM OF 7 DAYS ADVANCE NOTICE PRIOR TO PERFORMING THIS WORK.

13. NO UNDERGROUND WORK SHALL BE "BURIED" UNTIL INSPECTED AND APPROVED BY THE OWNER'S REPRESENTATIVE.

14. ALL EXPOSED PVC TO BE COATED FOR UV RESISTANCE, SEE SPECIFICATIONS.

ABBREVIATIONS

AB	ANCHOR BOLT
AC	ASPHALTIC CONCRETE
ANC	ANCHOR
APPROX	APPROXIMATE
APPVD	APPROVED
ASSY	ASSEMBLY
BFV	BUTTERFLY VALVE
BLDG	BUILDING
BO	BLOW-OFF
BV	BALL VALVE
CHKV	CHECK VALVE
CL	CENTER LINE
CMU	CONCRETE MASONRY UNIT
CND	CONDUIT
CO	CLEAN OUT
CONC	CONCRETE
CONST	CONSTRUCTION
COP	COPPER
CORP	CORPORATION
CPLG	COUPLING
CR	CRUSHED ROCK
CSP	CONCRETE SEWER PIPE
D	DRAIN
DET	DETAIL
DI	DUCTILE IRON
DIA	DIAMETER
DIM	DIMENSION
DR	DRAIN
DWG	DRAWING
DWY	DRIVEWAY
EA	EACH
EL	ELEVATION
E/ELEC	ELECTRIC(AL)
EOP	EDGE OF PAVEMENT
EQ	EQUAL
ESMT	EASEMENT
EW	EACH WAY
EXIST	EXISTING
FA	FOUL AIR
FAB	FABRICATE
FD	FLOOR DRAIN
FIN GR	FINISH GRADE
FITG	FITTING
FLEX	FLEXIBLE
FLG	FLANGE
FLR	FLOOR
FM	FORCE MAIN
FTG	FOOTING
GALV	GALVANIZED
GRVL	GRAVEL
GV	GATE VALVE
HORIZ	HORIZONTAL
ID	INSIDE DIAMETER
J-BOX	JUNCTION BOX
JT	JOINT
LB	POUNDS
LF	LINEAR FOOT
LS	LONG SLEEVE
MATL	MATERIAL
MAX	MAXIMUM
MFR	MANUFACTURER
MH	MANHOLE
MIN	MINIMUM
MJ	MECHANICAL JOINT
ML	MIXED LIQUOR
MMDWF	MAX MONTH DRY WEATHER FLOW
MMWWF	MAX MONTH WET WEATHER FLOW
NIC	NOT IN CONTRACT
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
NO.	NUMBER
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
OHA	OREGON HEALTH AUTHORITY
OPNG	OPENING
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
OWRD	OREGON WATER RESOURCES DEPARTMENT
PE	PLAIN END
PERF	PERFORATED
PERP	PERPENDICULAR
PDF	PEAK DAY FLOW
PGE	PORTLAND GENERAL ELECTRIC
PROP	PROPOSED
PRV	PRESSURE REDUCING VALVE
PS	PUMP STATION
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PVC	POLYVINYL CHLORIDE
PW	POTABLE WATER
RAS	RETURN ACTIVATED SLUDGE
RDCR	REDUCER
REINF	REINFORCE(D)(ING)(MENT)
REQ'D	REQUIRED
RESTR	RESTRAINED
RFCA	RESTRAINED FLANGED COUPLING ADAPTER
RS	RAW SEWAGE
R/W	RIGHT-OF-WAY
SCHED	SCHEDULE
SD	STORM DRAIN
SF	SQUARE FEET
SHT	SHEET
SLP	SLOPE
SPECS	SPECIFICATIONS
SPL	SPOOL
SS	SANITARY SEWER
SST	STAINLESS STEEL
STA	STATION
STD	STANDARD
STL	STEEL
T	TELEPHONE
TB	THRUST BLOCK
TELM	TELEMETRY
TEMP	TEMPORARY
THK	THICK
TYP	TYPICAL
VV	VALVE VAULT
VERT	VERTICAL
W	WATER
W/	WITH
XFMR	TRANSFORMER

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GENERAL

GENERAL NOTES & ABBREVIATIONS

PROJECT NO.: 21-3310 SCALE: AS NOTED DATE: February 2022

SHEET G-2

2 ##

PIPE & FITTING SYMBOLS

PLANT | SCHEMATIC

- WELDED JOINT
- FLANGED JOINT
- GROOVED END JOINT
- MECHANICAL JOINT
- PUSH-ON JOINT (RUBBER GASKET)
- FLANGED COUPLING ADAPTER
- DOUBLE BALL FLEXIBLE EXTENSION COUPLING
- FLEXIBLE COUPLING W/ THRUST RING
- 90° BEND UP
- 90° BEND DOWN
- TEE UP
- TEE DOWN
- LATERAL UP
- LATERAL DOWN
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- UNION
- BLIND FLANGE
- CAP
- LONG SLEEVE
- FLEXIBLE COUPLING
- FITTING (45°)

VALVE SYMBOLS

PLANT | SCHEMATIC

- BUTTERFLY VALVE
- GATE VALVE
- GLOBE VALVE
- BALL VALVE
- BALANCING VALVE
- PLUG VALVE (TOP)
- PLUG VALVE (SIDE)
- 3-WAY PLUG VALVE
- CHECK VALVE
- SWING CHECK VALVE
- DOUBLE CHECK ASSEMBLY
- BALL SWING CHECK
- SILENT CHECK VALVE
- PRESSURE REDUCING VALVE
- ALTITUDE CONTROL VALVE
- SOLENOID VALVE
- RELIEF VALVE
- NEEDLE VALVE
- HOSE BIBB (SIDE)
- REDUCED PRESSURE BACKFLOW PREVENTER W/ GATE VALVES
- HOSE BIBB (TOP)

TOPOGRAPHIC LEGEND

	EXISTING	PROPOSED
WATERLINE	10"W	12"DI W
ELECTRICITY	E	E
GAS	4"G	4"G
FIBER OPTIC	FO	2"FO
TELEPHONE/TELEMETRY	T	T
CABLE TELEVISION	CATV	CATV
SANITARY SEWER LINE	8"SS	8"SS
SANITARY SEWER FORCE MAIN	6"FM	6"FM
STORM DRAIN	8"SD	8"SD
CULVERT		18"D
ABANDON PIPE		
DRAINAGE DITCH		
CREEK CENTERLINE		
BARBWIRE FENCE		
CHAIN LINK FENCE		
TEMPORARY SILT FENCE		
STRAW WATTLES		
TREE/BUSH LINE		
CENTERLINE		
EASEMENT/PROPERTY LINE		
RIGHT-OF-WAY		
EDGE OF PAVEMENT/AC		
EDGE OF GRAVEL		
CURB		
SIDEWALK	S/W	
STRUCTURE OR FACILITY		
CONTOUR MINOR		
CONTOUR MAJOR	200	200
MANHOLE		
CLEAN-OUT		
CATCH BASIN/FIELD INLET		
ECOLOGY BLOCK		
VALVE		
AIR INJECTION ASSEMBLY		
BLOW-OFF ASSEMBLY		
AIR RELEASE ASSEMBLY		
FIRE HYDRANT ASSEMBLY		
WATER METER		
REMOVABLE BOLLARD		
BOLLARD		
PULL BOX/JUNCTION BOX		
UTILITY POLE		
GUY WIRE		
LIGHT POST		
MAILBOX		
SIGN		
BENCHMARK		
TREE DECIDUOUS		
TREE CONIFEROUS		
TREE TO BE REMOVED		X
SURFACE ELEVATION	+ 17[illegible]	

SECTION AND DETAIL DESIGNATIONS

SECTION DESIGNATIONS

A / 2 — SECTION LETTER DESIGNATION; SHEET WHERE SECTION IS SHOWN *

SECTION
SCALE:

A / 2 — SECTION LETTER DESIGNATION; SHEET FROM WHICH SECTION IS TAKEN *

DETAIL DESIGNATIONS

DETAIL
SCALE:

2 / 2 — DETAIL NUMBER; SHEET FROM WHICH DETAIL IS TAKEN *

* NOTE: IF PLAN AND SECTION FOR DETAIL CALL-OUT AND DETAIL ARE SHOWN ON THE SAME DRAWING, DRAWING NUMBER IS REPLACED WITH A DASH.

MISCELLANEOUS PIPING SYMBOLS

- STRAINER
- SIGHT GLASS
- PRESSURE GAUGE W/ COCK
- PRESSURE SWITCH W/ COCK
- M — METER
- SP — SLIP-ON JOINT PIPE
- R — RESTRAINED JOINT PIPE

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LEGEND

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SHEET G-3

3 ##

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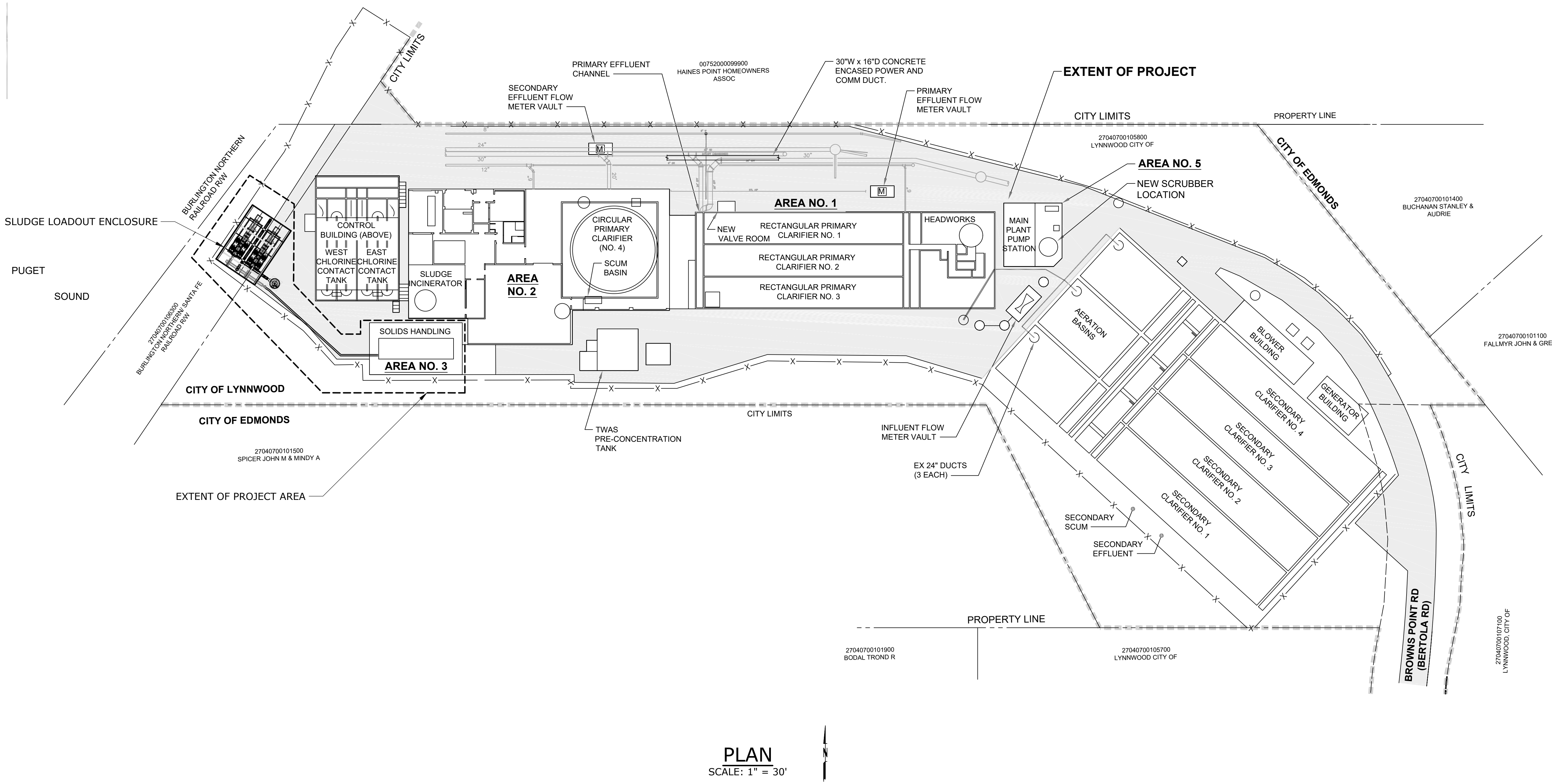

PLAN
SCALE: 1" = 30'

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CIVIL

OVERALL SITE PLAN

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SHEET
C-1
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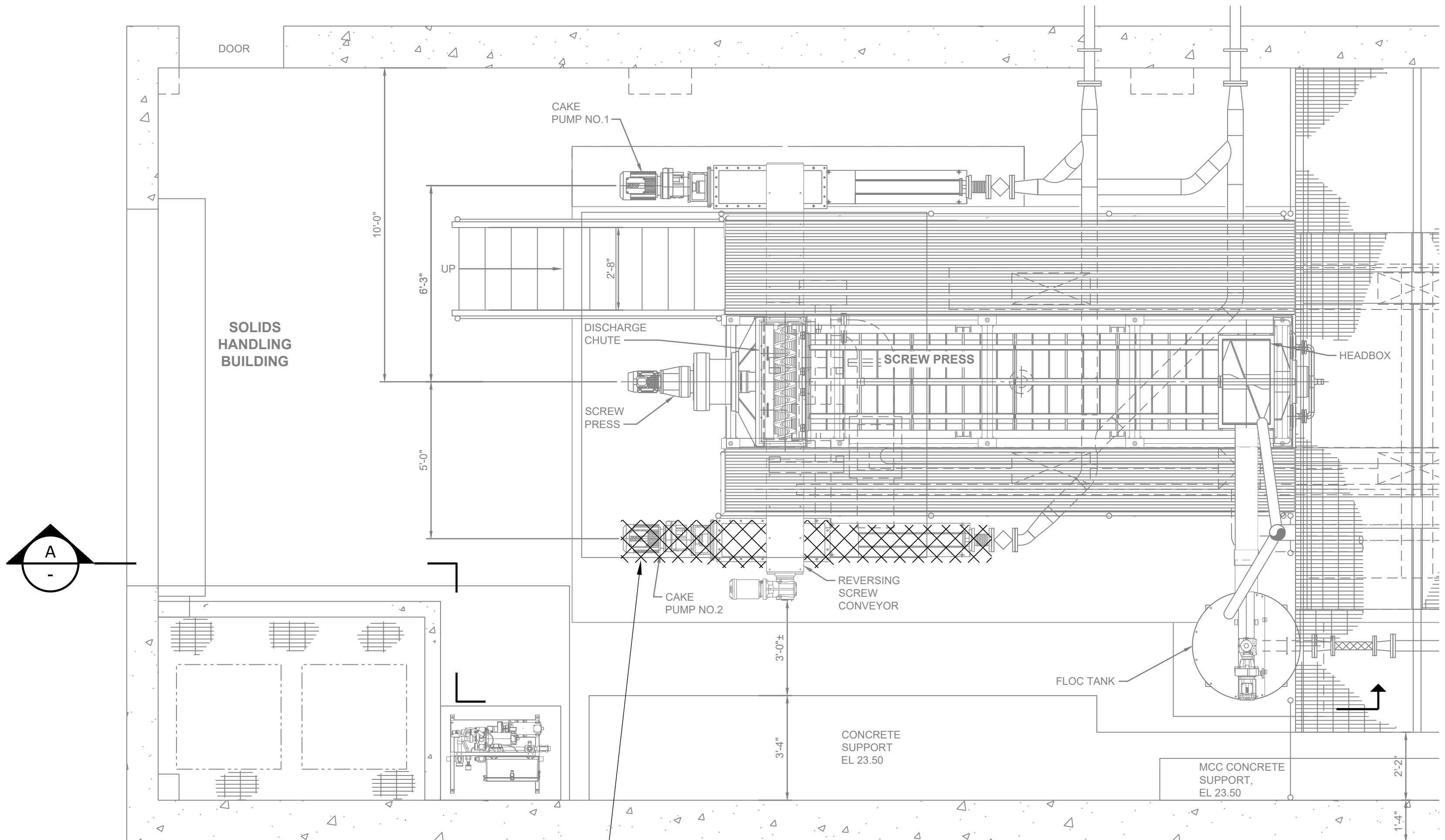
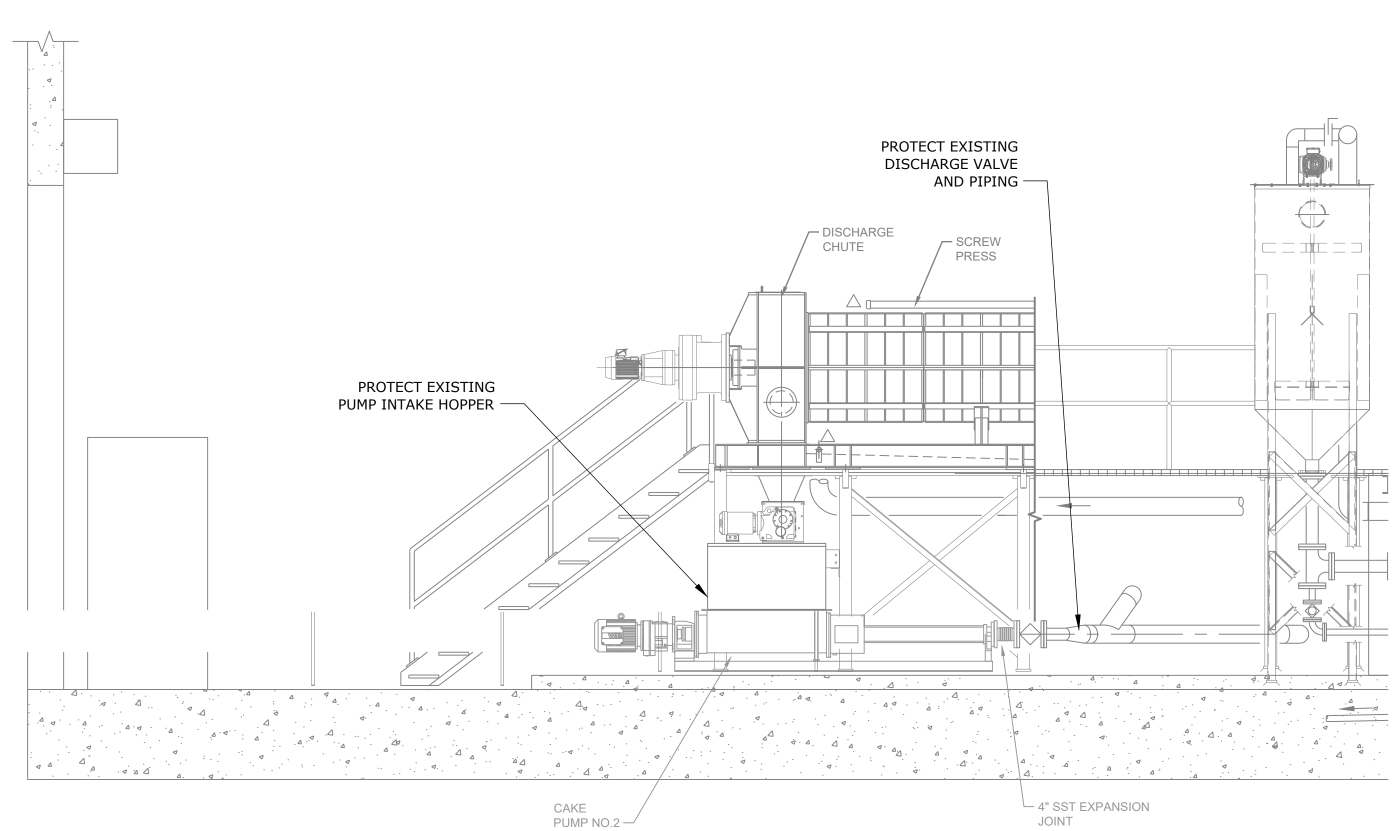


REMOVE AND SALVAGE CAKE PUMP NO. 2
AND EXPANSION JOINT, SEE PHOTO DETAIL 1

PLAN
SCALE: 3/8" = 1'-0"



SECTION A -
SCALE: 3/8" = 1'-0"

PHOTO DETAIL 1 -
SCALE: NTS

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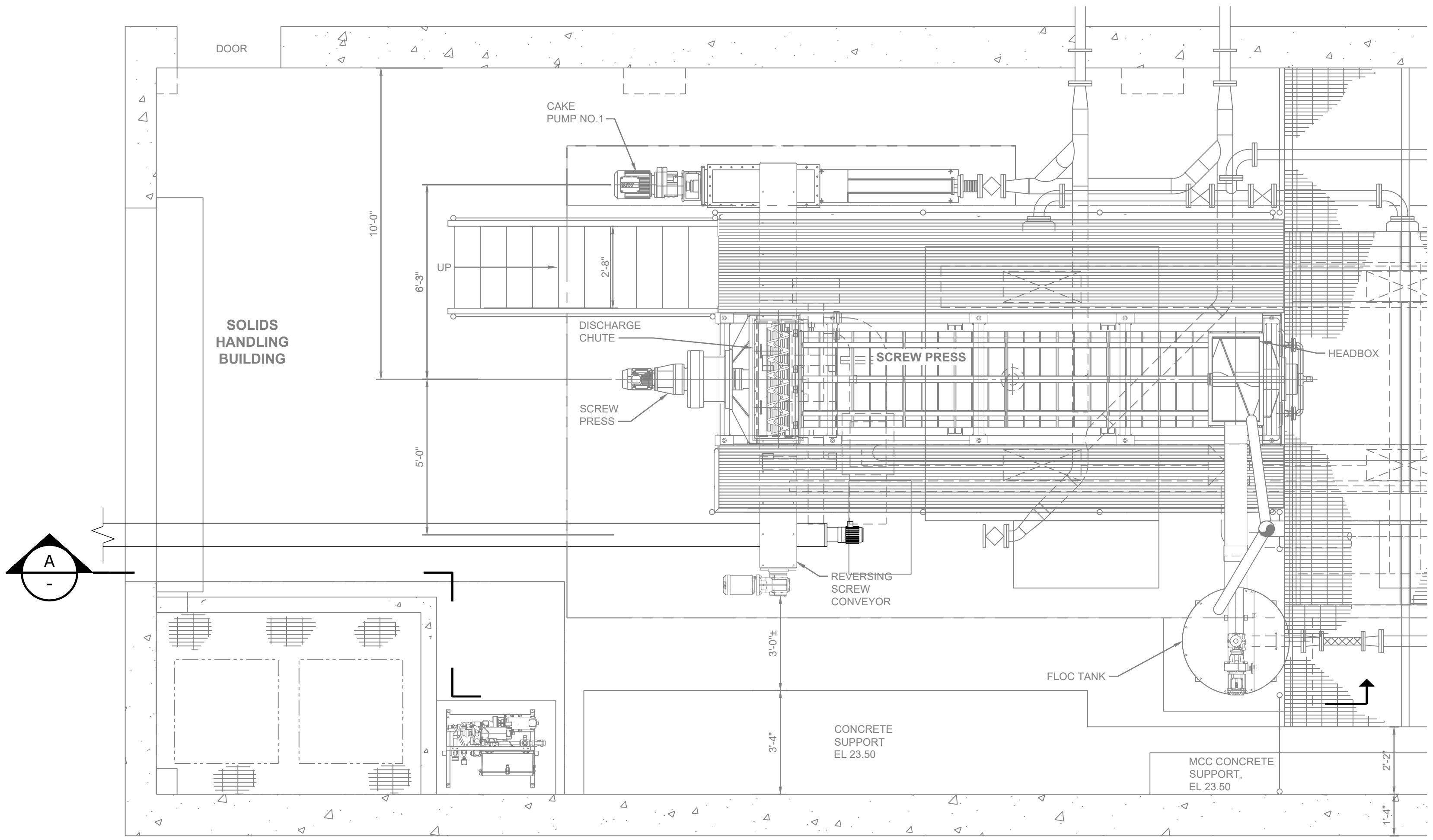
MECHANICAL

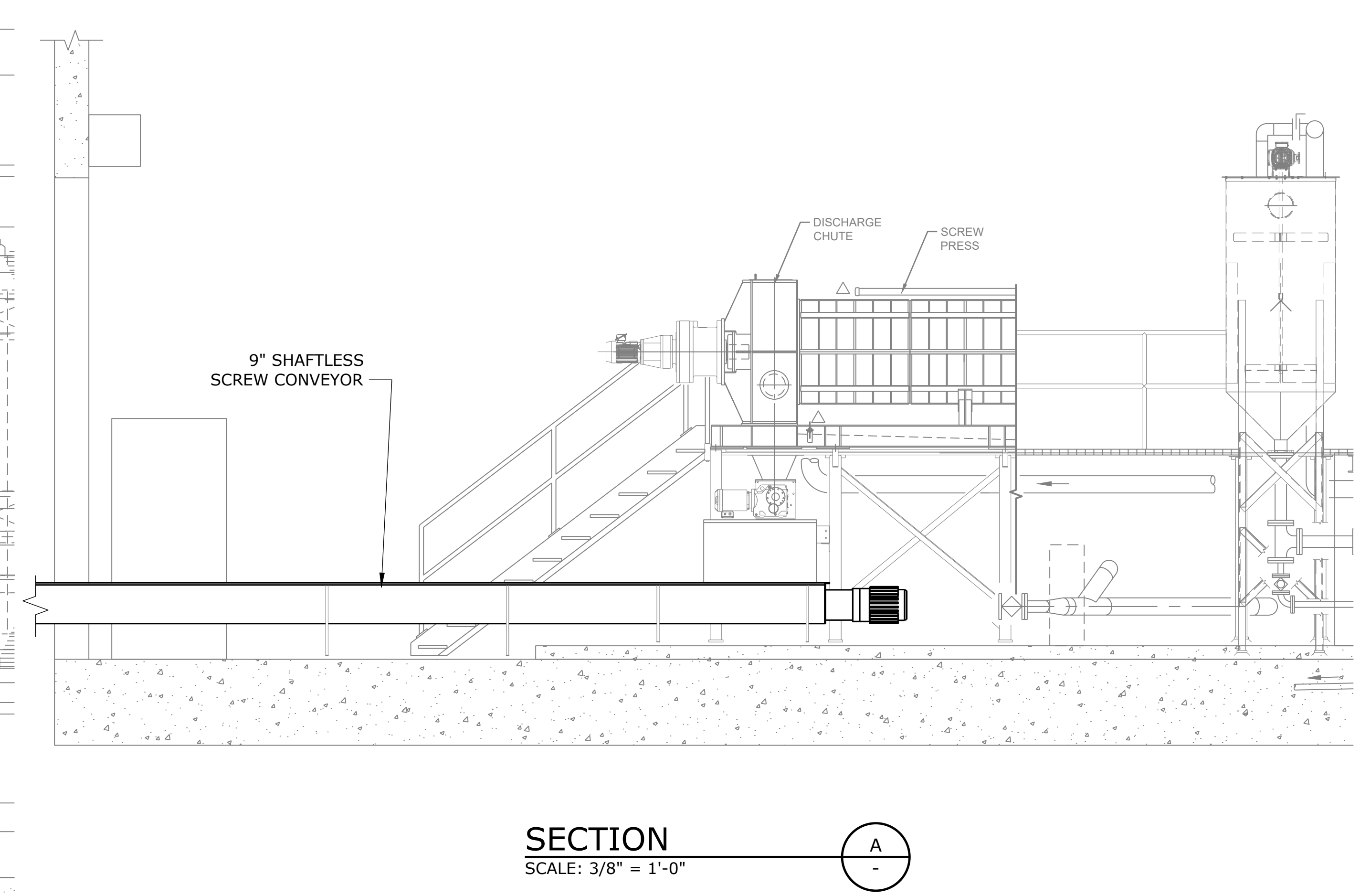
SLUDGE HANDLING BUILDING DEMOLITION PLAN AND SECTION

PROJECT NO.: 21-3310 SCALE: AS NOTED DATE: February 2022

SHEET M-2
9 ##



PLAN
SCALE: 3/8" = 1'-0"



SECTION A
SCALE: 3/8" = 1'-0"

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NO.	DATE	BY	REVISION

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MECHANICAL
SLUDGE HANDLING BUILDING SCREW CONVEYOR PLAN AND SECTION

PROJECT NO.: 21-3310 | SCALE: AS NOTED | DATE: February 2022

SHEET
M-3
10 ##

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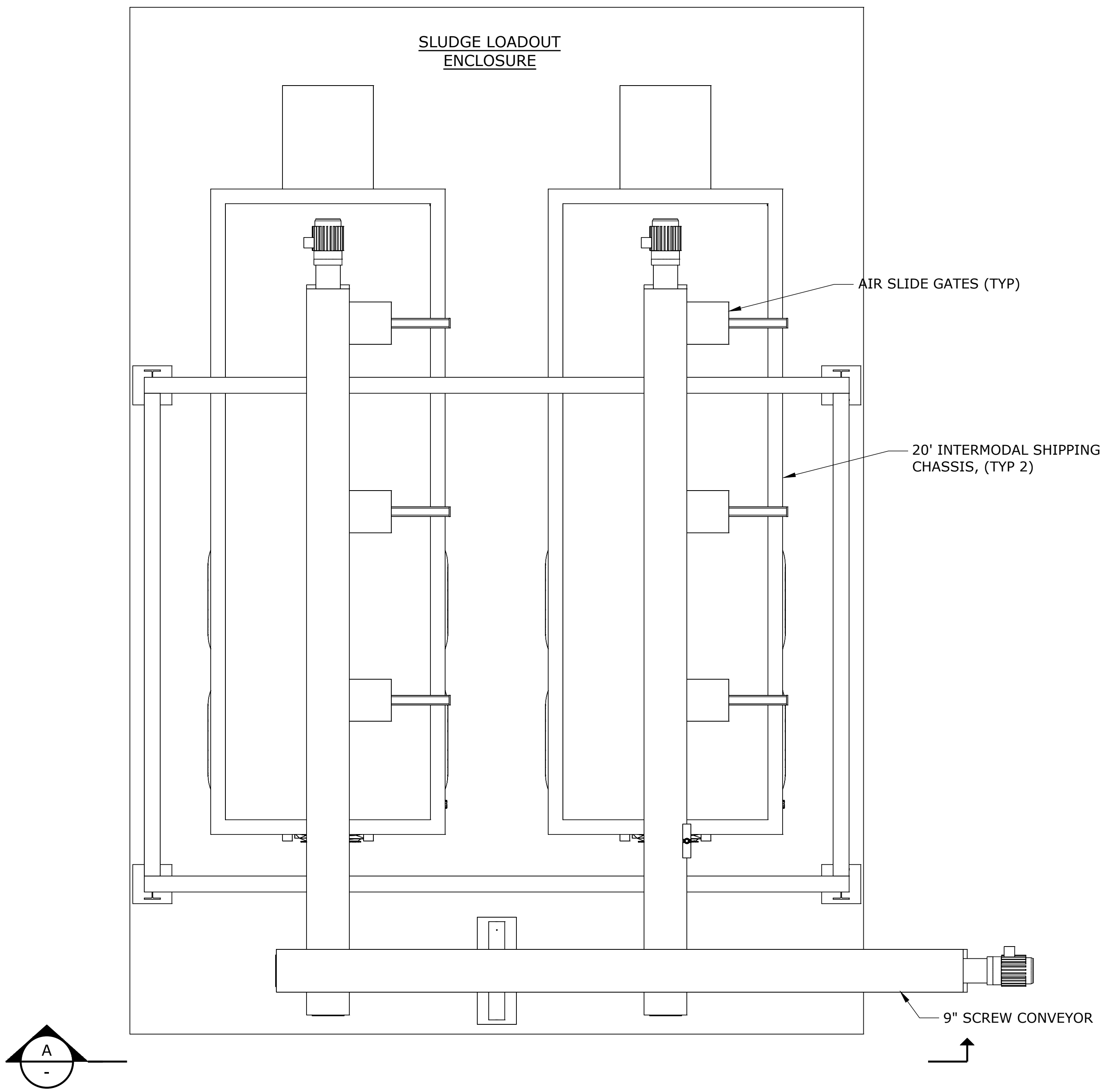
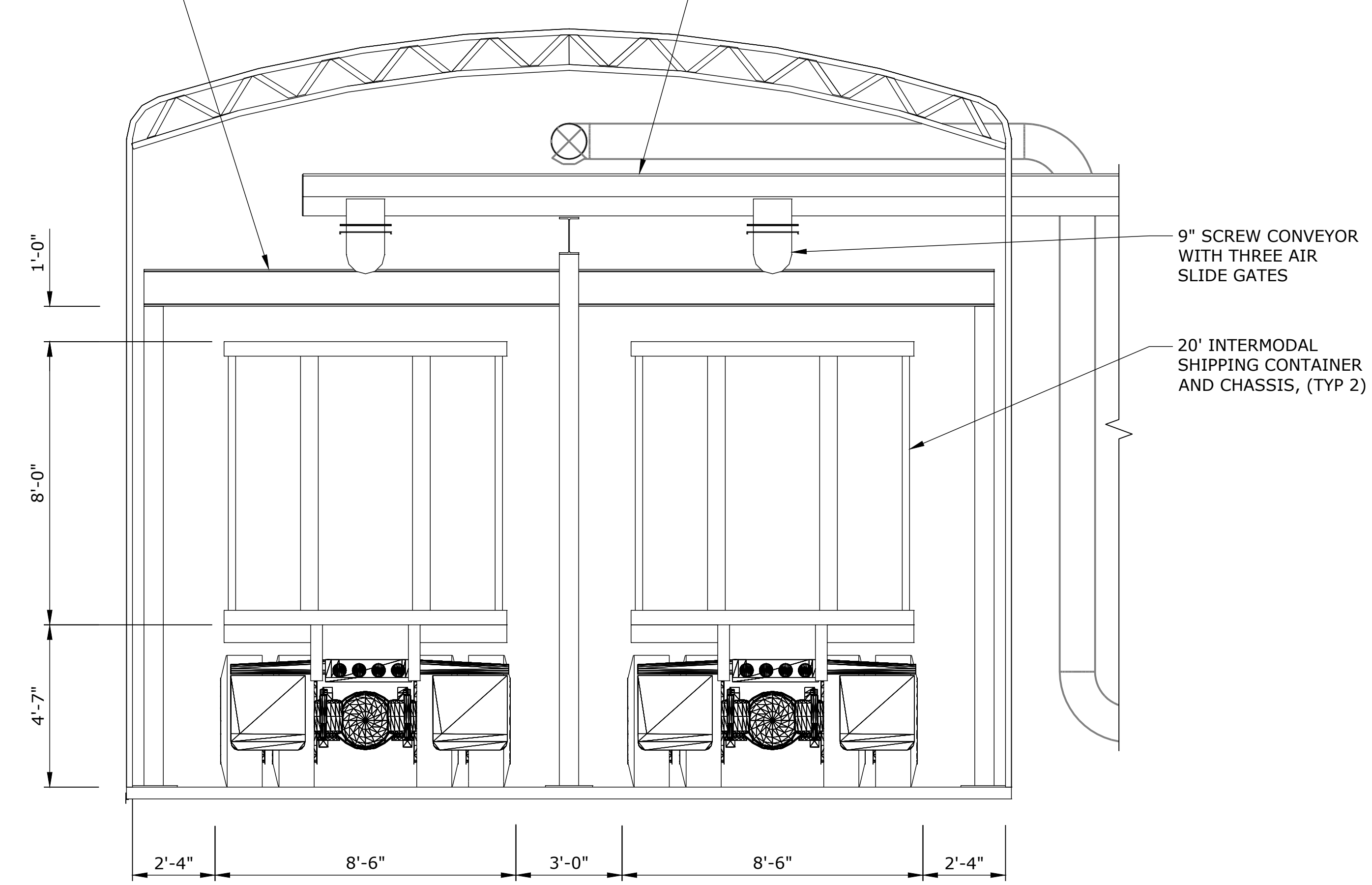


PLAN
SCALE: 3/8" = 1'-0"



SECTION
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NO.	DATE	BY	REVISION

NOTICE
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MECHANICAL

SLUDGE LOADOUT PLAN AND SECTION

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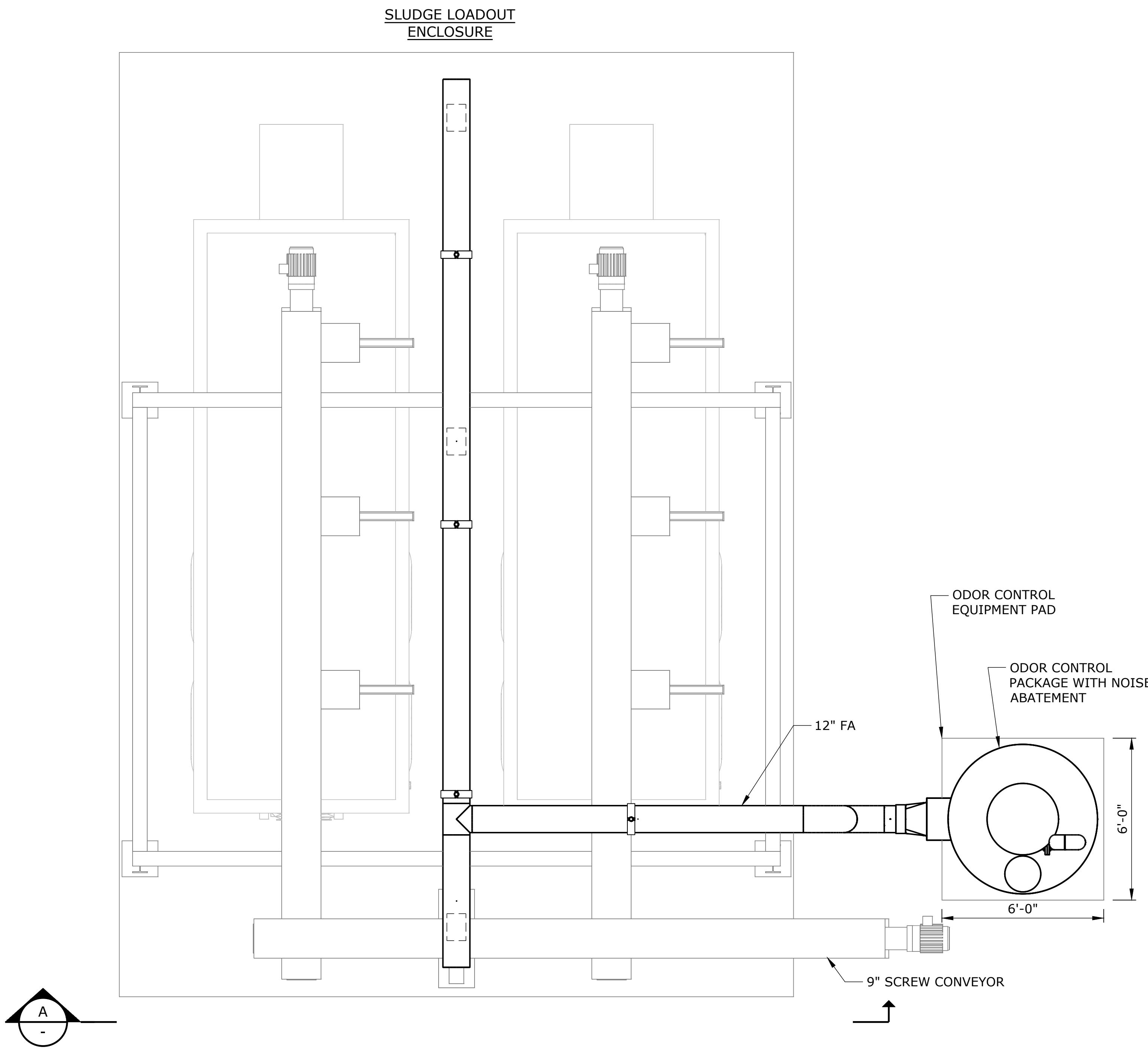
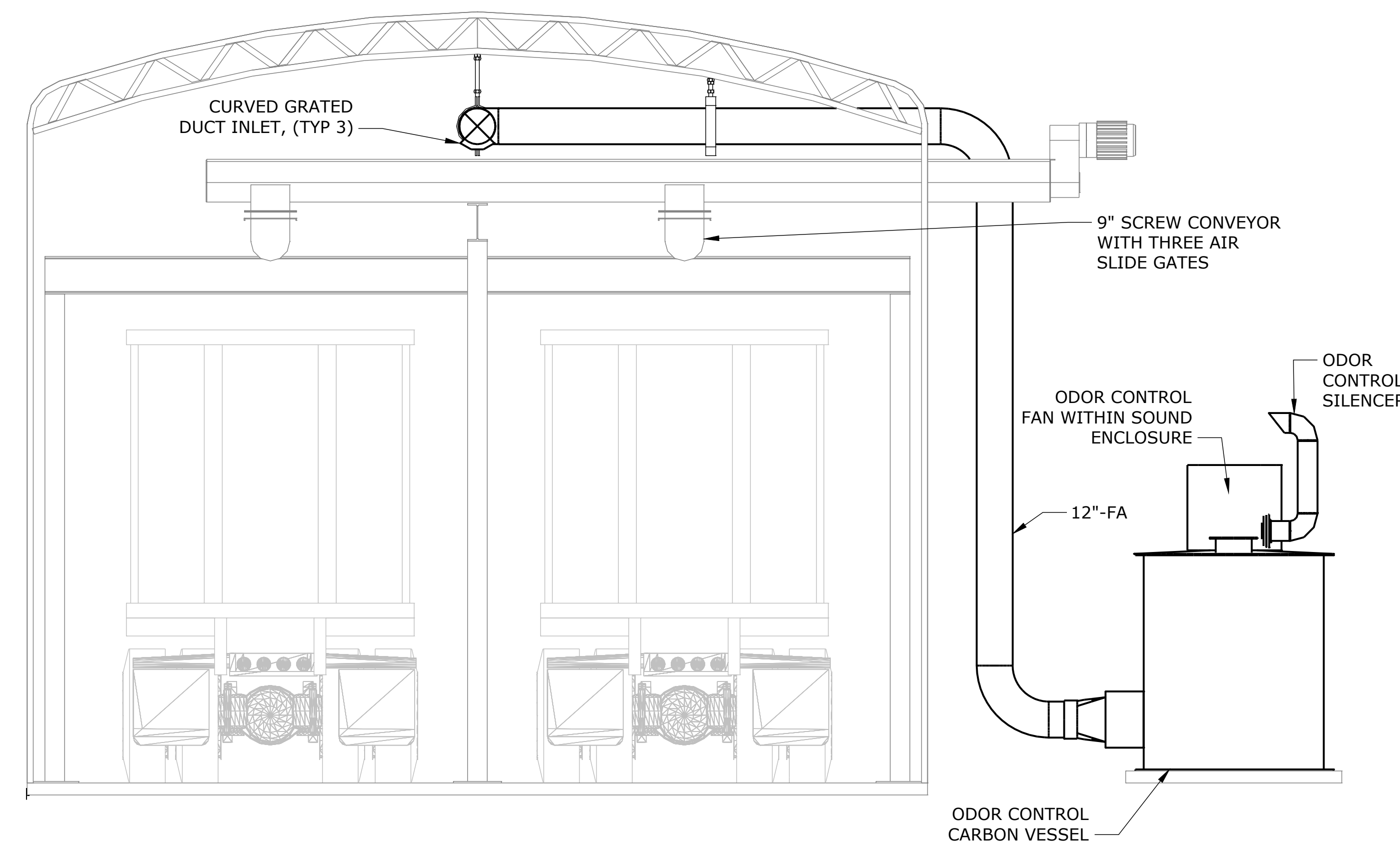
SHEET
M-4
11 ##



PLAN
SCALE: 3/8" = 1'-0"



SECTION
SCALE: 3/8" = 1'-0"
A
-

30% SUBMITTAL

NO.	DATE	BY	REVISION

NOTICE
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

PMD
DESIGNED
TMB
DRAWN
XXX
CHECKED

PRELIMINARY ONLY
DO NOT USE FOR CONSTRUCTION
FEBRUARY 2022
Murraysmith
www.murraysmith.us

murraysmith

LYNNWOOD WASHINGTON
LYNNWOOD WWTP INTERIM SLUDGE DISPOSAL DESIGN AND SDC

MECHANICAL
ODOR CONTROL PLAN AND SECTION

PROJECT NO.: 21-3310 | SCALE: AS NOTED | DATE: February 2022

SHEET
M-5
12 ##

H:\EVT_Projects\21\3310 - Lynnwood, WA - WWTP Interim Sludge Disposal Design And SDC\CAD\Sheets\21-3310-WA-M-5.dwg M-5 2/9/2022 9:40 AM PATRICK.DAVIS 23.0s (LMS Tech)

ATTACHMENT 2

Austin Mac Inc.

Manufacturer of Custom Engineered and Standard Conveyors

Company Overview

Austin Mac has been in business for over 37 years. We are based in Seattle, WA with a 20,000 sq ft manufacturing facility to design and build any conveyor system to meet your needs. At Austin Mac we consider each customer's needs to be unique. We provide a multitalented professional staff with years of hands on workmanship. Our goal is to produce long lasting, trouble free solutions custom designed to your requirements.

Shaftless and Ribbon Screw Conveyors

Features

- Designed for sticky wet materials without plugging
- Vertical, Horizontal, or Incline installations
- Replaceable Ultra High Molecular Weight (UHMW) Wear Liners, dual color
- No Intermediate or tail bearings to impede the flow of material or leak
- Ability to Push or Pull material with a direct drive motor
- Multiple discharge points
- Low energy consumption, low wear, low rpm
- Ease of maintenance, No mess, self contained
- Bolted lids for odor control and safety
- Screw conveyors over 100 feet with a single motor

Austin Mac Inc.

2739 Sixth Avenue South
Seattle WA , 98134
PO Box 3746-98124

Phone: (800) 423-6251
Fax: (425) 682-4442
Web site: Austinmacinc.com

Austin Mac Inc.

Advantages

- Local Spare Parts in stock for quick delivery (Seattle WA).
- Quick turnaround for repairs and same day emergency service.
- High quality at a competitive price, we are a small company with low overhead.
- Austin-Mac does not outsource the construction. We design, fabricate and assemble.

Technical Support

With 100's of combined years of experience designing and building conveyors, Austin Mac can help with complete knowledge and experience to solve any material handling and storage problem you may have.

Other Products

- Shafted Screw Conveyors
- Belt Conveyors
- Bucket Elevators
- Live Bottom Hoppers
- Drag Chain Conveyors

Represented by:

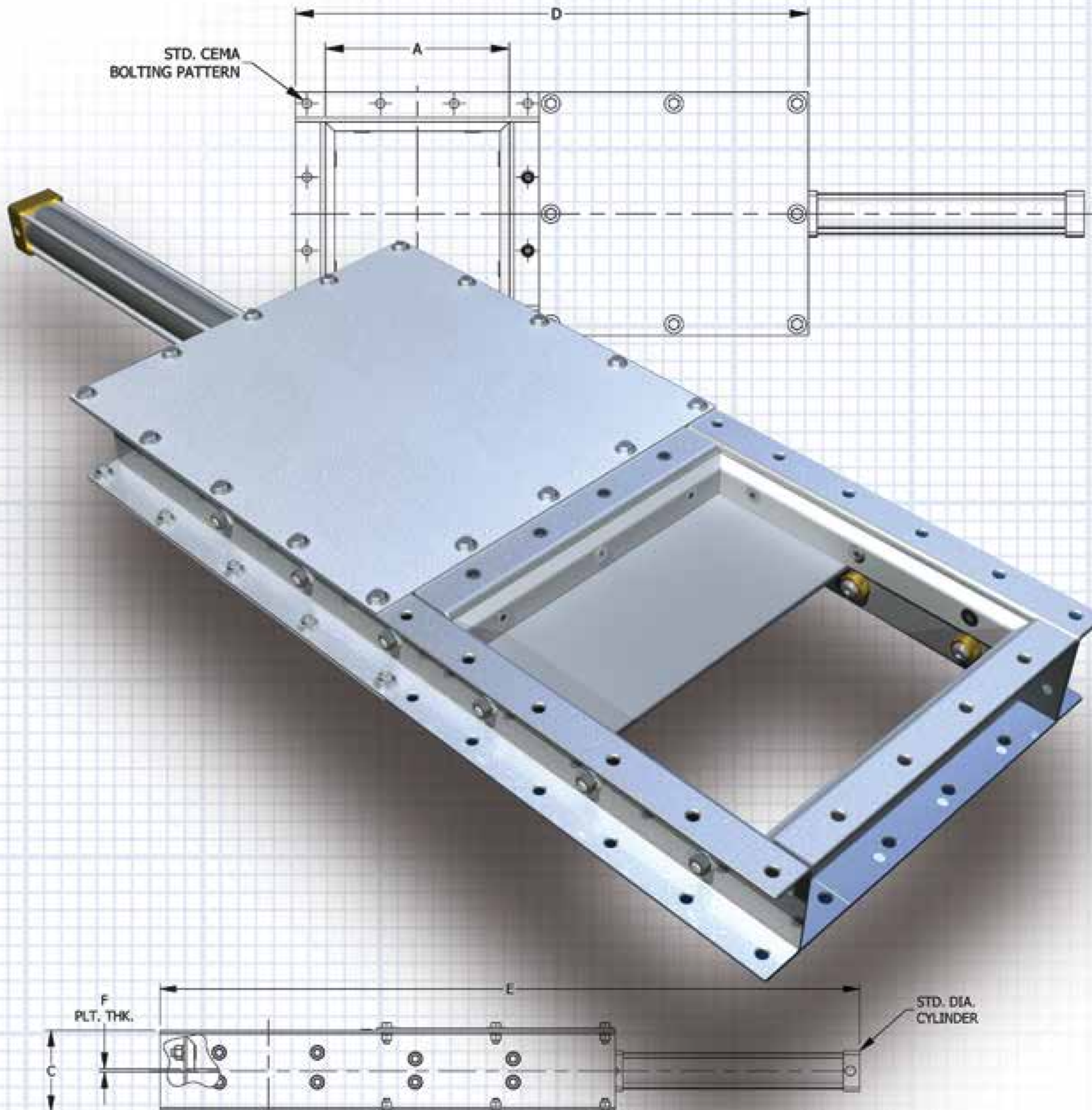
Pedroni & Co. LLC

4580 Klahanie Dr. SE #271
Issaquah, WA 98029
Phone (425) 369-6164 Fax (425) 963-8600
www.pedroni-co.com

Design
Engineering
Manufacturing

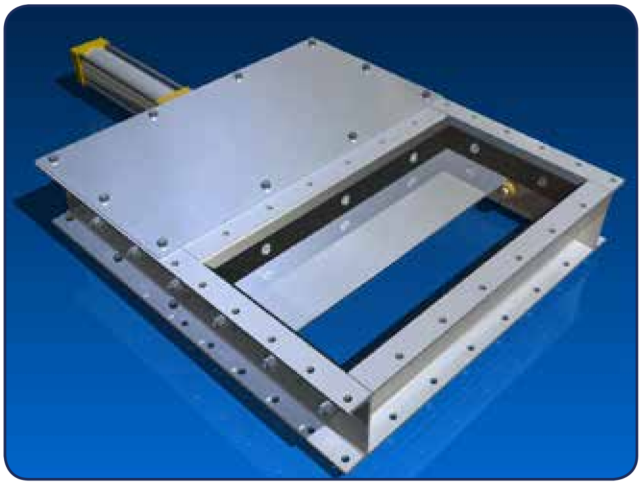
ENGINEERING GUIDE

Pneumatic Slide Gates

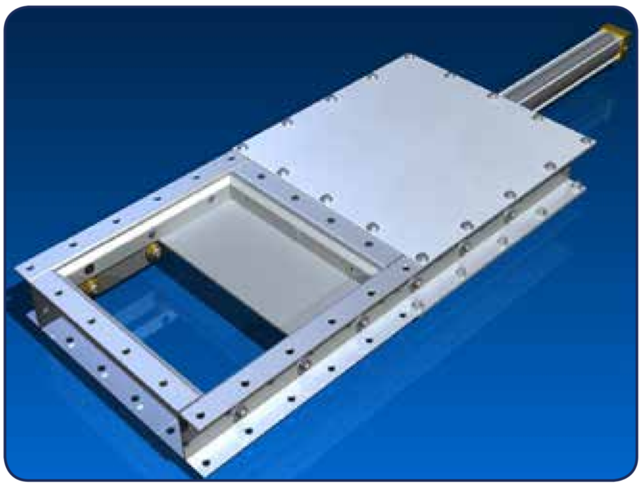


Release Date 9.1.15

KWS Pneumatic Slide Gates



KWS pneumatic slide gates are used in a wide variety of bulk material handling applications. They can be used on the bottom of screw conveyors at intermediate discharge locations to divert product to another location, below silos to stop the flow of product to downstream equipment or even as emergency shut-off gates to stop material surges.



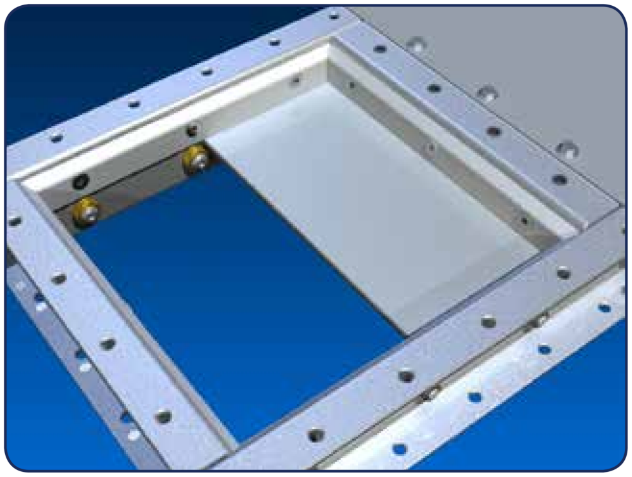
KWS's pneumatic slide gates use a pneumatic or air operated cylinder to actuate the slide plate open and closed. Typically, plant air pressure (approximately 80 psi) is all that is required to power this multi-use slide gate. The slide plate is guided by bronze-bushed rollers on the bottom and 1/2" thick UHMW slide plate retainers on the top. The rollers require no grease and are adjustable in order to provide years of maintenance free service. Replacement parts are low cost and stock items at KWS and available for overnight delivery.

FEATURES

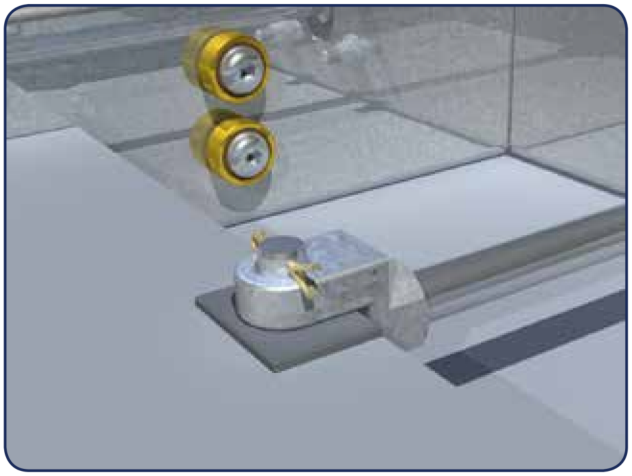
All Welded Construction – Slide gate frames are designed and constructed as one weldment to provide maximum rigidity for heavy industrial applications.

Heavy Duty Slide Plate – Slide plates are made from 3/16" up to 1/2" thick solid carbon or stainless steel to withstand product pressure and head load. The corners of the slide plate are beveled to prevent binding when opening and closing the gate. The pneumatic cylinder is directly attached to the slide plate for a compact and economical design.

Low Friction Rollers – Stainless steel rollers with graphite-impregnated bronze bushings are provided for smooth operation of the slide gate. The rollers are totally maintenance-free and self-lubricating.



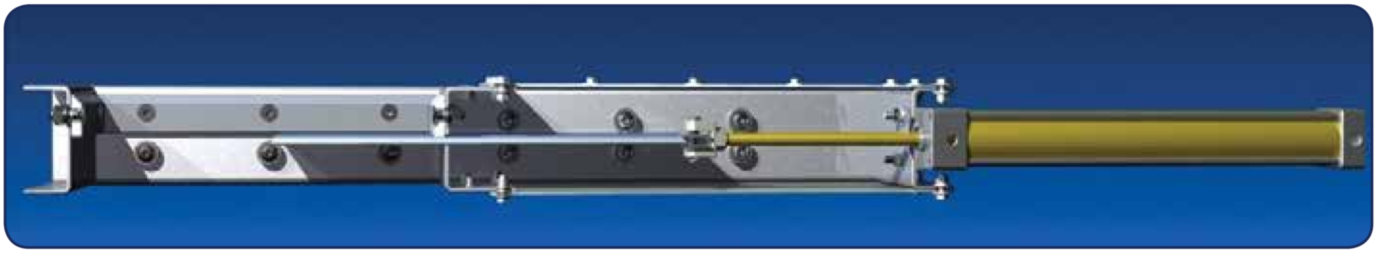
UHMW Retainers – ½-inch thick Ultra High Molecular Weight Polyethylene (UHMW) slide plate retainers are held in place with countersunk bolts on each side. The countersunk bolts are used to avoid obstructing material flow. The top of the UHMW retainers are beveled to divert product flow around the edges of the slide plate and protect the rollers below. UHMW is used because of its durability and high release properties.



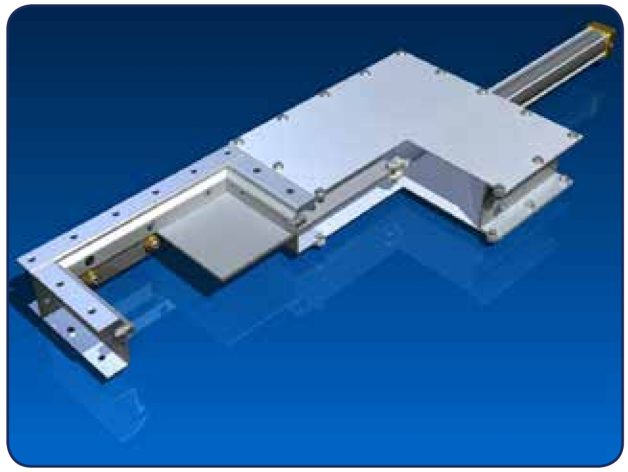
BENEFITS

Compact Design – The KWS pneumatic slide gate's compact design allows it to fit in almost any space. The height is only 5" and length and width are minimized using 3D CAD design technology. The compact, modular design allows for the integration of solenoids, filter/regulators, and position switches.

Versatile and Rugged – Custom designed pneumatic slide gates can be built to fit any application. The slide gate frame and slide plate can be fabricated from a wide variety of materials and thicknesses. Inlet and discharge transitions can be adapted to fit any opening configuration. Large diameter bore cylinders can be utilized for head loads and tough applications. This versatility allows the design to be custom tailored to fit any application and/or design conditions.



DESIGN STANDARDS

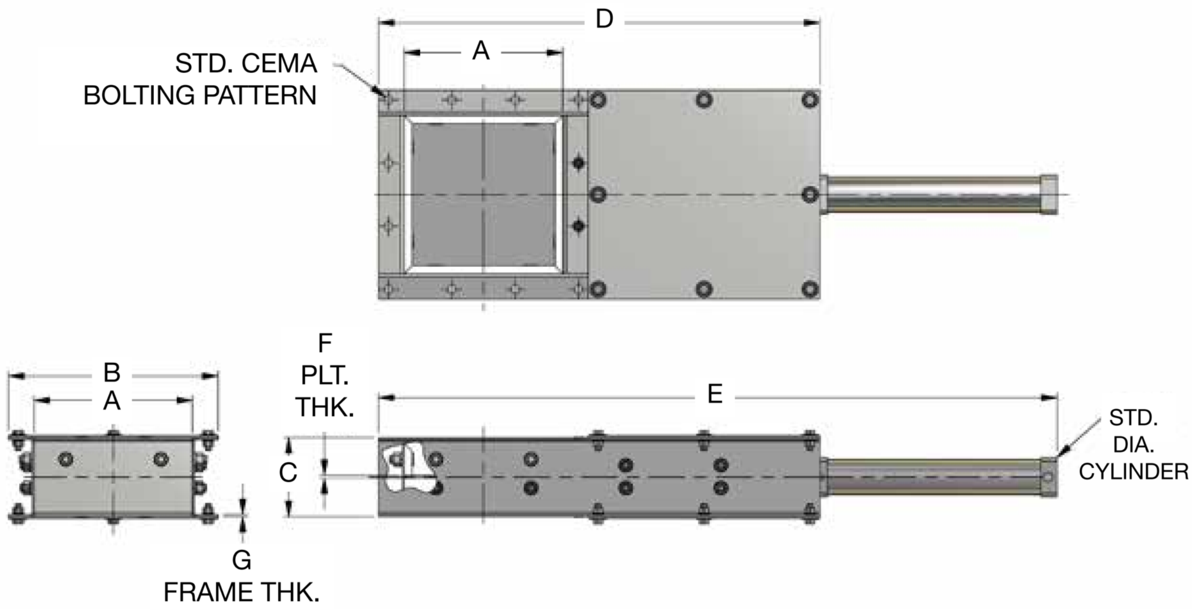


KWS standard pneumatic slide gate cylinders operate most effectively when supplied with 80 psi of clean and dry air. The standard design slide gates are not designed to be operated under a head load; however, hopper/silo discharge slide gates can be engineered to meet your specific application. Please contact the KWS sales and engineering staff with any of your unique slide gate applications today. We can provide a solution for you!

KWS Pneumatic Slide Gate Standard Construction

Gate Size	Inside Square Dimension	Body Thickness	Blade Thickness	Cylinder Bore
6”	7”	10 GA	3/16”	2”
9”	10”	10 GA	3/16”	2”
10”	11”	10 GA	3/16”	2”
12”	13”	3/16”	1/4”	2”
14”	15”	3/16”	1/4”	2”
16”	17”	3/16”	3/8”	2 ½”
18”	19”	3/16”	3/8”	2 ½”
20”	21”	3/16”	3/8”	2 ½”
24”	25”	3/16”	3/8”	2 ½”
30”	31”	1/4”	3/8”	4”
36”	37”	1/4”	1/2”	4”

DIMENSIONAL STANDARDS



DIMENSION CHART (IN)								
CONVEYOR DIAMETER	PART NUMBER	A	B	C	D	E	F	G
6	PG610F	7”	10”	5”	1’-9 3/8”	2’-4 1/2”	3/16”	10 GA.
9	PG910F	10”	1’-1 1/4”	5”	2’-3 7/8”	3’-6 7/8”	3/16”	10 GA.
10	PG1010F	11”	1’-2 1/4”	5”	2’-4”	3’-7 7/8”	3/16”	10 GA.
12	PG12316F	13”	1’-5 1/4”	5”	2’-8 7/8”	4’-1 1/2”	1/4”	3/16”
14	PG14316F	15”	1’-7 1/4”	5”	3’-1 7/8”	4’-8 9/16”	1/4”	3/16”
16	PG16316F	17”	1’-9 1/4”	5”	3’-7 7/8”	5’-4 1/2”	3/8”	3/16”
18	PG18316F	19”	2’-0 1/4”	5”	3’-9 5/8”	5’-7 7/8”	3/8”	3/16”
20	PG20316F	21”	2’-2 1/4”	5”	4’-2 11/16”	6’-5”	3/8”	3/16”
24	PG24316F	25”	2’-6 1/4”	5”	4’-11 3/4”	7’-4”	3/8”	3/16”
30	PG30250F	31”	3’-1”	6”	6’-0 1/8	8’-11”	3/8”	1/4”
36	PG36250F	37”	3’-7”	6”	7’-0 1/8	10’-7”	1/2”	1/4”

KWS

Design
Engineering
Manufacturing

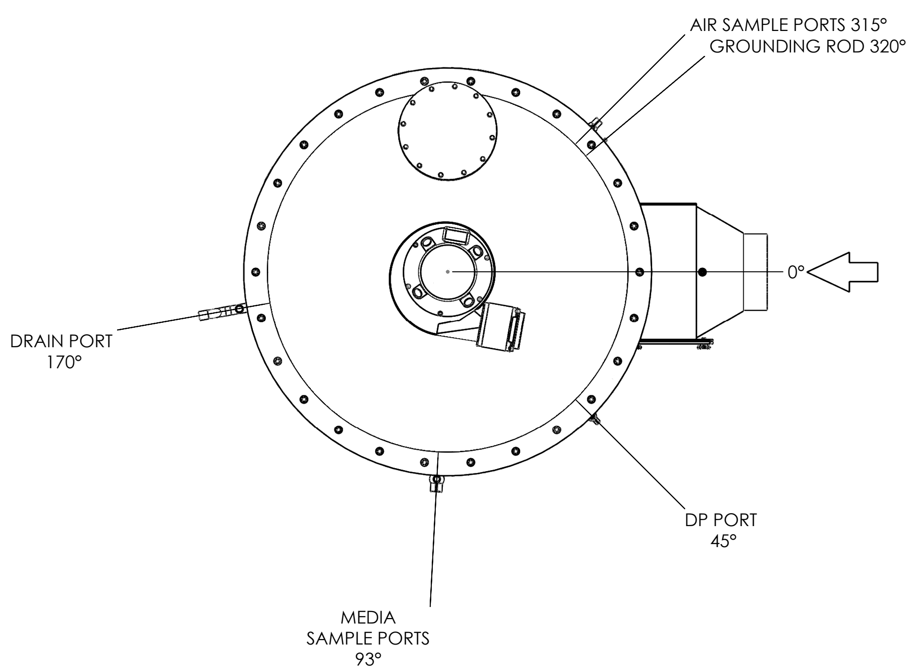
ISO 9001
Certified

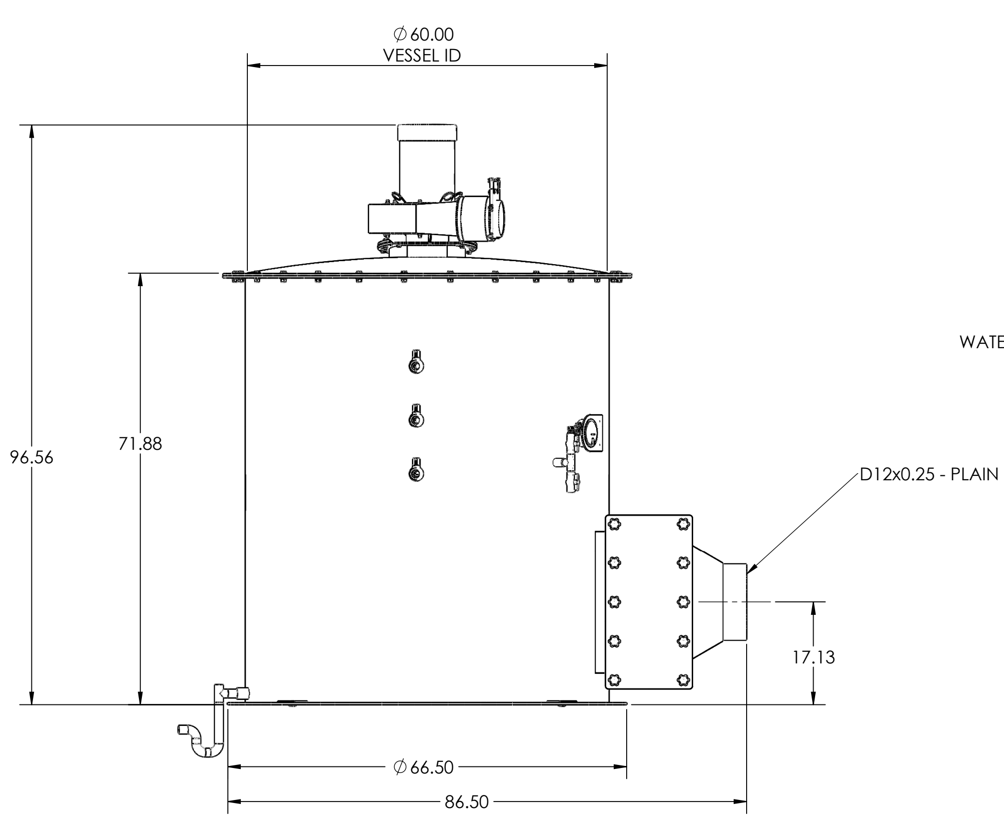
MADE IN THE USA

3041 Conveyor Drive | Burleson, TX 76028
Toll-free: (800) 543-6558 | Local Phone: (817) 295-2240 | Fax: (817) 447-8528
Inquiries: sales@kwsmfg.com | www.kwsmfg.com

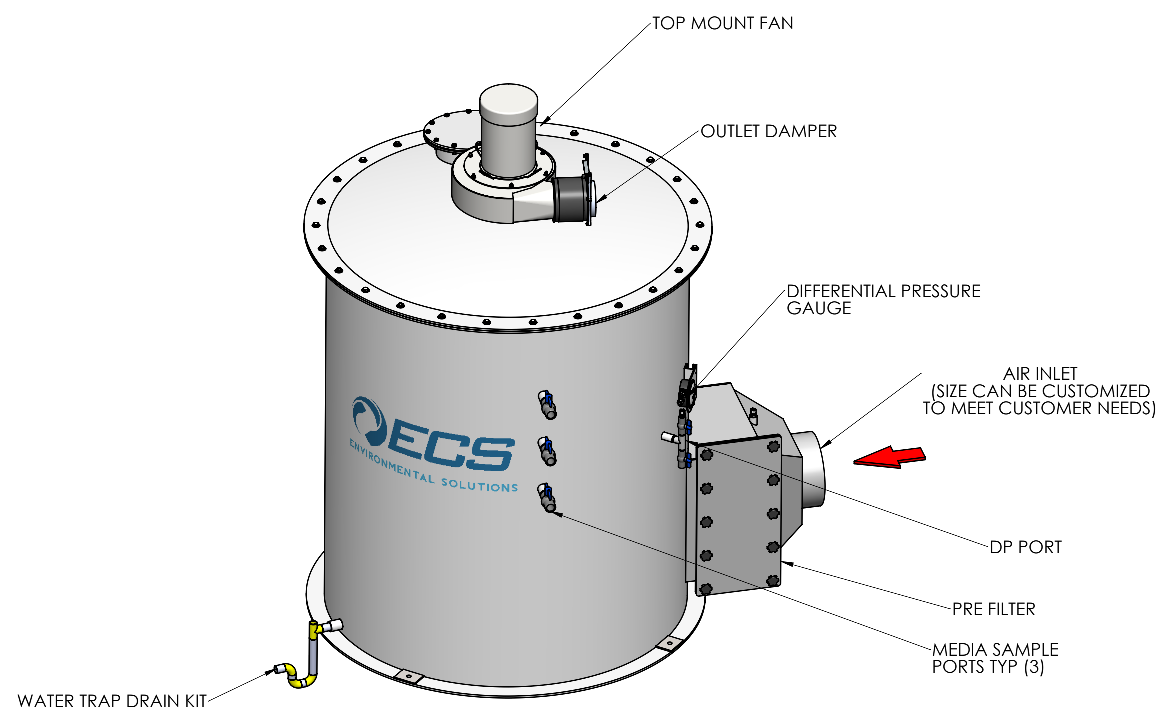
PLAN VIEW

THIS IS A GENERAL ARRANGEMENT
THAT CAN BE CUSTOMIZED TO MEET CUSTOMER'S SPECIFIC NEEDS.





ELEVATION



ISOMETRIC VIEW

60 SERIES SYSTEM DATA	
MODEL:	V1-TM-1000
CARBON CAPACITY:	59 CUBIC FEET
BED VELOCITY:	51 FPM
EBRT:	3.53 SECONDS
SYSTEM PRESSURE DROP:	4.5" W.C.
FAN DATA	
MODEL:	NYB CPB 140608-0898
DESIGN:	1000 CFM @ 8" W.C.
MOTOR:	01-60-120V / 5 HP / 56.00 FLA
	03-60-480V / 5 HP / 7.60 FLA
SOUND ATTENUATION DATA (5' PROXIMITY)	
WITHOUT ATTENUATION	78 DB
WITH ATTENUATION	55 DB

*PRESSURE DROP INDICATED ABOVE IS BASED ON DENSE PACK GRANULAR CARBON WHICH IS A "WORST CASE" SCENERIO

NOTES:

1. STANDARD SYSTEM INLET TO BE PLAIN END. CONNECTIONS TO PS 15-69 TABLE 2/ASTM 3982 & ANSI 16.5 FLANGES ARE AVAILABLE VIA FERNCO CONNECTIONS.
2. VESSEL CONSTRUCTION IS FRP
   1. RESIN SYSTEM IS A CLASS 1 FLAME RESISTANT VINYL ESTER
   2. ALL INTERNAL SURFACES HAVE A 100-MIL COROSION BARRIER
   3. EXTERIOR SURFACES TO HAVE UV-INHIBITOR APPLIED
3. NOZZLE ORIENTATIONS ARE PLACES FOR CLARITY AND CAN BE CHANGED TO FIT SITE CONTITIONS
4. FLOODED WEIGHT IS ONLY APPLICABLE IF UNIT IS GOING TO BE FILLED WITH WATER FOR REGENERATION OR HYDROSTATIC TESTING
5. OPERATING WEIGHT INCLUDES ALL ACCESORIES AND ACTIVATED CARBON
6. ALL FASTENERS ARE 316 SATINLESS STEEL
7. GASKET MATERIAL TO BE EDPM UNLESS SPECIFIED OTHERWISE

ESTIMATED ASSEMBLED WEIGHTS:

EMPTY: 757 LBS
FLOODED: 8072 LBS
OPERATING: 2642 LBS

REV	DESCRIPTION	BY	CHKD	DATE
0	INITIAL RELEASE	-	-	-

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/4"
ANGULAR: ± 3° BEND ±
TWO PLACE DECIMAL ± .125
THREE PLACE DECIMAL ± .060

	NAME	DATE
DRAWN	Admin	03/01/2017
CHECKED		
APPROVED	-	
MATERIAL		

ECS ENVIRONMENTAL SOLUTIONS

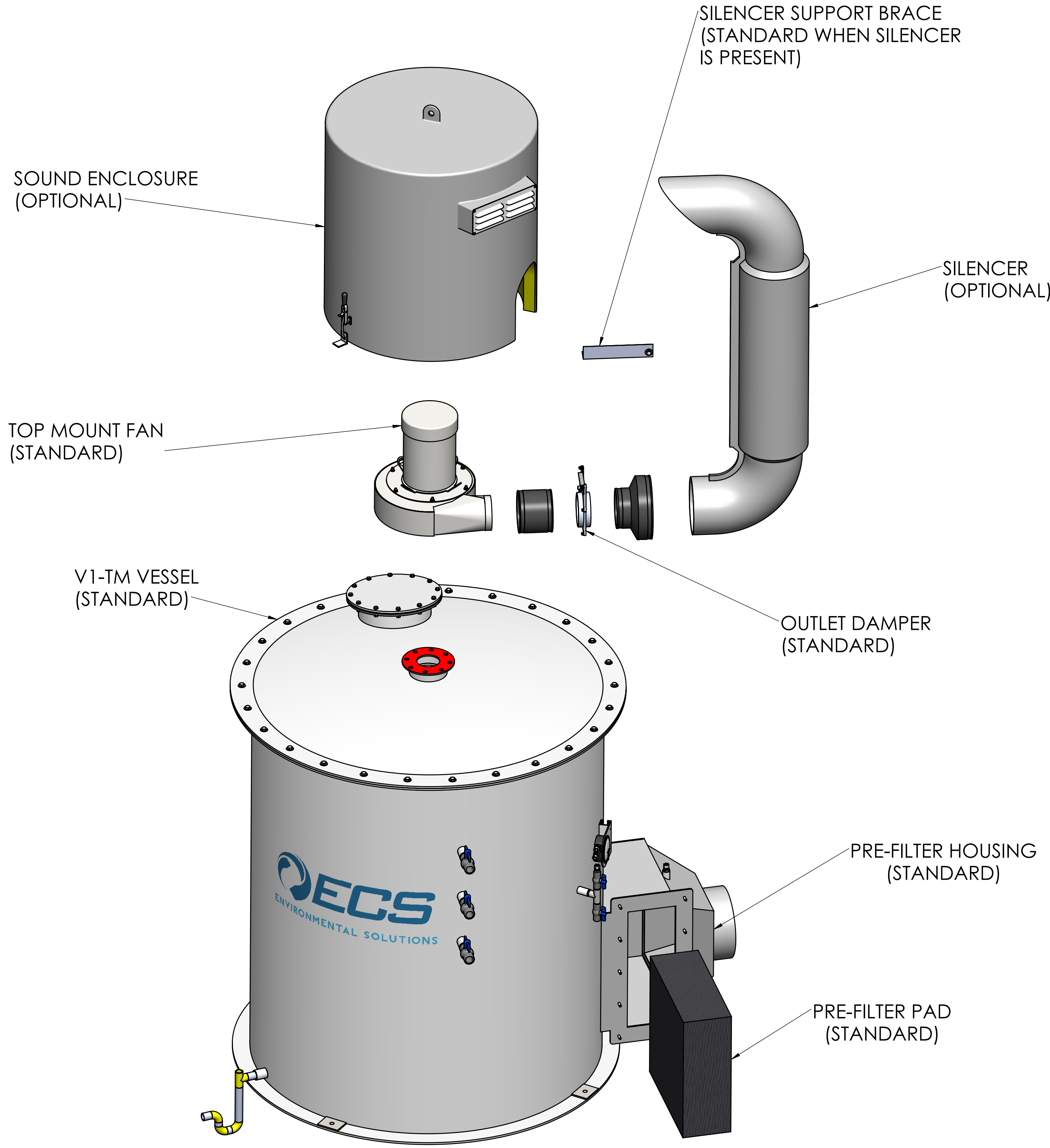
CUSTOMER:
JOB:
TITLE: V1-TM-1000
SIZE: D
PART NUMBER: V1
REV: A
SCALE: 1:16 DO NOT SCALE DRAWING SHEET 1 OF 2

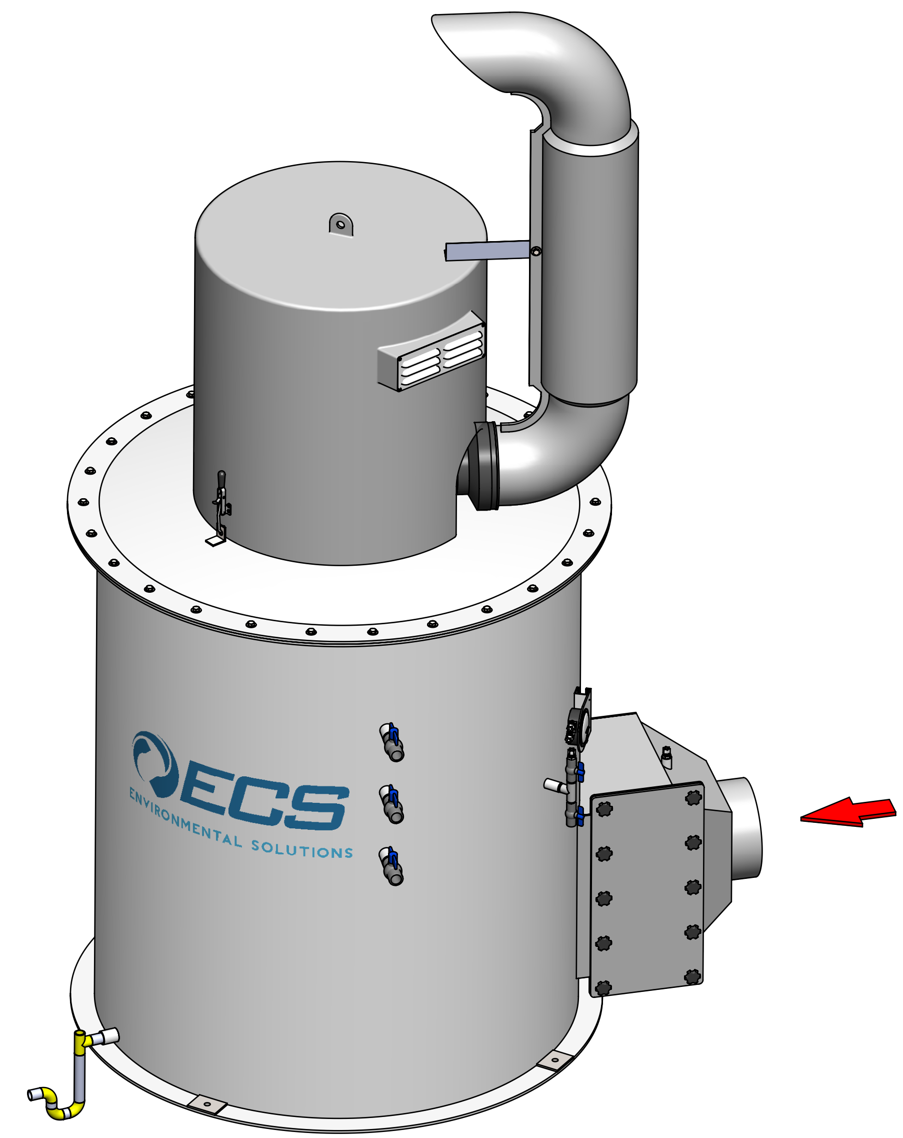
THE ECS V1-TM-1000 COMES STANDARD WITH:

- V1 ABSORBER VESSEL
- PRE-FILTER
- FAN
- OUTLET DAMPER

OPTIONAL SOUND ATTENUATION PACKAGE:

- FAN SOUND ENCLOSURE
- FAN OUTLET SILENCER





UNLESS OTHERWISE SPECIFIED:		NAME	DATE	CUSTOMER:
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/4" ANGULAR: ± 3° BEND ± TWO PLACE DECIMAL ± .125 THREE PLACE DECIMAL ± .060	DRAWN	Admin	03/01/2017	JOB:
	CHECKED			
	APPROVED	-		
	MATERIAL			TITLE: V1-TM-1000
PROPRIETARY AND CONFIDENTIAL THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF ECS ENVIRONMENTAL SOLUTIONS. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF ECS ENVIRONMENTAL SOLUTIONS IS PROHIBITED.	ECS ENVIRONMENTAL SOLUTIONS			SIZE D · PART NUMBER: V1 · REV A
				SCALE: 1:12 · DO NOT SCALE DRAWING · SHEET 2 OF 2

ECS ENVIRONMENTAL SOLUTIONS

SULFADSORB - HC

0.30 HIGH CAPACITY ACTIVATED CARBON

Technical Data Sheet

DESCRIPTION:
ECS Sulfadsorb-HC carbon is a coconut-based activated carbon that offers the highest hydrogen sulfide adsorption capacity available. The carbon is a high quality extruded 4 mm pellet and provides a 0.30 g/cc capacity (min) for hydrogen sulfide removal. .

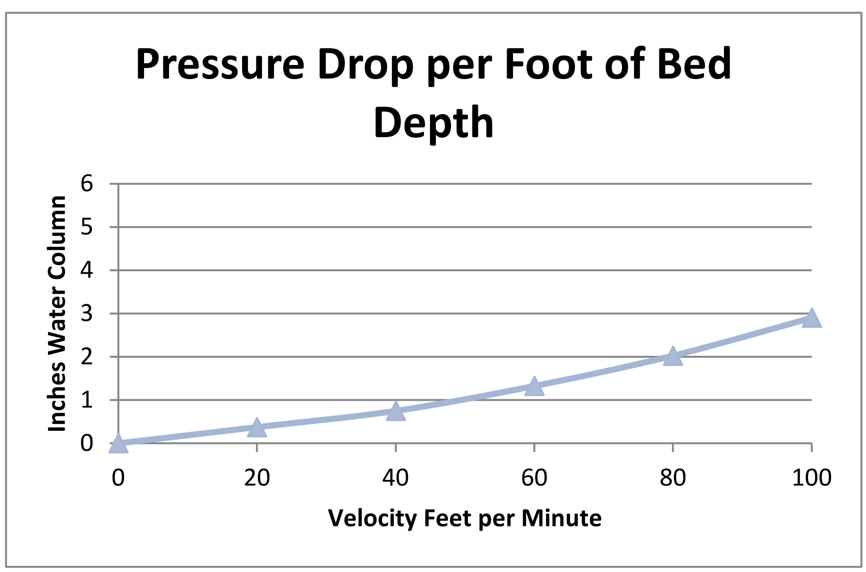
APPLICATIONS:
Odor Control and VOC removal from air; typically in sewage and wastewater treatment plants.

TYPICAL PROPERTIES:

Minimum H_2S Breakthrough Capacity:	0.30 g H_2S removed per cc of carbon
Maximum Moisture:	5% by weight
Apparent Density:	0.45 g/cc
Minimum Carbon Tetrachloride Activity:	60%
Minimum Hardness Number:	95
Maximum Ash Content:	5% by weight

FEATURES:

- Higher H_2S and VOC adsorption capacity compared to traditional activated carbon
- Free of chemical impregnates, removes risk of bed fires
- Prolonged media bed life
- Safe for landfill disposal when used for typical H_2S treatment applications



2201 Taylor's Valley Rd.
Belton, TX 76513

ECS ENVIRONMENTAL SOLUTIONS
www.ecs-env.com

254.933.2270 phone
254.933.2212 fax

Blue-White®

M1

FLEXFLO® Peristaltic Metering Pump

Video link: ▶

Features

> Tube Failure Detection senses tube rupture. No false triggering.

> Heavy duty display shield protects pump controls.

> Remote Start/Stop, which is one non-powered dry contact closure.

> Compatible with Blue-White's Flow Verification Sensor.

> Relay outputs include a single 250V/3A and a single solid state.

> SCADA Inputs include: 4-20mA.

NSF Certified to NSF / ANSI Standard 61 | c ETL us | CE | NEMA 4X

Highlights

Flow Range
.0001 – 5.60 GPH
.0004 – 21.2 LPH

Pressures
100 PSI
(6.89 bar)

Turndown ratio
10,000 : 1

Exclusive
Enhanced Tube Failure Detection
(TFD+)

Motor
Brushless
DC

Warranty
5 Years

Control Methods

Control Methods	Manual Control	4-20mA Input	Remote Start/Stop	Alarm Output	FVS	Motor Status Output
M1	•	•	•	•	•	•

For more help and information regarding **M1**, please visit www.blue-white.com or scan this QR code.

Engineering Specifications

Maximum Working Pressure (Excluding pump tubes)	100 PSI (6.89 bar)
Maximum Fluid Temperature	185 °F (85 °C)
Maximum Viscosity	5,000 centipoise
Maximum Suction Lift	30 ft. of water at sea level (14.7 atm psi)
Ambient Operating Temperature	14 °F to 115 °F (-10 °C to 46 °C)
Ambient Storage Temperature	-40 °F to 158 °F (-40 °C to 70 °C)
Operating Voltage	115V60Hz 1 PH (0.6A max.)
	220V50Hz 1 PH (0.3A max.)
	230V60Hz 1 PH (0.3A max.)
	230V50Hz 1 PH (0.3A max.)
	240V50Hz 1 PH (0.3A max.)
Power Cord Options	115V60Hz = NEMA 5/15 (USA)
	230V60Hz = NEMA 6/15 (USA)
	220V50Hz = CEE 7/VII (EU)
	240V50Hz = AS 3112 (Australia/New Zealand)
	230V50Hz = BS 1363/A (UK)
Motor	Brushless DC, 50W.
Duty Cycle	Continuous
Motor Speed Adjustment Range	10,000:1 (0.01% - 100%) Max rpm = 65rpm
Maximum Overall Dimensions	7.25” W x 9” H x 10” D (18.5 W x 22.9 H x 25.2 D cm)
Product Weight	6 lb. (2.7 Kg)
Approximate Shipping Weight	13 lb. (5.9 Kg)
Approximate Shipping Dimensions	10.5” W x 13.75” H x 11” D (26.7 W x 35 H x 28 D cm)
Enclosure	NEMA 4X (IP66), Valox® (PBT) Thermoplastic & PA12
RoHS Compliant	Yes
Standards	NSF/ANSI 61, cETLus, CE

Materials of Construction

Non-wetted Components:	
Enclosure:	Valox® (PBT) & PA12 thermoplastic
Pump Head:	Valox® (PBT) thermoplastic
Pump Head Cover:	Polycarbonate
	Permanently lubricated sealed motor shaft support ball bearing.
Cover Screws:	Stainless steel, polypropylene cap
Roller Assembly:	Rotor: Valox® (PBT)
	Rollers: Nylon
	Roller Bearings: Bronze
TFD+ System Sensor:	Polysulfone (PES)
Power Cord:	3 Conductor, SJTW-A water-resistant
Tube Installation Tool:	GF Nylon
Mounting Brackets and Hardware:	316 Stainless steel screws, GF Nylon bracket

Wetted Components:	
Pump Tube Assembly:	Tubing : Flex-A-Prene®, Flex-A-Thane® or Flex-A-Chem®
	Adapter Fittings: PVDF

Output Specifications

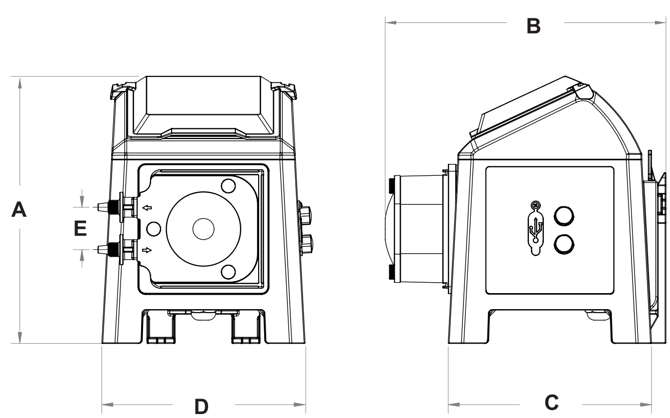
Tube Model	Feed Rate		Max Speed	Max Pressure	Max Temperature
	GPH	LPH	RPM	PSI (bar)	°F (°C)
A1-1*	.0001 - 1.09	.0004 - 4.13	65	65 (4.50)	130 (54)
A1-3*	.0005 - 5.60	.0021 - 21.2	65	50 (3.45)	130 (54)
A1-6*	.0001 - 1.35	.0005 - 5.14	65	100 (6.89)	185 (85)
A1-7*	.0004 - 4.17	.0015 - 15.8	65	50 (3.45)	185 (85)
A1-8*	.0003 - 3.09	.0011 - 11.7	65	50 (3.45)	130 (54)

NOTE: Data pertains to both “T” and “M” connection types.

Dimensions

Dim	Inch	cm
A	9.46”	24.02
B	9.92”	25.19
C	7.18”	18.23

Dim	Inch	cm
D	7.18”	18.23
E	1.5”	3.81



Model Number Matrix

FLEXFLO® Model Number

M1	FLEXFLO® Peristaltic Metering Pump

Power Cord (Operating voltage requirement 96VAC to 264VAC)

4	115V 50/60Hz, power cord NEMA 5/15 plug (US)
5	230V 50/60Hz, power cord NEMA 6/15 plug (US)
6	220V 50/60Hz, power cord CEE 7/V11 plug (EU)
8	240V 50/60Hz, power cord AS 3112 plug (Australia/New Zealand)
9	230V 50/60Hz, power cord BS 1363/A plug (United Kingdom)

Pump Tube Size and Material

1	1/4” OD Flex-A-Thane® | 0.0001-1.09 GPH | 65 PSI
3	7/16” OD Flex-A-Thane® | 0.0005-5.60 GPH | 50 PSI
6	3/8” OD Flex-A-Prene® | 0.0001-1.35 GPH | 100 PSI
7	7/16” OD Flex-A-Prene® | 0.0004-4.17 GPH | 50 PSI
8	7/16” OD Flex-A-Chem® | 0.0003-3.09 GPH | 50 PSI

Inlet/Outlet Connection Size, Connection Type

T	3/8” OD x 1/4” ID Tube Compression Fitting
M	1/2” Male NPT Fitting
MB	1/2” Male BSPT Fitting, Natural PVDF (Kynar)

M1	4	-	1	T	**Sample Model Number**

Accessories

KIT-S07
STAR III 7 GALLON TANK, PP

KIT-S15
STAR III 15 GALLON TANK, PP

KIT-S30
STAR III 30 GALLON TANK, PP

KIT-MB
FLOOR MOUNTING BRACKETS

CABLE-UAC
USB A-C CABLE - 3 ft.

KIT-M12
TWO M12 CABLES - 9.8 ft.

*KIT-M12-3 THREE M12 CABLES

NOTE: Accessories sold separately.

5300 Business Drive, Huntington Beach, CA 92649
TEL 714-893-8529 | FAX 714-894-9492 | www.blue-white.com | sales@blue-white.com

SPECIFICATIONS

ECO Valve

...because we all live downstream

Back Pressure / Pressure Relief Valves

- *available in PVC, CPVC, PVDF, polypropylene and 316L stainless steel*
- *long life single sealing diaphragm (laminated PFTE, Viton, EPDM or PVC)*
- *field adjustable pressure setting 7 - 150 PSIG (48 - 1034 kPa)*
- *CPVC bonnet for higher temperature and chemical resistance rating*

PRIMARY FLUID
SYSTEMS INC.

Call Toll Free 1-866-324-6422
Tel (905) 333-8743 Fax (905) 333-8746

E-Mail:
ecovalve@ecovalve.ca
www.ecovalve

ECO Valve Back Pressure/Pressure Relief Valve

Description:

Back Pressure/Pressure Sustaining/Anti Syphon

ECO Valve is a diaphragm style two port back pressure/pressure sustaining valve designed to provide and control a continuous pressure on the discharge side of a positive discharge style pump, such as metering pumps. ECO Valve assists with the proper seating of the valve check assembly and accurate filling of the pump housing chamber for a more efficient and accurate running pump. (Factory set @ 50 psig / 345kPa)

Pressure Relief

ECO Valve is also designed to be used as a 2 port off line pressure relief valve to help protect the discharge side of positive displacement pumps from system failure due to over pressure caused by a blockage or
accidental valve closure on the downstream side of the pump. (Factory set @ 50 psig / 345kPa)

Flanged

Union

Features

- no moving parts in wetted chamber; superior choice for "dirty" fluid applications
- high flow capacity with lower pressure drop
- optional diaphragm materials
- colour coded caps indicate size
- sizes from 1/4" to 4" (DN 8 to DN 100)
- 10 configurations: threaded, socket, union and flanged
- injection mould design with fewer moving parts
- high ambient temperature range
- gauge port available in either flow direction

NPT/BSPT

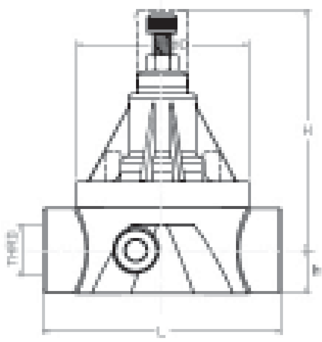
Socket

Ideal for metering pump/chemical dosing applications

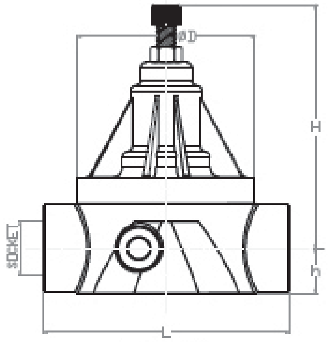
Designed for long life and ease of installation and maintenance

Exceptional 3 year warranty

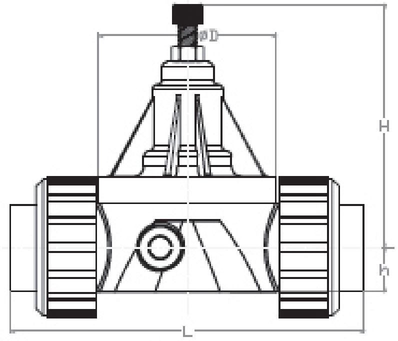
Body Configuration Models ECO-25, ECO-38, ECO-50



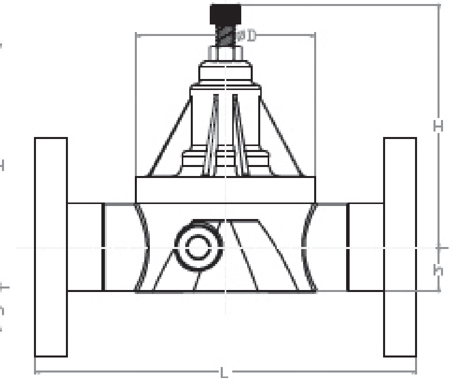
Threaded Female



Socket



Union



Flanged

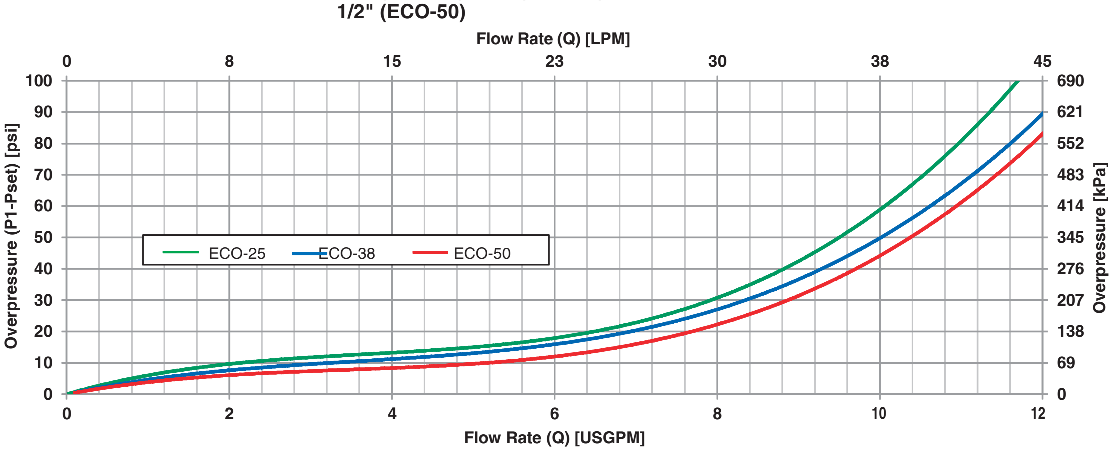
Nominal Size		PVC, CPVC, PP & PVDF						
NPS inch	DIN DN	ØD inch mm	h inch mm	H inch mm	L inch mm	L inch mm	L inch mm	L inch mm
Series A					Thread	Socket	Flanged	Union
1/4"		2.50	0.66	4.48	3.40	3.40	N/A	6.00
	8	63.5	16.7	113.9	86.4	86.4		152.4
3/8"		2.50	0.66	4.48	3.40	3.40	N/A	6.00
	10	63.5	16.7	113.9	86.4	86.4		152.4
1/2"		2.50	0.66	4.48	3.40	3.40	5.40	6.00
	15	63.5	16.7	113.9	86.4	86.4	137.2	152.4

Nominal Size		316L Stainless Steel					
NPS inch	DIN DN	ØD inch mm	h inch mm	H inch mm	L inch mm	L inch mm	L inch mm
Series A					Thread	Socket	Flanged
1/4"		2.50	0.60	4.47	2.50	2.50	N/A
	8	63.5	15.2	113.5	63.5	63.5	
3/8"		2.50	0.49	4.58	2.50	2.50	N/A
	10	63.5	12.4	116.3	63.5	63.5	
1/2"		2.50	0.60	4.72	2.50	2.50	6.25
	15	63.5	15.2	119.9	63.5	63.5	158.8

Overpressure vs. Flow Rate

ECO Valve

1/4" (ECO-25), 3/8" (ECO-38) and 1/2" (ECO-50)



The overpressure vs. flow rate curve is based on a valve spring pressure of 50 PSIG (345 kPa).

P1 = working pressure
P set = 50 PSIG (345 kPa)

Example:
ECO-25
100 PSIG - 50 PSIG = 50 PSIG = 9.5 USGPM

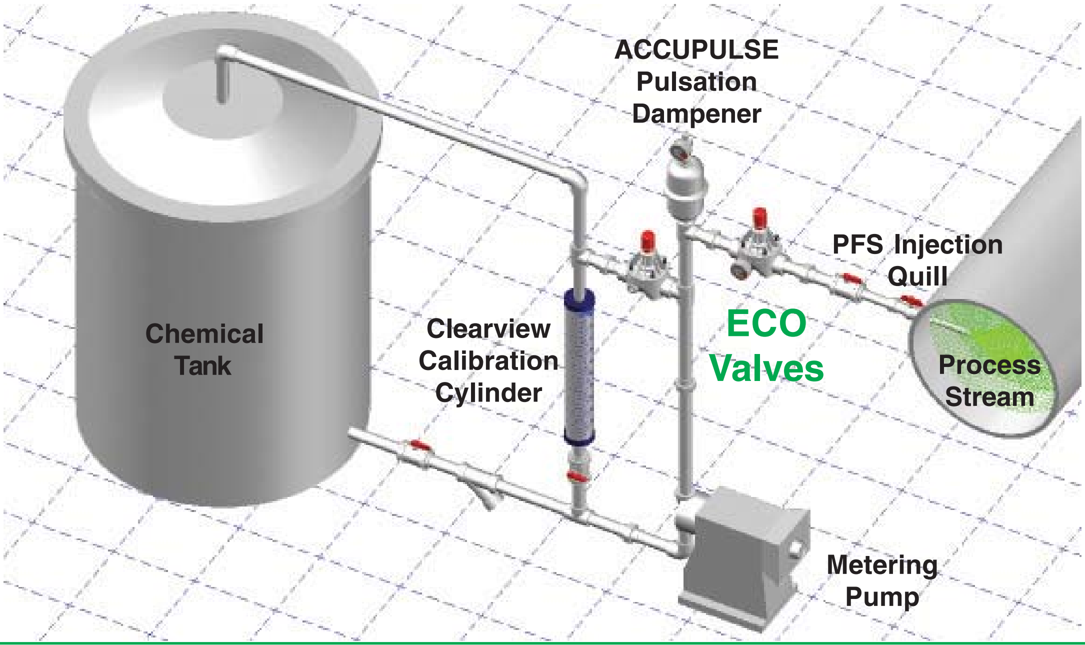
690 kPa - 345 kPa = 345 kPa = 36 LPM

Maximum Pressure PSIG (kPa) vs. Temperature									
Temperature		Valve Material							
C°	F°	PVC PSIG	kPa	CPVC PSIG	kPA	PP PSIG	kPa	PVDF PSIG	kPa
20	68	150	1034	150	1034	150	1034	150	1034
30	86	110	758	150	1034	150	1034	150	1034
40	104	70	483	150	1034	100	689	150	1034
50	122	30	207	140	965	65	448	150	1034
60	140	NR	NR	130	896	36	248	150	1034
70	158	NR	NR	105	724	NR	NR	135	931
80	176	NR	NR	75	517	NR	NR	120	827

The maximum pressure rating for valves regardless of size is 150 PSIG (1034 kPa) at 73° F (22°C)

NR = not recommended

ECO Valve Back Pressure/Pressure Relief Valve



Typical Installation

Ordering Information

Example: Part # ECO - 50J - PP - V __

Back Pressure/Pressure Relief Valve
2 Port Design

Sizes Available:
25 = DN 8 = 1/4"
38 = DN 10 = 3/8"
50 = DN 15 = 1/2"
55 = DN 15 = 1/2" (High Flow)
75 = DN 20 = 3/4"
100 = DN 25 = 1"
110 = DN 25 = 1" (High Flow)
125 = DN 32 = 1 1/4"
150 = DN 40 = 1 1/2"
200 = DN 50 = 2"
220 = DN 50 = 2" (High Flow)
300 = DN 75 = 3"
400 = DN 100 = 4"

Connections Available:
A = NPT
B = BSPT
C = Socket (ANSI)
D = Socket (DIN)
E = Flanged (ANSI)
F = Flanged (DIN)
G = Union X NPT (plastic only)
H = Union X BSPT (plastic only)
I = Union X Socket (ANSI) (plastic only)
J = Union X Socket (DIN) (plastic only)

Options
NL = gauge port - NPT (left to right flow)
BL = gauge port - BSP (left to right flow)
NR = gauge port - NPT (right to left flow)
BR = gauge port - BSP (right to left flow)

Diaphragms
P = PVC (standard on all PVC valves)
T = PTFE backed EPDM (standard on all except PVC valves)
E = EPDM
V = Viton

Body Materials
PVC = polyvinylchloride
PP = polypropylene
PVDF = polyvinyldene fluoride
CPVC = chlorinated polyvinyl chloride (Corzan)
S/S = 316L Stainless Steel

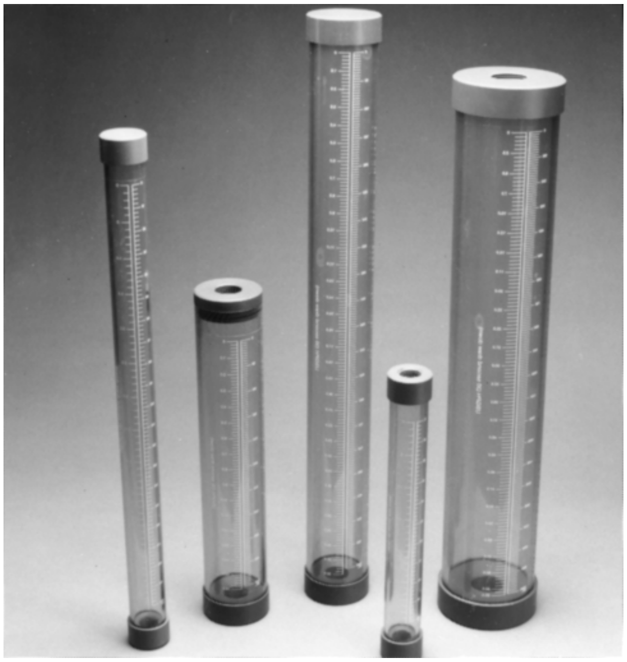
Note: Viton "O" ring seals are standard on all union style valves. EPDM and PTFE encapsulated rings are available for an additional charge. Please contact our sales order desk for pricing.

Distributed by:

SPECIFICATIONS

Griffco Valve Inc.
6010 N.Bailey Ave, Ste 1B
Amherst, NY 14226
Phone: 1 800-474-3326
Fax: 1 716-835-0893

PVC CALIBRATION CYLINDERS



Griffco calibration cylinders are designed to enhance the performance of chemical feed systems by providing a verification of the flow rate of the chemical feed pump. Robust construction of clear PVC with an easy to read graduation in mls and gph. Available in three models: EZ-Clean, Vented, and Open Top; and 13 sizes; 100 mL through 20,000 mL as detailed here.

Features:

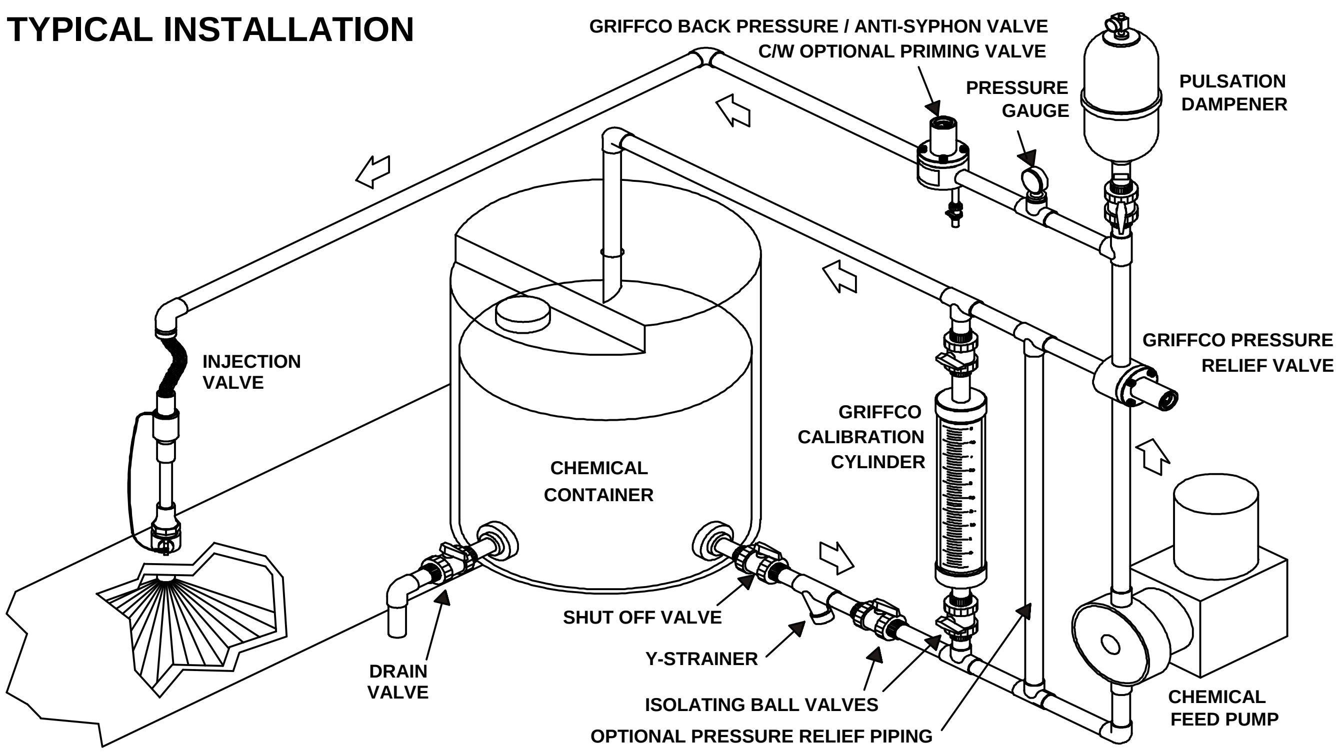
- **High Reliability / Low Cost**
- **High Contrast Graduation Markings**
- **Clear Easy-View Tube**
- **Robust Construction**
- **Direct GPH Readout**
- **Sealed Top with Overflow Connection**
- **Optional EZ-Clean Model**
- **Optional Open Top with Dust Cap**

Operation:

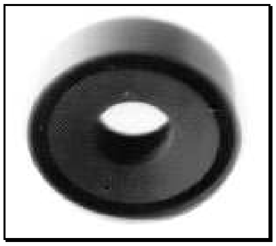
Griffco calibration cylinders are installed in the suction line to the chemical metering pump. Two isolating valves, (not supplied) must be installed in the suction line as per the drawing below. The top of the cylinder should be vented back to the storage tank or to drain.
Fill the cylinder to the top mark then close the valve from the chemical tank. Switch on the chemical feed pump and draw down the chemical in the cylinder for 30 seconds. Switch the pump off. The reading on the right side of the cylinder is a direct readout of USgph.
Alternatively, observe the volume withdrawn on the ml scale. To convert to LPH or GPH use this formula:
LPH = (volume÷draw time) x 3.6
GPH = (volume÷draw time) x 0.952

Note: Max. cylinder pressure is 15 psi.

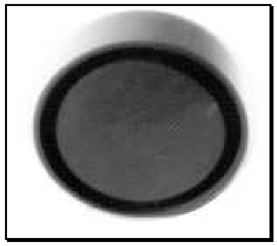
TYPICAL INSTALLATION



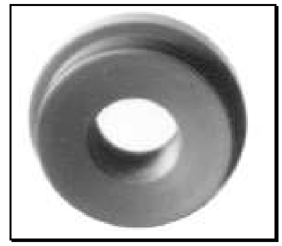
Description of models:



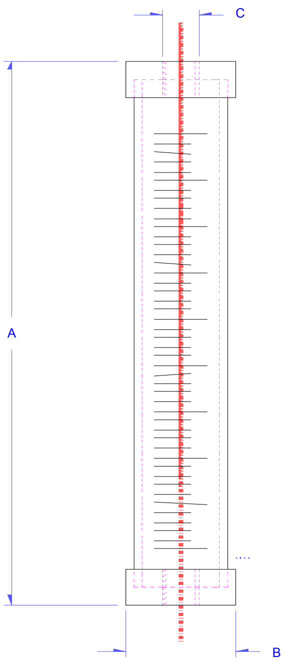
Sealed:
Top is glued to cylinder and contains a vent or overflow connection. (FNPT). Used in applications where there is a positive suction head and a permanent installation is desired.



Loose Cap:
Top is loose and does not have a connection in the top. Dust cover only. Used in applications where there is no positive suction head and the cylinder must be filled from the top.



EZ-Clean: (Avail. 100 – 7000 mL only)
Top is sealed with an O-ring and has a vent connection, but removable for easy cleaning. Used in applications where frequent cleaning is required such as polymer, alum, ferric chloride or chlorine.



Capacity (mL)	Capacity (Usgph)	Scale (mL)	Scale (Usgph)	A (in)	B (in)	C (in)
100	**3.17**	1	.1	11	1.5	1/2
200	**6.34**	1	.1	19	1.5	1/2
300	**9.51**	5	.2	13	2.2	1/2
500	**15.85**	5	.2	13	2.5	3/4
1,000	**31.70**	5	.2	22	2.5	3/4
2,000	**63.40**	10	1	20	3.7	1
3,000	**95.10**	10	1	17	4.9	1 1/2
4,000	**126.80**	10	1	37	3.7	1
5,000	**158.50**	10	1	28	4.9	1 1/2
7,000	**221.90**	10	1	38	4.9	1 1/2
10,000	**317.00**	100	5	25	6.95	2
15,000	**475.50**	100	5	36	6.95	2
20,000	**634.00**	100	5	47	6.95	2

Chemical Resistance Guide (For a more complete listing see our Chemical Resistance Guide - Request Bulletin # CRG 1000-94)

RECOMMENDED

Acetic Acid 10-20%
Acetylene
Adipic Acid
Alum
Aluminium Alum
Aluminium Chloride
Aluminium Fluoride
Aluminium Hydroxide
Aluminium Oxychloride
Aluminium Nitrate
Aluminium Sulfate
Ammonia (dry-gas)
Ammonium Acetate
Ammonium Alum
Ammonium Bifluoride
Ammonium Carbonate
Ammonium Chloride
Ammonium Hydroxide
Ammn. Metaphosphate
Ammonium Nitrate
Ammonium Persulfate
AmmoniumPhosphate
Ammonium Sulfate
Ammonium Sulfide
Ammonium Thiocyanate
Arsenic Acid
Barium Carbonate
Barium Chloride
Barium Hydroxide
Barium Sulphate
Barium Sulfide
Beer
Benzoic Acid
Black Liquors
Bleach (12% Cl)
Borax
Boric Acid
Bromic Acid
Cadmium Cyanide
Calcium Bisulfide
Calcium Bisulfite
Calcium Carbonate
Calcium Chloride
Calcium Hydroxide
Calcium Hypochlorite
Calcium Nitrate
Carbon Dioxide
Carbonic Acid
Caustic Potash
Caustic Soda
Chlorine Water
Chrome Alum
Citric Acid
Copper Carbonate
Copper Chloride
Copper Cyanide
Copper Fluoride
Copper Nitrate
Copper Sulphate
Cupric Fluoride
Detergents
Dextrose
Distilled Water
Ethylene Glycol
Fatty Acids
Ferric Chloride
Ferric Hydroxide
Ferric Nitrate
Ferric Sulfate
Ferrous Chloride
Ferrous Sulfate
Fluorosilicic Acid 25%
Gallic Acid
Gasoline
Glycerine
Glycol
Glycolic Acid
Hydrobromic Acid 20%
Hydrochloric Acid 35%
Hydrocynac Acid
Hydrogen Peroxide 90%
Hydrogen Sulfite
Kraft Liquors
Latic Acid 25%
Lead Acetate
Lead Chloride
Lead Sulfate
Linoleic Acid
Linseed Oil
Lithium Bromide
Malic Acid
Mercuric Chloride
Mercuric Cyanide
Mercury
Methyl Alcohol
Methyl Sulfuric Acid
Milk
Muratic Acid
Nitric Acid 10% - 60%
Oleic Acid
Ozone
Palmitric Acid 10%
Perchloric Acid 10%
Phosphoric Acid 10%
Phosphoric Acid 25%
Phosphoric Acid 75%
Phosphoric Acid 85%
Potassium Alum
Potassium Bicarbonate
Potassium Borate
Potassium Bromate
Potassium Carbonate
Potassium Chlorate
Potassium Chloride
Potassium Cyanide
Potassium Fluoride
Potassium Hydroxide
Potassium Nitrate
Potsm Permanganate
Plating Solutions
Sea Water
Silicic Acid
Silver Cyanide
Silver Nitrate
Sodium Acetate
Sodium Alum
Sodium Bicarbonate
Sodium Bisulfate
Sodium Carbonate
Sodium Cyanide
Sodium Hydroxide
Sodium Hypochlorite
Stannic Chloride
Sulfuric Acid 3%
Sulfuric Acid 10%
Sulfuric Acid 33%
Sulfuric Acid 50%
Sulfuric Acid 70%
Trisodium Phosphate
Water, Deionized
Water, Distilled
Water, Salt
Zinc Chloride
Zinc Sulfate

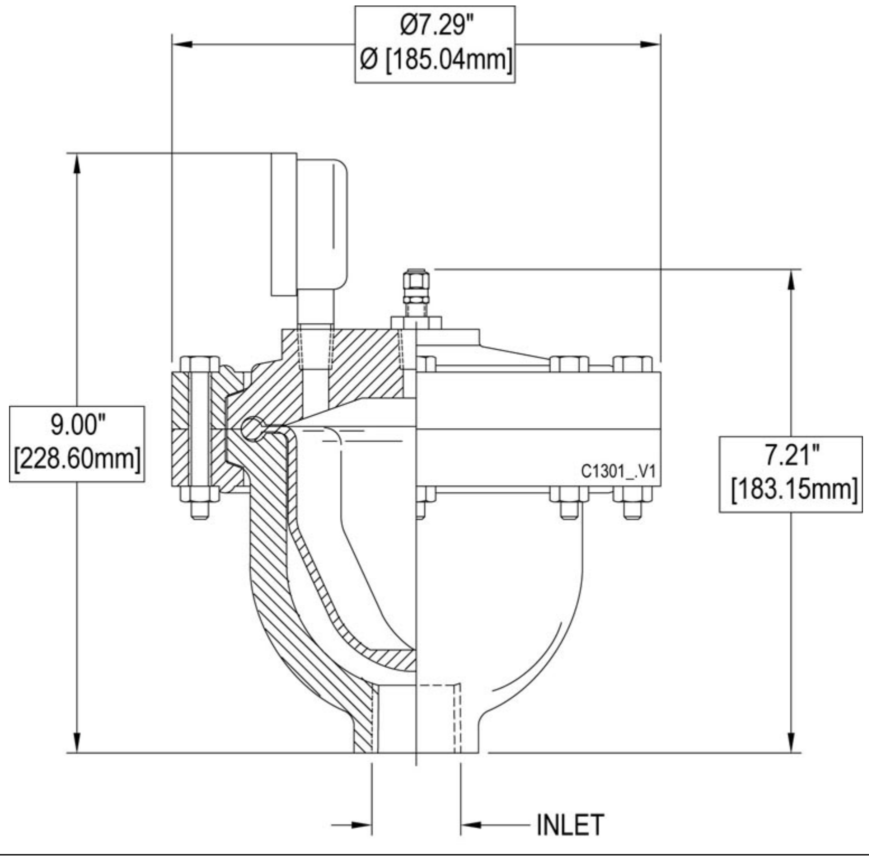
NOT RECM'D

Acetic Acid
Acetone
Ammonia (liquid)
Ammonium Fluoride
Amyl Acetate
Benzene
Bromine, Liquid
Bromine, water
Butyl Acetate
Carbon Bisulfide
Carbon Tetrachloride
Chlorine Gas
Chlorine (wet)
Chromic Acid 10%
Chromic Acid 50%
Ethers
Fluorine Gas
Hydrofluoric Acid 50%
Iodine
Nitric Acid Anhydrous
Nitric Acid 68%
Perchloric Acid 15%
Perchloric Acid 70%
Sulfur Dioxide (wet)
Sulfuric Acid 80-94%
Titanium Tetrachloride
Tributyl Phosphate
Turpentine

DIMENSIONAL DRAWING
C1315V-SW

MODEL #:	C1315V
AIR CONTROL:	CHARGE
BLADDER:	VITON
CAPACITY:	36 CUBIC INCHES/0.59 LITERS
INLET:	0.5" SOCKET WELD - US
MAXIMUM PRESSURE:	150 PSI/10 BARS
NONWETTED HOUSING:	PVC
WETTED HOUSING:	PVC

DIMENSIONAL DRAWING
(TOLERANCE ± .25")



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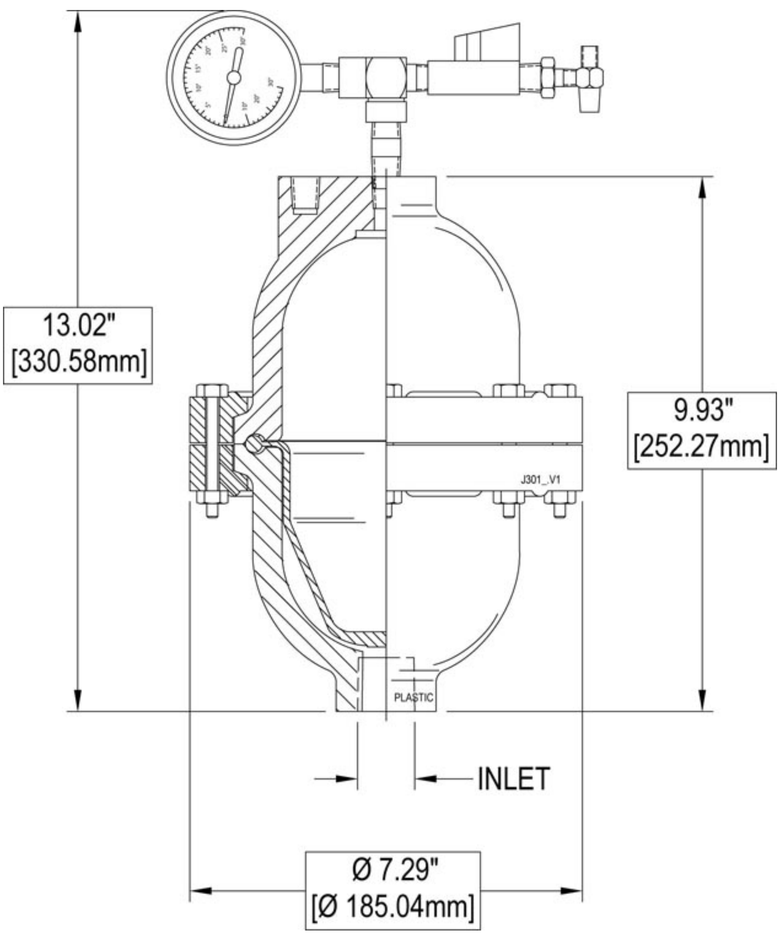
TEL: 800.603.7867 • 951.342.3100 • FAX: 951.342.3101
SALES@BLACOH.COM • WWW.BLACOH.COM

DIMENSIONAL DRAWING
J315V-SW

MODEL #:	J315V-SW
AIR CONTROL:	J
BLADDER:	VITON
CAPACITY:	85 CUBIC INCHES/1.4 LITERS
INLET:	1/2" SOCKET
MAXIMUM PRESSURE:	30 PSI/2.07 BARS
NONWETTED HOUSING:	PVC
WETTED HOUSING:	PVC

DIMENSIONAL DRAWING
(TOLERANCE ± .25")



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ACCUGUARD Diaphragm Seals

Without proper protection, process fluids can contaminate and damage in-line instrumentation. ACCUGUARD Diaphragm Seals are designed to protect and isolate pressure gauges and expensive instrumentation from corrosive, high temperature, or viscous, process media.

□□□□r□□□

- Transfers process pressure accurately without direct contact with process fluids
- Removes the need for expensive instrumentation
- Easily installed and available in five chemically resistant Materials of Construction
- Optional Diaphragm Materials
- Available with ¼" & ½" Bottom Connection Sizes in FNPT & BSPT Female Connection Types
- Thermoplastic Units Rated to 240 PSIG (16 BARG) @ 21°C (70°F)
- 316L S/S Units Rated to 5800 PSIG (400 BARG) @ 21°C (70°F)
- Approved – 316 S/S Diaphragm Seals with CRN (Canadian Registration Number)

HOW TO ORDER - AccuGuard

Example Part Number: AG25A25A-PVC-V-M-[Optional Gauge]

AG 25 A 25 A - PVC - V - M - [Optional Gauge]

See Gauge List

AccuGuard Diaphragm Seal (AG)

Connection Size (Top)
25 = 1/4"

Connection Type (Top)
A = FNPT

Connection Size (Bottom)
25 = 1/4"
50 = 1/2"

Connection Type (Bottom)
A = FNPT
B = BSPT

Options
M = Mounted Gauge/Glycerin Filled

Diaphram Materials
V = Viton (Thermoplastic Body Only)
E = EPDM (Thermoplastic Body Only)
T = PTFE (Thermoplastic Body Only)
S/S = 316 S/S (S/S & S/SV Body Only)

Body Materials
PVC = Polyvinylchloride
CPVC = CPVC Corzan
PP = Polypropylene (Not Available with PTFE Diaphragm)
PVDF = Polyvinyldene Fluoride (PTFE Diaphragm Only)
S/S = 316L Stainless Steel
S/SV = Vented 316L Stainless Steel

- Optional Gauge Appears as Separate Line Item When Ordered
- Diaphragm Seals With Gauges = Glycerin Filled As Standard
- 1/4" & 1/2" MNPT Nipples Available - Call Factory for Details

murraysmith

ATTACHMENT 3

ENGINEERS ESTIMATE OF PROBABLE COSTS

murraysmith

PROJECT:	Lynnwood WWTP Interim Sludge Disposal	Prepared By:	PMD, XX
PHASE:	Schematic Design	Date:	2/9/2022
ENR CCI:	11185.51	Project No.	21-3310
			Class 5 Estimate

Items	Construction Cost	Capital Cost
Sludge Treatment and Conveyance	$717,300	$896,600
Sludge Loading	$936,400	$1,170,500
Total Cost	$1,653,700	$2,067,100

This estimate is in 2022 dollars. This construction cost estimate is an opinion of cost based on information available at the time of the estimate. Final costs will depend on actual field conditions, actual material and labor costs, market conditions for construction, regulatory factors, final project scope, method of implementation, schedule, and other variables. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs currently and is subject to change as the project design matures. Murraysmith has no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means, and methods of executing the work or of determining prices, competitive bidding or market conditions, practices, or bidding strategies. Murraysmith cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown.

Project: Lynnwood WWTP Interim Sludge Disposal Schematic Design
Client: City of Lynnwood
Project No: 21-3310
Date: 2/9/2022

Produced by: XX,PMD
Class 5 Estimate

Sludge Treatment and Conveyance

Item No.	Item	Unit	QTY	Materials	Installation	Total
Civil Site Prep/Earthwork						
1	Existing Pumps Demolition	LS	1		$6,000.00	$6,000.00
	Subtotal					$6,000.00
Structural						
2	RC - Slab on Grade	CY	5	$300.00	$200.00	$2,500.00
	Subtotal					$2,500.00
Mechanical						
3	Chemical Feed System	LS	1	$4,500.00	$900.00	$5,400.00
4	104' Shaftless Screw Conveyors	LS	1	$207,000.00	$41,400.00	$248,400.00
5	Conveyor Supports, MS, Painted	LS	1	$60,000.00	$12,000.00	$72,000.00
	Subtotal					$320,400.00
Electrical Instrumentation and Control						
6	Cord and Switch	LS	1	$5,000.00	$1,000.00	$6,000.00
7	Control Panel	EA	1	$40,000.00	$8,000.00	$48,000.00
8	Electrical, Instrumentation, and Controls (20%-mech)	LS	1	$64,080.00		$64,080.00
	Subtotal					$64,080.00
Construction Material & Labor Subtotal:						$392,980.00

Markups		
Mobilization (10%)	$	39,298.00
General Conditions (8%)	$	31,438.40
Contractor O&P (12%)	$	47,157.60
Subtotal	**$**	**510,874.00**
Tax (10.4%)	$	53,130.90
Construction Contingency (30%)	$	153,262.20
Total Construction Cost	**$**	**717,267.10**
Engineering, Legal, and Administration (25%)	$	179,316.77
Total	**$**	**896,583.87**

Project: Lynnwood WWTP Interim Sludge Disposal Schematic Design
Client: City of Lynnwood
Project No: 21-3310
Date: 2/9/2022

Produced by: XX,PMD
Class 5 Estimate

Sludge Loading

Item No.	Item		Unit	QTY	Materials	Installation	Total
Civil Site Prep/Earthwork							
1	Excavation		CY	74		$22.00	$1,628.00
		Subtotal					$1,628.00
Structural							
2	Sludge Loadout Enclosure (pre-engineered structure)		SF	875	$55.00	$13.00	$59,500.00
3	RC - Slab on Grade		CY	49	$300.00	$200.00	$24,500.00
		Subtotal					$84,000.00
Mechanical							
4	Shaftless Screw Conveyor		LS	1	$95,000.00	$19,000.00	$114,000.00
5	9'' CEMA Air Slide Gates		EA	8	$3,500.00	$700.00	$33,600.00
6	Conveyor Supports, MS, Painted		LS	1	$60,000.00	$12,000.00	$72,000.00
7	Terminal Tractor		LS	1	$42,599.00	$0.00	$42,599.00
8	Activated Carbon System		LS	1	$73,000.00	$14,600.00	$87,600.00
9	Odor Control Ductwork	PVC	LF	55	$76.07	$39.82	$6,373.95
		Subtotal					$356,172.95
Electrical Instrumentation and Control							
10	Cord and Switch		LS	1	$5,000.00	$1,000.00	$6,000.00
11	Control Panel		EA	1	$40,000.00	$8,000.00	$48,000.00
12	Electrical, Instrumentation, and Controls (20%-mech)		LS	1	$71,235.00		$71,235.00
		Subtotal					$71,235.00
Construction Material & Labor Subtotal:							$513,035.95

Markups		
Mobilization (10%)	$	51,303.60
General Conditions (8%)	$	41,042.88
Contractor O&P (12%)	$	61,564.31
Subtotal	**$**	**666,946.74**
Tax (10.4%)	$	69,362.46
Construction Contingency (30%)	$	200,084.02
Total Construction Cost	**$**	**936,393.22**
Engineering, Legal, and Administration (25%)	$	234,098.30
Total	**$**	**1,170,491.52**

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