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City of Bellingham, Washington

Post Point Wastewater Resource Recovery

Facility Planning Report

Post Point Biosolids Project

July 2022

Brown AND Caldwell

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Post Point Biosolids Facility Planning Report

Prepared for
City of Bellingham, WA
July 1, 2022

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This is a draft and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon; consult the final report.

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List of Abbreviations

AA	average annual
AACE	Advancement of Cost Engineering International
ADWF	average dry weather flow
ASB	activated sludge basins
ATAD	autothermal thermophilic aerobic digestion
BC	Brown and Caldwell
BFP	belt filter press
bgs	below ground surface
BMC	Bellingham Municipal Code
BOD	biochemical oxygen demand
BWF	base wastewater flow
ºC	degrees Celsius
CAP	Cleanup Action Plan
CEPT	chemically enhanced primary treatment
CFP	Clean Fuels Program
CFR	Code of Federal Regulations
cfu	colony forming units
CH_4	methane
CHP	combined heat and power
CIP	cast-in-place
City	City of Bellingham
CNGC	Cascade Natural Gas Corporation
CO_2	carbon dioxide
CPARB	Capital Projects Advisory Review Board
CSO	combined sewer overflow
CY	cubic yards
CZM	Coastal Zone Management
DB	Design-Build
DBB	Design-Bid-Build
DO	dissolved oxygen
DSST	Digested Solids Storage Tanks
D/T	dilutions-to-threshold
DT	detection threshold
dtpd	dry tons per day
DWF	dry weather flow
ECC	extruded coal-based carbon
Ecology	Washington Department of Ecology
EDR	Engineering Design Report
EPA	Environmental Protection Agency
EQ	exceptional quality
ESA	Environmental Science Associates
°F	degrees Fahrenheit
FBI	fluidized-bed incinerator
FEMA	Federal Emergency Management Agency
FPDB	Fixed-Price Design-Build
ft^2	square feet
GBT	gravity belt thickeners
GC/CM	General Contractor/Construction Manager
GHG	greenhouse gas
GIS	geographical information system
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
H_2S	hydrogen sulfide
HC	high-capacity
HGWS	high groundwater season
HHV	higher heating value
lb	pound
lb/hr	pounds per hour
LCFS	Low Carbon Fuel Standard
LOI	letter of interest
LWWSD	Lake Whatcom Water and Sewer District
MACT	maximum achievable control technology
MAD	mesophilic anaerobic digestion
mg	milligram
mgd	million gallons per day
mg/L	milligrams per liter
MHF	multiple-hearth furnaces
mL	milliliter
MMDWF	maximum month dry weather flow
MPN	most probable number
MTCA	Model Toxics Control Act
N_2	nitrogen
NEPA	National Environmental Policy Act

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NFPA	National Fire Protection Association
NPDES	National Pollution Discharge Elimination System
NHPA	National Historic Preservation Act
NPV	net present value
NTU	nephelometric turbidity unit
NWCAA	Northwest Clean Air Agency
O_2	oxygen
O&M	operation and maintenance
OLR	organic loading rates
PDM	Progressive Design-Build
PDWWF	peak day wet weather flow
PIDWF	peak instantaneous dry weather flow
PIWWF	peak instantaneous wet weather flow
PLC	programmable log controller
Post Point	Post Point Resource Recovery Plant
Project	Biosolids Project
PS	primary sludge/solids
PSGNP	Puget Sound General Nutrient Permit
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
REC	recognized environmental conditions
RFP	Request for Proposal
RFS	Renewable Fuel Standard
RI/FS	Remedial Investigation/Feasibility Study
RIN	Renewable Identification Number
RNG	renewable natural gas
RRC	Resource Recovery Center
SCADA	supervisory control and data acquisition
scfm	standard cubic feet per minute
SEPA	Stave Environmental Policy Act
SRT	solids retention time
SSC	Sanitary Sewer Company
TBL+	triple bottom line plus
TIN	total inorganic nitrogen
TM	Technical Memorandum
TPAD	temperature-phased anaerobic digestion
TS	total solids
TSS	total suspended solids
UGA	urban growth area
USGS	US Geological Survey
VAR	vector attraction reduction
VCP	Voluntary Cleanup Program
VS	volatile solids
WA-TDZ	Washington Tsunami Design Zone Maps
WAC	Washington Administrative Code
WAS	waste activated sludge
WDFW	Washington Department of Fish and Wildlife
WHB	waste heat boiler
WIFIA	Water Infrastructure Finance and Innovation Act
WT	wet tons

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Section 1

Introduction

This report, entitled City of Bellingham Biosolids Facility Planning Report (Biosolids Facility Plan), describes and documents the planning phase of the City of Bellingham's (City) Post Point Resource Recovery Plant (Post Point) Biosolids Project (Project). This section summarizes the Project purpose, background, history, needs, and goals.

1.1 Purpose

This Biosolids Facility Plan, an update to the City's comprehensive *2011 Wastewater Facility Planning Report* (Carollo Engineers, 2011), was prepared in accordance with Washington Administrative Code (WAC) Chapter 173-240 and the State of Washington, Criteria for Sewage Works Design guidance for submittal to the Washington Department of Ecology (Ecology).

The City has been evaluating alternative biosolids management approaches in the context of aging infrastructure, population growth, changing regulatory requirements, increasing energy costs, and new technologies available for biosolids processing. In addition, the City is seeking a biosolids management approach that aligns with the community's strong sustainability ethic, including their desire to preserve and recover resources, reduce greenhouse gas emissions, and find economically viable solutions that reflect environmental and social considerations in the selection of City initiatives and projects. This planning process has followed a three-phased approach in considering all possible alternatives, then narrowing down options to a preferred biosolids and energy management alternative.

The purpose of the Biosolids Facility Plan is to update the biosolids and energy chapter in the City's all-inclusive, comprehensive 2011 Wastewater Facility Planning Report, to include the Phase 1, 2, and 3 biosolids planning efforts made from Fall 2016 through 2021. This Biosolids Facility Plan provides updated information based on studies performed since the 2011 Wastewater Facility Planning Report was approved by Ecology, continues the evaluation of possible long-term biosolids management and energy alternatives, establishes and describes the preferred alternative, and formally adds it to the City's Capital Improvements Plan.

1.2 Scope

The Biosolids Facility Plan primarily focuses on biosolids management and includes updates to flow and load projections, regulatory requirements, evaluation of desired biosolids and biogas end use alternatives, alternatives screening, selection of a preferred conceptual alternative, and further development of the preferred alternative's technical requirements for the biosolids improvements and associated processes necessary to achieve the City's desired beneficial end uses.

In addition, the Biosolids Facility Plan includes consideration of the impacts to the liquid stream resulting from the addition of new biosolids treatment systems that relate to imminent nutrient regulations, specifically for nitrogen, in the Puget Sound region. The City's future National Pollution Discharge Elimination System (NPDES) permits are likely to require nutrient reduction measures that may come with significant cost and footprint implications. This Biosolids Facility Plan does not include a selected alternative for addressing future nitrogen limits, but it does include conceptual evaluations of liquid stream impacts resulting from future nitrogen removal.

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1.3 Background

The City currently uses multiple-hearth furnaces (MHF) to incinerate wastewater residual solids recovered from Post Point. The existing MHFs are aging and facing additional permitting requirements for air emissions. The City desires a more sustainable, long-term solids management solution, and has initiated investigations of alternative means of managing its wastewater solids and finding beneficial uses for the products, including biosolids and biogas, generated by the treatment process.

1.3.1 Preliminary Biosolids Management Evaluations – 2010 and 2012

The City completed initial preliminary studies of biosolids management options in 2010 and 2012. The Biosolids Facility Plan is a continuation of prior City efforts to plan and implement the approach to transforming Post Point into a resource recovery facility. The 2011 Wastewater Facility Planning Report–Appendix F included the *City of Bellingham Biosolids Plan* (CDM, 2010), which assessed the condition and capacity limitations of the existing MHF solids handling system and provided preliminary biosolids and energy evaluation to identify a long-term biosolids processing solution.

The 2010 report included a comparison of the potential biosolids and energy alternatives and a recommended implementation approach over a 25-year planning horizon (2010 to 2035). The 2010 report indicated that the MHFs were nearing the end of their useful life, the solids loading of the system was approaching capacity limits, and there are high maintenance costs associated with MHFs. The report recommended near-term modifications to the existing solids treatment equipment and operations, in particular for the dewatering and incineration systems, and recommended the City begin planning for an alternative biosolids handling strategy.

In 2012, the City completed the *Biosolids Business Case Evaluation* (CDM, 2012) that further evaluated different solids handling alternatives and provided financial, social, and environmental considerations for each alternative. The alternatives included continued operation of the existing MHFs, a new fluidized bed incineration system, and anaerobic digestion system coupled with sludge drying. The 2012 report provided comparisons and considerations related to cost, site footprint, reliability and redundancy, and other factors, but it did not include recommendations as to which alternative to pursue.

1.3.2 Current Biosolids Planning

In 2016, the City retained the Brown and Caldwell/Carollo Engineers team (Project Team) to further develop and evaluate a comprehensive list of biosolids management alternatives and select a preferred alternative for implementation. The initial Project planning was performed in two phases: Phase 1 included the initial identification of all potential biosolids and energy alternatives, the screening to identify viable alternatives for further evaluation, and the selection of a preferred conceptual alternative. In February 2019, the results of Phase 1 were summarized in Technical Memorandum (TM) No. 1—Preferred Conceptual Alternative (Appendix A). Phase 2 further developed the preferred conceptual alternative and evaluated specific processes for biosolids treatment, biogas end uses, and other processes. In May 2019, the results of Phase 2 were summarized in TM 2—Final Alternative Selection (Appendix B). The preferred alternative identified during Phase 2 planning was Alternative 3B–Temperature-phased Anaerobic Digestion (TPAD) and Soil Blending with Biogas Upgrading. Refer to Section 5 for more details about Phase 1 and Phase 2 evaluations.

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Phase 3 of the Project included further development of the recommended alternative details and culminated in the publication of this Biosolids Facility Plan. This Biosolids Facility Plan includes TPAD processes, biogas upgrading, other necessary solids handling improvements, and ancillary facilities at Post Point. Due to public concern over contaminants of emerging concern, the City continues to evaluate the biosolids end-use alternatives.

1.3.3 Post Point Resource Recovery Plant History

The City's wastewater treatment was served by the Whatcom Creek Treatment Plant from 1947 to 1974. The Whatcom Creek Treatment Plant provided primary wastewater treatment and discharged to the mouth of the Whatcom Creek, which is a tributary of Bellingham Bay. The City replaced the Whatcom Creek Treatment Plant with the new Post Point Wastewater Treatment Plant (now named Post Point Resource Recovery Plant) in 1974, which was sited by Harris Avenue and 4th Street just southwest of Amtrak's Fairhaven Station. The old facility was decommissioned and now serves as a fish hatchery in Maritime Heritage Park. Figure 1-1 is an aerial of the existing Post Point Resource Recovery Plant.

Figure 1-1. Aerial of Post Point Resource Recovery Plant at Harris Avenue and 4th Street

Initially, Post Point provided only primary treatment for up to 55 million gallons per day (mgd) and discharged the effluent to Bellingham Bay after chlorination. The solids from treatment were thickened, dewatered, and then incinerated. The ash from the incinerators was disposed of in a landfill.

In 1993, a consent decree was negotiated between the City and the United States Environmental Protection Agency (EPA) requiring Post Point upgrades to secondary treatment. The upgrades included adding a high-purity oxygen activated sludge secondary treatment system, three secondary clarifiers, and other plant improvements. The new secondary process allowed Post Point to remove up to 95 percent of contaminants during liquids treatment.

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Between 2006 and 2009, BOD loadings to Post Point exceeded 85 percent capacity for 3 consecutive months. In addition, the projected population growth at the time indicated the plant capacity would be exceeded within 5 years. These two factors triggered the need for planning capacity upgrades per NPDES permit requirements. Both the 2009 Bellingham Comprehensive Sewer Plan and the 2011 Facilities Planning Report provided recommendations for additional major improvements to add secondary treatment capacity at Post Point, which were completed in 2014. These improvements focused on the liquids stream and included modifying the primary effluent pump station, converting the high-purity oxygen system to a diffused aeration system, and constructing two new activated sludge basins, an external anaerobic selector, a new secondary clarifier, and a new blower facility.

1.4 Project Need

The Project need stems from multiple key drivers, including:

- Aging infrastructure, capacity limits, and increasingly stringent air quality regulations from the EPA. Incineration is Post Point's existing solids disposal approach. The two existing MHFs are at the end of their service life, capacity-limited, and face stricter air quality regulations from the EPA for air emissions. The MHFs are also energy intensive, sometimes requiring supplemental natural gas to maintain steady-state operation. The MHFs do not have opportunity for energy recovery. These limitations have significantly increased operation and maintenance (O&M) costs.
- Aligning infrastructure investments with City values and strategic objectives. An additional key project driver is the opportunity to transform Post Point into a facility that recovers resources, such as biosolids and biogas, rather than disposing of them. This approach to resource recovery better aligns with the City's values and strategic objectives for environmental sustainability as described in the City's Legacy Statements and Strategic Commitments, as discussed in Section 1.5.

1.5 Project Goals

The goal for this Project is to develop, define, and describe the future biosolids management approach for Post Point, inclusive of the existing and new biosolids facility processes and associated biogas treatment systems. In parallel with the biosolids project, there are changing regulatory requirements related to nutrient discharge from point sources to address nitrogen pollution in Puget Sound and the Salish Sea. Ecology's current direction toward nutrient reduction in future general and/or individual NPDES permits for Post Point (and all dischargers to Puget Sound) will carry significant cost and treatment footprint impacts. Because the proposed biosolids facilities will impact the nitrogen balance within Post Point, the Biosolids Facility Plan considers nutrient removal implications for the liquid stream in tandem with the biosolids improvements (Section 8).

The City's Legacy Statements and Strategic Commitments have guided the Post Point planning process by setting clear criteria that the recommended solution for Post Point must strive to achieve. These criteria include environmental, financial, social, and technical considerations. The Legacy Statements and Strategic Commitments represent the community's strong sustainability ethic, including its interest in resource recovery and preservation, goals for reducing greenhouse gas emissions, and interest in promoting environmental and social considerations with economically viable solutions.

The recommended solution, anaerobic digestion and biogas upgrading is supported by Bellingham City Council and was one of the highest scoring alternatives for each category (environmental, social, financial, and technical).

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1.6 Authority and Management

The City owns Post Point and, in addition to other services, the City's Public Works Department operates and maintains Post Point and its wastewater collection system. Post Point also receives wastewater from the Lake Whatcom Water and Sewer District (LWWSD). The Public Works Department includes Engineering and Operations divisions that both support wastewater services. The City's Superintendent of Plants oversees day-to-day planning, O&M, and laboratory services of both Post Point and the water treatment plant with support from a team of O&M staff. The plant is staffed at all times. Post Point operates its own state-certified laboratory.

Post Point's discharge is governed by its NPDES permit (Appendix C) approved and authorized by Ecology. Ecology has authority to administer NPDES permits in Washington State on behalf of the EPA.

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Section 2

Planning Area Characteristics

The required capacity and configuration of the Post Point facility is influenced by external demands and requirements and the unique characteristics of its service area. These factors evolve over time and include service area changes (e.g., annexations and new sewer connections), incoming flows and loadings, population growth, inflow and infiltration, and regulatory requirements.

Section 2 summarizes the Project Team's biosolids flow and load projection analysis and results. TM 3—Flow and Load Projections (Appendix D) provides more in-depth discussion related to this effort.

Section 2 also describes the planning area characteristics that form the basis for sizing and configuring the wastewater and biosolids treatment facilities. The regulatory framework and requirements for Post Point that also contribute to sizing and configuration are discussed in Section 3.

The planning horizon for this Biosolids Facility Plan is 20 years (through 2045), consistent with Ecology guidelines. The City's published 2011 Wastewater Planning Report covers liquid stream planning through 2036.

2.1 Wastewater Service Area

Post Point receives wastewater discharge from the City of Bellingham (within City limits), Urban Growth Area (UGA), and Lake Whatcom Water and Sewer District (LWWSD). The sanitary sewer service area is more than 30 square miles, extending to Kelly Road to the north, Lake Samish Road to the south, Lake Whatcom to the east and Bellingham Bay to the west. Wastewater services include operating and maintaining more than 325 miles of conveyance system piping (including sewer mains and force mains), 27 pump stations, a combined sewer overflow (CSO) structure, and Post Point. These facilities are managed by the Public Works Department, with the Operations and Maintenance Divisions performing system operations and maintenance.

In 2021, the Project Team analyzed the wastewater service area and sewered population changes for City Limits, UGA, and LWWSD using geographic information system (GIS) data, historic population provided by the Washington State Office of Financial Management, City/UGA and LWWSD population projections from their respective Comprehensive Plans, and household data provided by the City. Projections for the service area are described in the following sections.

2.2 Population Projections

To meet Ecology guidelines, the Project Team calculated the 20-year flow and load projections for the Post Point service area by estimating the sewered population. The entities connected to the sewer system are considered "sewered population" and the entities without sewer connections/service are "unsewered population." The two primary factors impacting the sewered population projections are the rate of population growth and the percentage of sewered population. Population growth (or decrease) affects the flow volumes discharged to Post Point.

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Based on the City's 2016 Comprehensive Plan, the Lake Whatcom Water and Sewer District Sewer Comprehensive Plan 2020 Update, and the City's current GIS data (as of 2021), the Project Team established the current rate of population growth and the percent of sewered population through the end of the respective planning periods and linearly extrapolated the data to the year 2045. Unless otherwise established in the referenced planning documents, the analysis conservatively assumed that 100 percent of the population would be sewered by the year 2045. Table 2-1 provides the current and projected sewered population for the each of the entities within the wastewater service area.

Table 2-1. Current and Projected Sewered Population

Year	City Limits Sewered population	UGA Sewered Population[a]	LWWSD Sewered Population	Total Sewered Population[b]
2020	90,100	5,765	11,576	107,441
2036	109,638	9,990	12,273	131,901
2045	120,844	12,979	12,666	146,489

a. The Geneva area is located within the Bellingham UGA and serviced by LWWSD. For the purposes of this analysis, the associated population is not included in the UGA sewered population and only included under LWWSD sewered population

b. Sum of City limits, UGA, and LWWSD sewered populations.

2.3 Wastewater Flows and Loads

The following sections describe the projections for wastewater flows and loads.

2.3.1 Flow Projections

The Project Team calculated flow projections by applying a residential, per capita base wastewater flow (BWF) to the projected future population, adding the projected commercial/industrial flow, and then by multiplying the resulting combined residential, commercial, and industrial BWF projection by the peaking factors developed for each flow parameter (average dry weather flow [ADWF], maximum month dry weather flow [MMDWF], etc.). The BWF includes residential, commercial, and industrial discharges and is defined as the average of the flow during the driest 3 months (June through August) to minimize the impact of infiltration and inflow on this parameter. The Project Team calculated the per capita flows and peaking factors based on the Post Point historical flow from a recent 5-year-period (2014–2019) from various discharge sources (e.g., residential, commercial, and industrial). Given the population growth assumptions outlined in the 2016 Bellingham Comprehensive Plan, flows are projected to increase even though the flow data from 2014 through 2019 shows very little growth.

As stated above, the projected BWF was determined by multiplying the future population by the historical average residential per capita flow and adding in the projected commercial/industrial flow. The current residential per capita wastewater generation rate is 76 gallons per capita per day (gpcd) and, using a conservative assumption that water consumption patterns will not change from current values, was used as the basis for forecasting future flows. Commercial/industrial flows were projected by multiplying the current commercial/industrial flows by the projected increase in the employment population from Bellingham's 2016 Comprehensive Plan. Maximum flows were developed by multiplying the combined BWF by the selected peaking factors.

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Post Point's peak flow capacity is assumed to be capped at 72 mgd, including peak day wet weather flow (PDWWF), peak instantaneous wet weather flow (PIWWF), and peak instantaneous dry weather flow (PIDWF), consistent with the recommendations of the Comprehensive Sewer Plan and *2011 Wastewater Facility Planning Report* (Carollo Engineers, 2011).

Table 2-2 details the projections for all flow parameters.

Table 2-2. Flow Projection Summary (mgd)

Flow Component	2020	2045
BWF	9.3	12.7
ADWF	10.4	14.3
AWWF	15.1	20.7
MMDWF	17.5	23.9
MMWWF	24.3	33.2
MWDWF	21.2	29.0
MWWWF	32.8	44.9
PDDWF	29.7	40.6
PDWWF	60.7	72.0
PIDWF	62.2	72.0
PIWWF	72.0	72.0

AWWF: Average Wet Weather Flow

MMWWF: Maximum Month Wet Weather Flow

PDDWF: Peak Day Dry Weather Flow

2.3.2 Influent Load Projection

The future wastewater solids loadings to Post Point were calculated for three main parameters (total suspended solids [TSS], biochemical oxygen demand [BOD], and ammonia) to establish the basis of design. The pollutant load parameters for BOD, TSS, and ammonia include average annual (AA), maximum month, maximum 2 week, maximum week, peak 3 day, and peak day. Similar to the flow projection, the years 2014 to 2019 historical loads to Post Point for the three main parameters were used to establish the AA per capita load values and to project the year 2045 loadings. A multi-step data analysis was performed to identify outlier data points, which were excluded from the projection.

Residential AA loads were projected by multiplying the selected per capita load by the projected population. Estimated commercial/industrial loads are projected by multiplying the current estimated commercial/industrial loads by the projected growth in employment as documented in the 2016 Comprehensive Plan. Total AA loads are the sum of the residential and commercial/industrial loads. Maximum loads were developed by multiplying the AA loads by the selected peaking factors. Table 2-3 summarizes the year 2045 AA and maximum month influent loads.

Table 2-3. Projected Influent Load in 2045

Load Component	TSS Adjusted Projection (ppd)	BOD Adjusted Projection (ppd)	Ammonia Adjusted Projection (ppd)
Average Annual	32,000	28,000	3,400
Maximum Month	39,000	34,000	5,000

ppd = pounds per day

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2.3.3 Solids Load Projection

The influent load projections were used in a whole-plant dynamic BioWin model calibrated to the latest calendar year of Post Point's operational data at the time of the analysis (2019) to estimate the primary sludge (PS) and waste activated sludge (WAS) loads. The dynamic model was configured to estimate PS and WAS loads for the year 2020 and 2045 influent flows and loads with 1) the current liquid stream process, 2) with anaerobic digestion of the combined solids, and 3) with side stream treatment of the dewatering return (for enhanced nitrogen removal) as shown in Table 2-4.

In addition, the Project Team considered the solids impact of potentially treating nitrogen (N) in the liquid stream at Post Point. Based on a feasibility analysis that included technology screening and evaluation, adding a tertiary process to remove nitrogen from the secondary effluent would yield the highest solids load to the digestion process. Table 2-4 also summarizes the estimated solids load from this process configuration.

Table 2-4. Total Solids Load Projection for Existing System and with Tertiary Nitrogen Removal

Load	2020, with Digestion and Side Stream Treatment		2045, with CEPT, Digestion and Side Stream Treatment		2045, with CEPT, Digestion, Side Stream Treatment and Tertiary N Removal	
	PS (ppd)	WAS (ppd)	PS (ppd)	WAS (ppd)	PS (ppd)	WAS (ppd)
Average Annual	14,800	13,600	21,000	18,100	25,700	21,700
Maximum Month	17,700	16,500	27,100	21,400	32,500	27,600
Maximum 2 Week	18,500	17,200	27,300	23,700	34,100	28,700
Maximum Week	22,300	18,400	31,500	24,300	38,100	29,400
Peak 3 Day	29,300	18,900	40,800	26,600	47,400	32,000
Peak Day	45,600	17,200	62,500	25,300	69,400	31,200

CEPT = chemically enhanced primary treatment

ppd = pounds per day

The maximum month solids projections summarized in TM 3—Flow and Load Projections, Table 7-1 (Appendix D) without the solids from the nitrogen removal processes are approximately 6 percent less at year 2045 than the 2035 projections developed in the *City of Bellingham Biosolids Business Case Evaluation* (CDM, 2012). The solids projections with the nitrogen removal process are approximately 1 percent less at year 2045 than the 2035 projections developed in the *City of Bellingham Biosolids Plan* (CDM, 2010). The current projections are essentially pushed out 10 years because the previous projections assumed growth in solids from 2007 through 2020 (CDM 2010) and growth in solids from 2011 to 2020 (CDM, 2012), which the City has not observed in actual monitoring data.

Whereas Table 2-4 projects raw primary and secondary solids loads from Post Point, Section 6 provides projections of digested biosolids, biosolids products, and biogas from the recommended anaerobic digestion system.

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2.4 Inflow and Infiltration

Inflow is defined as surface runoff that enters a sewer system through maintenance hole covers, exposed broken pipe and defective pipe joints, cross connections between storm sewers and sanitary sewers, and illegal connection of roof leaders, cellar drains, yard drains, or catch basins. Infiltration occurs when groundwater enters a sewer system through broken pipes, defective pipe joints, or illegal connections of foundation drains. The Biosolids Facility Plan does not include projections for future inflow and infiltration.

To comply with Section S4.E of the NPDES permit, the City publishes an infiltration and inflow evaluation twice per permit cycle. Excessive infiltration is defined by I/I Analysis and Project Certification (EPA, 1985), as dry weather flow (DWF) during a high groundwater season (HGWS) in excess of 120 gallons gpcd. The City's latest Infiltration-Inflow Evaluation Report (City of Bellingham, April 2021) concluded that the estimated 5-year (2016–2020) DWF-HGWS has been lower than the guideline of 120 gpcd developed by the EPA for infiltration, averaging 105 gpcd. In addition, total annual rainfall in 2020 was 3 inches more than in 2009, and both plant average daily flow and estimated HGWS-DWF were lower. When compared to the EPA guidelines, the findings indicate the collection system is not considered to have excessive infiltration. The City's recommendation is to continue its inflow and infiltration management programs that include a number of inflow and infiltration reduction measures.

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Section 3

Regulatory Requirements

Section 3 summarizes the applicable regulatory requirements for the Post Point liquid stream and solids stream.

3.1 Liquid Treatment Regulatory Requirements

Post Point currently provides secondary treatment for the City's wastewater prior to discharge to Bellingham Bay. Ecology issued NPDES permit No. WA0023744 for Post Point (Appendix C) that was effective July 1, 2014, and expired June 30, 2019. The NPDES permit has been administratively extended and will remain in effect until Ecology issues a new permit.

The City's current NPDES permit has defined and permitted three outfalls, with Outfall 001 serving as the primary discharge location. Outfall 002 is an alternate discharge location permitted to be used when Outfall 001's hydraulic capacity is exceeded (passive weir) and only during heavy rain events or for quarterly testing. Both Outfalls 001 and 002 discharge wastewater effluent. Outfall 003 is a permitted CSO location from the C Street CSO Structure that discharges collection system overflow containing untreated and combined stormwater and sewage.

In addition, bypass of the secondary treatment process is authorized when the facility flow rate exceeds 37 mgd caused by a wet weather event. These CSO-related bypass flows still require preliminary and primary treatment as well as disinfection.

Section 3.1 describes regulatory limits enforced by the current Post Point individual municipal wastewater NPDES permit (as of 2020). Ecology is currently drafting the next cycle of the individual NPDES permit. In January 2022, Ecology issued a new Puget Sound General Nutrient Permit. Although the current Post Point NPDES permit does not place effluent limits on inorganic nitrogen compounds, Ecology has communicated that those limits will be issued with the next permit(s).

Table 3-1 provides the current effluent discharge limits for Outfall 001. Table 3-2 provides effluent discharge limits for Outfall 002.

Table 3-1. Post Point NPDES Permit Effluent Requirements–Outfall 001

Parameter	Average Monthly	Average Weekly
Biochemical Oxygen Demand (5-day) (BOD_5)	30 milligrams per liter (mg/L) 8,582 pounds per day (lb/day) 85% removal of influent BOD	45 mg/L 12,873 lb/day
Total Suspended Solids (TSS)	30 mg/L 8,582 lb/day 85% removal of influent TSS	45 mg/L 12,873 lb/day
Parameter	**Average Monthly**	**Maximum Daily**
Total Residual Chlorine	0.198 mg/L	0.429 mg/L

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Table 3-1. Post Point NPDES Permit Effluent Requirements–Outfall 001		
Parameter	**Minimum**	**Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria	200 per 100 milliliter (mL)	400/100 mL

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 condition S.13 of the permit. The ACEC equals 3% effluent.

Table 3-2. Post Point NPDES Permit Effluent Requirements–Outfall 002		
Parameter	**Average Monthly**	**Average Weekly**
BOD_5[a]	30 mg/L 8,582 lb/day 85% removal of influent BOD	45 mg/L 12,873 lb/day
TSS	30 mg/L 8,582 lb/day 85% removal of influent TSS	45 mg/L 12,873 lb/day
Parameter	**Average Monthly**	**Maximum Daily**
Total Residual Chlorine[a]	0.033 mg/L	0.048 mg/L
Parameter	**Minimum**	**Maximum**
pH	6.0 standard units	9.0 standard units
Parameter	**Monthly Geometric Mean**	**Weekly Geometric Mean**
Fecal Coliform Bacteria	200/100 mL	400/100 mL

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 condition S.13 of the permit. The ACEC equals 27% effluent.

a. Chlorine limits are for discharges during exercise and/or maintenance of Outfall 002.

The NPDES permit also regulates facility loadings to Post Point. Table 3-3 summarizes the flows and waste loads design criteria that must not be exceeded.

Table 3-3. Post Point NPDES Permit Requirements–Facility Loadings	
Parameter	**Maximum Month Value**
Design Flow	34.3 mgd
BOD Influent Loading	39,800 lb/day
TSS	45,500 lb/day

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3.1.1 Combined Sewer Overflow Conditions

Per Special Conditions Section S10 of the NPDES permit, the City may discharge domestic wastewater from Outfall 003 when wet weather events overload the combined sewer system. The performance standard for controlled CSO outfalls is an average of no more than one discharge event, caused by precipitation, per outfall per year. Ecology evaluates compliance with this standard on a 5-year rolling average basis. The City is required to operate Post Point at a maximum treatable flow during these wet weather events to limit the magnitude, frequency, and duration of CSOs. In addition, the City is required to implement measures to control solid and floatable materials from CSOs and to follow a public notification process. The City has not used Outfall 003 since 2009.

3.1.2 Future NPDES Permit Considerations

While this Biosolids Facility Plan focuses on the biosolids improvements for Post Point, the planning process must consider the impacts of future regulatory requirements, including new regulations for the liquid stream. As previously described, the Puget Sound General Nutrient Permit was issued by Ecology in January 2022 addresses effluent nutrient discharges from wastewater treatment plants to surface waters. The current NPDES permit does not require effluent monitoring of nitrogen compounds. These future, increasingly stringent nutrient limits would pose additional requirements on the biosolids improvements project. Section 8.1 describes the potential impacts from the new general permit and/or new individual Post Point NPDES permit in more detail as they relate to nitrogen removal and the biosolids planning process.

3.2 Biosolids Regulatory Requirements

The City's implementation of a new biosolids management program that beneficially uses biosolids will require a general permit. A new statewide general permit for biosolids management was issued in 2020. Additionally, any facilities in Washington that treat, store, use, or dispose of the City's biosolids may require a general permit; however, certain facilities, such as compost and soil-blending operations, may be designated under the jurisdiction of the local health department. Ecology has stated that there is some flexibility, and each facility is evaluated on a case-by-case basis. Typically in Washington, the local health department defers to Ecology as the permit holder and regulatory body.

The City's new biosolids management program may allocate a portion or all of its biosolids for local and regional beneficial use. This program will be subject to the regulations outlined below.

3.2.1 Regulatory Agency

The usage, land application, and disposal of biosolids in Washington State is governed by the WAC Chapter 173-308, which are inclusive of the federal standards established under the EPA's Title 40, Code of Federal Regulations (CFR) Part 503 (Part 503). Compliance with Ecology's permit requirements ensures compliance with the minimum federal standards; thus, the WAC standards are used as a design basis for this project. The authority to regulate biosolids and issue separate state permits for biosolids management programs is granted to Ecology in Chapter 70.95J Revised Code of Washington (RCW). Washington State does not have fully delegated authority from the EPA and may not implement the Part 503 Rule independent of federal oversight. The EPA Region 10 office is responsible for biosolids program oversight, including federal permits, compliance monitoring, and enforcement issues associated with the implementation of the Part 503 requirements. All applicable facilities in the state must meet requirements set forth by both state and federal programs.

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WAC 173-308 has additional restrictions including, but not limited to:

- Washington State regulations do not permit Class A pathogen reduction through EPA Part 503 Alternative 3 (Other Processes) and Alternative 4 (Unknown Processes).
- Biosolids must be significantly treated to remove manufactured inerts (plastics, metals, ceramics, etc.) prior to final disposition.
- Biosolids sold or given away in a bag or other container must be appropriately labeled or an information sheet must be provided.
- Biosolids must be applied to the land in a manner approved by Ecology and at specified agronomic rates.

Table 3-4 summarizes some of the major WAC requirements that may apply to the City but is not a comprehensive list of all applicable codes. Note that the City may partner with a third party to provide off-site biosolids services related to trucking, processing, and distributing a final biosolids product from Post Point. As such, regulatory compliance for this element of the project could be delegated to the third party.

Table 3-4. Potential Applicable Washington Administrative Codes for Post Point Biosolids Management

WAC	Description
173-308-030	Commercial fertilizers are subject to Washington State Department of Agriculture regulations. Biosolids that meet the definition of a commercial fertilizer must comply with chapter 15.54 RCW and Chapter 16-200 WAC.
173-308-140	Addresses biosolids sampling and analytics methods.
173-308-190	Biosolids must be applied to the land in a manner approved by the department and at agronomic rates.
173-308-200	Provides exemptions based on Exceptional Quality (EQ) designation of biosolids.
173-308-205	Biosolids must be treated via physical screens or another method to significantly reduce manufactured inerts.
173-308-260	Biosolids sold or given away in a bag or other container must meet EQ standards.
173-308-280	Provides requirements for facilities storing biosolids or sewage sludge.

3.2.2 Biosolids Regulations

Biosolids to be land-applied can be classified as either Class A or Class B based on meeting pathogen reduction and vector attraction reduction (VAR) requirements. Class A biosolids must meet strict pathogen standards and can be used without restrictions. Class B biosolids must meet less stringent pathogen requirements, with application restricted to crops and limited human and animal exposure. Biosolids that are provided as bagged or bulk products must meet Exceptional Quality (EQ) biosolids designation. EQ biosolids are required to meet the pollutant concentration limits in Column 3 of Table 3-7, at least one of the Class A pathogen reduction requirements, and at least one of the VAR requirements.

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WAC 173-308 designates biosolids as either Class A or Class B based on the treatment processes and the density of pathogens or indicator organisms in the final product. Class A biosolids require that the density of fecal coliform in the biosolids must be less than 1000 most probable number (MPN) per gram of total solids (dry weight basis), or the density of *Salmonella sp*. bacteria in the biosolids must be less than three MPN per 4 grams of total solids (dry weight basis) at the time the biosolids are used, at the time the biosolids are prepared for sale or give away in a bag or other container for application to the land, or at the time the biosolids or material derived from biosolids is prepared to meet the requirements for exemption in WAC 173-308-200. Class A biosolids can be met from one of the four alternatives shown in Table 3-5. Class B biosolids require that fecal coliform be less than 2,000,000 MPN per gram of total dry solids or 2,000,000 Colony Forming Units per gram of total dry solids. This can be met by meeting one of the three alternatives shown in Table 3-5.

Table 3-5. Alternatives for Pathogen Reduction

Alternatives for Class A Pathogen Reduction[a]	Alternatives for Class B Pathogen Reduction
General requirement that the density of either: • Fecal coliform in the biosolids must be less than 1000 MPN per gram of total dry solids *or* • *Salmonella sp*. bacteria in the biosolids must be less than three MPN per 4 grams of total dry solids	General requirement that the geometric mean of the density of either: • Fecal coliform in the biosolids must be less than 2,000,000 MPN per gram of total dry solids *or* • 2,000,000 Colony Forming Units per gram of total dry solids

• Alternative 1: Time and Temperature
  • Biosolids are thermally treated with specific requirements for time and temperature depending on solids concentration
	• Alternative 1: Testing
	  • A minimum of seven samples of the biosolids are tested and comply with the required Class B fecal coliform maximums stated above

• Alternative 2: ph, Time, Temperature, and Percent Solids
  • Biosolids are treated to pH and time requirements followed by air drying to achieve a minimum percent solids
	• Alternative 2: Process to Significantly Reduce Pathogens
	  • Biosolids are treated with a process from an approved list of “Process to Significantly Reduce Pathogens”

• Alternative 3: Process to Further Reduce Pathogens
  • Biosolids are treated with a process from an approved list of “Process to Further Reduce Pathogens”
	• Alternative 3: Equivalent Process to Significantly Reduce Pathogens
	  • Biosolids are treated with a process that is equivalent to a “Process to Significantly Reduce Pathogens”

• Alternative 4: Equivalent Process to Further Reduce Pathogens • Biosolids are treated with a process that is equivalent to a “Process to Further Reduce Pathogens”	-

a. Washington State regulations do not allow EPA CFR 40 Part 503 Alternative 3 (Other Processes) and Alternative 4 (Unknown Processes).

3.2.3 Vector Attraction Reduction

Class A and Class B both must also meet one of the listed VAR requirements at the same time or after meeting the requirements for pathogen classification. These VAR requirements are summarized in Table 3-6.

Table 3-6. Alternatives for Vector Attraction Reduction

Alternatives for Class A and Class B Vector Attraction Reduction [a]
Alternative 1: Volatile Solids Reduction: The mass of volatile solids in the biosolids are reduced by a minimum of 38 percent. Bench-scale tests can be used to test when 38 percent is not achieved for aerobically and anaerobically digested solids[b].
Alternative 2: Specific Oxygen Uptake Rate (SOUR): The specific oxygen uptake rate for biosolids treated in an aerobic process must be less than or equal to 1.5 milligrams of oxygen per hour per gram of total solids (dry weight basis) at a temperature of 20°C.
Alternative 3: Aerobic Process: Biosolids must be treated in an aerobic process for 14 days or longer. During that time, the temperature of the biosolids must be higher than 40°C (104°F) and the average temperature of the biosolids must be higher than 45°C (113°F).

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Table 3-6. Alternatives for Vector Attraction Reduction
Alternatives for Class A and Class B Vector Attraction Reduction [a]
Alternative 4: pH Adjustment: The pH of the biosolids must be raised to 12 or higher by alkali addition and, without the addition of more alkali, must remain at 12 or higher for 2 hours and then at 11.5 or higher for an additional 22 hours.
Alternative 5: Percent Solids for Stabilized Solids: For biosolids that do not contain unstabilized solids generated in a primary wastewater treatment process, the percent solids must be equal to or greater than 75 percent based on the moisture content and total solids prior to mixing with other materials.
Alternative 6: Percent Solids for Unstabilized Solids: For biosolids that contain unstabilized solids generated in a primary wastewater treatment process, the percent solids must be equal to or greater than 90 percent based on the moisture content and total solids prior to mixing with other materials.

a. Washington State regulations refer to EPA CFR 40 Part 503 Option 9 and 10 to meet the vector attraction requirements separately in WAC 173-308-210.

b. Washington State regulations incorporate EPA CFR 40 Part 503 Options 2 and 3 as part of WAC 173-308-180 Alternative 1.

3.2.4 Pollutant Limits

WAC 173-308 sets standards for heavy metal pollutants with concentration limits and cumulative pollutant loading rate limits for biosolids that are applied to land. Table 3-7 includes biosolids "Ceiling Concentration Limits," which are the maximum allowable pollutant concentrations in biosolids that are land applied. Any of the pollutants that exceed these concentrations will reclassify the biosolids as solid waste and cannot be land applied.

Table 3-7. Land Application Pollutant Limits for Biosolids Applied to Land

Pollutant	Column 1 Ceiling Concentration Limits (mg/kg, dry weight)	Column 2 Cumulative Pollutant Loading Rate (kg/ha, dry weight)	Column 3 Limit Monthly Average (mg/kg, dry weight)
Arsenic	75	41	41
Cadmium	85	39	39
Copper	4,300	1,500	1,500
Lead	840	300	300
Mercury	57	17	17
Molybdenum	75	-	-
Nickel	420	420	420
Selenium	100	100	100
Zinc	7,500	2,800	2,800

kg/ha = kilograms per hectare

mg/kg = milligrams per kilogram

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Section 4

Existing Treatment Facilities

This section of the Biosolids Facility Planning Report describes the existing liquid stream and solid stream treatment processes at the Post Point Resource Recovery Plant (Post Point).

4.1 Post Point Resource Recovery Plant

Originally constructed in 1974, Post Point has been expanded (1994) or undergone select process improvements (2012) twice since then. The plant is situated on a 33-acre property located adjacent to Bellingham Bay in the Fairhaven neighborhood of Bellingham at 200 McKenzie Avenue. The property is comprised of two land parcels: a primary 30-acre site where most of the existing Post Point facilities are located, and a secondary 3.3-acre site in the northeast corner of the property (NE parcel) that originally included five metal buildings constructed in the mid-1940s. Before the City of Bellingham (City) purchased it in 2006, the smaller site was owned by Homeport Properties, a real estate agency. The NE parcel, zoned as Industrial Area 3, is physically located at 210 McKenzie Avenue. The main parcel is zoned as Public Area 2.

An intertidal lagoon, one of only seven pocket estuaries in Bellingham Bay, abuts the western side of the plant. The Burlington Northern Santa Fe Railway runs along the western side of the property on an elevated embankment that partially isolates the intertidal lagoon from Bellingham Bay. The Lower Padden Creek and Larrabee Trail partially encircles Post Point and provides views into the Post Point lagoon, wetlands, and the adjacent Great Blue Heron rookery. Post Point is fully fenced to limit public access to the plant.

The primary access to Post Point is via McKenzie Avenue on the northeastern side. An industrial and transportation district is located north of Post Point. Residential neighborhoods are located to the southwest, south, and southeast of Post Point and are separated by raised bluffs and a wooded area.

Figure 4-1 provides a map of the Post Point property and the existing facilities.

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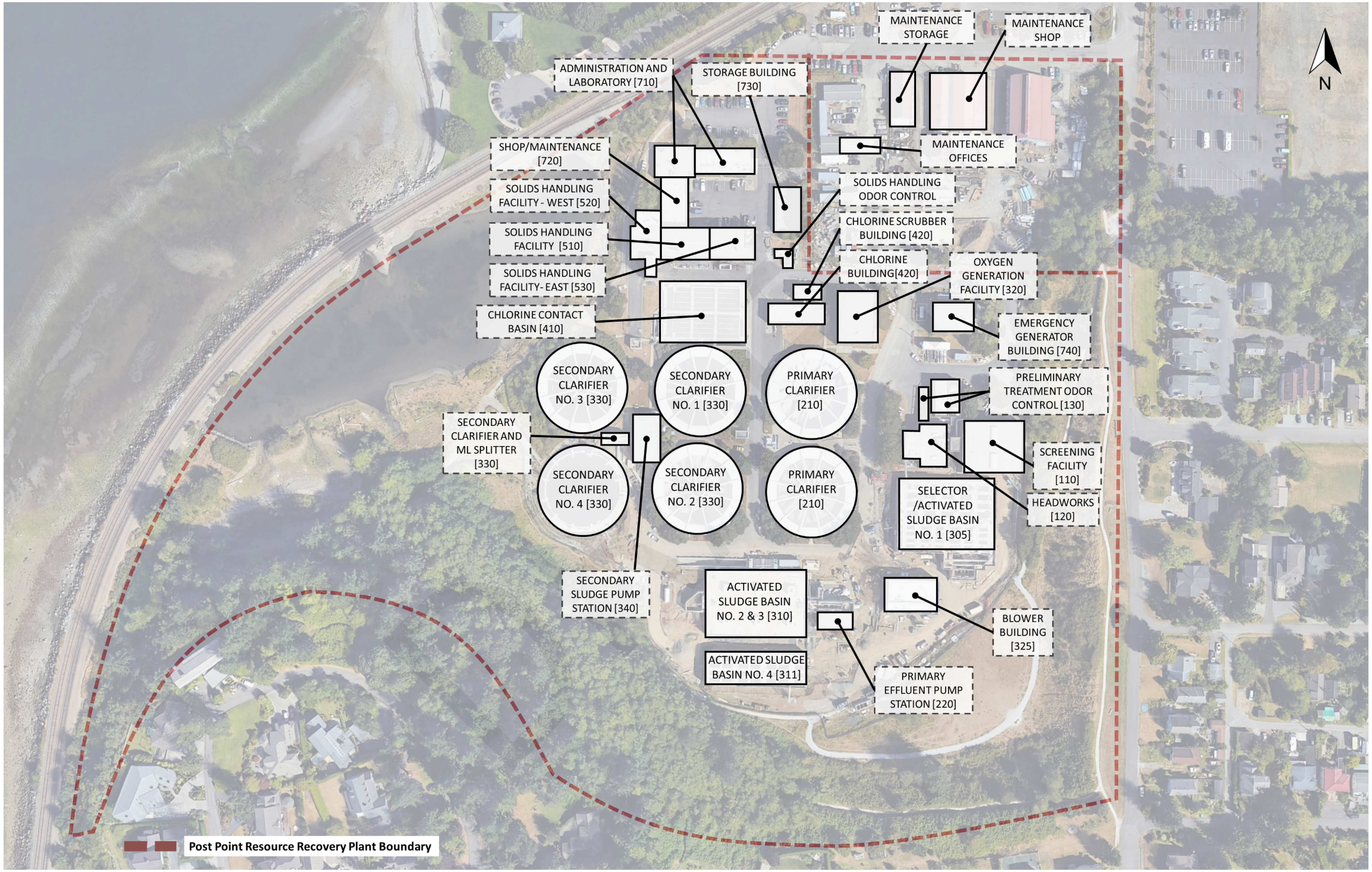

Figure 4-1. Post Point Facilities Map

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4.2 Existing Treatment Facilities

The following sections summarize the existing treatment facilities at Post Point.

4.2.1 Liquid Treatment Process

Post Point receives wastewater via gravity collection from the south end of the city and the Oak Street Pump Station. Wastewater enters the screenings facility by first passing under the septage dumping bay where septage may be directly dumped into the channel. Next, the wastewater passes through mechanical bar screen channels, after which the screenings are sent through a screw conveyor, dewatered, and collected for subsequent landfilling. At this point, a set of detritors use gravity to remove grit and heavier particulates from the flow. Two primary clarifiers further remove settleable solids and floating solids (scum) via gravity. The bottom clarifier mechanism arm collects the heavy settleable solids (primary sludge) which is pumped to the Solids Handling Facility. The primary effluent is pumped to secondary treatment.

The secondary treatment system is comprised of two main components: activated sludge and secondary clarification. The activated sludge system includes one external selector basin and four aerated basins. In the activated sludge basins, most of the organic material in the wastewater is consumed for microbial growth or oxidized. Particulates and colloidal material are caught in the flocculated activated sludge, which are then settled out in the secondary clarifiers. A portion of the settled material is returned to the activated sludge basins, thus providing for the continued operation of the process. The secondary effluent is chlorinated and flows to the chlorine contact basins for disinfection, dichlorination, and discharge to the Outfall 001.

During wet weather events, high flow may compromise complete secondary treatment at Post Point. To prevent washout of the activated sludge basins, a weir allows for primary effluent exceeding 40 million gallons per day (mgd) to be bypassed around the secondary treatment processes. The diverted flow is then blended with secondary effluent prior to disinfection.

Figure 4-2 shows a simplified process schematic of Post Point's liquid treatment process.

4.2.2 Screening Facility

The Screenings Facilities (110 Building) were built as part of the secondary expansion project in 1994. The facility includes a septage bay, bar screens, and influent flow measurement tools. The septage system has been decommissioned and septage haulers discharge to the main influent channel.

4.2.3 Headworks Building

The Headworks Building (120 Building) houses two, 30-foot-diameter grit basins and was constructed with the original plant in 1974. The grit system is comprised of gravity-fed detritus tanks and a grit collection mechanism. Grit dewatering cyclones and grit washers were constructed during the 1994 expansion.

4.2.4 Preliminary Odor Control Building

The Preliminary Odor Control Building (120 Building) houses the single-stage wet scrubbers for the Screenings Facility and Headworks Building and the activated carbon beds.

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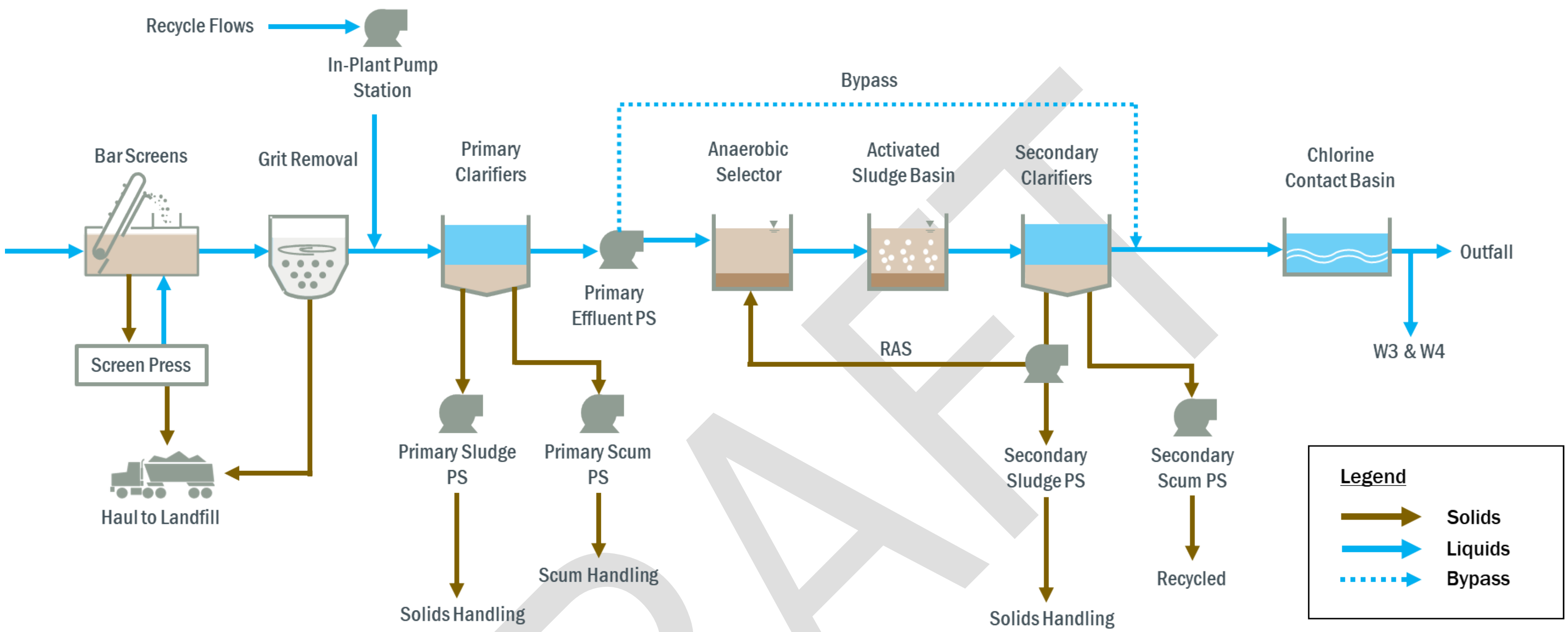

Figure 4-2. Post Point Simplified Process Schematic of Existing Liquid Treatment Process

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4.2.5 Primary Clarifiers

Two, 120-foot-diameter primary clarifiers (210 Facility) remove settleable solids from the wastewater during primary treatment. Built in 1974, these cast-in-place (CIP) concrete structures are mostly below grade with a cast-in-place architectural arch roof structure.

4.2.6 Primary Effluent Pump Station

The Primary Effluent Pump Station houses pumps which lift primary effluent from the wet well and convey flow either to the activated sludge system or allow secondary bypass for flow exceeding 40 mgd.

4.2.7 Activated Sludge Basins

One selector basin and four activated sludge basins (ASB) comprise the first half of the secondary treatment process at Post Point. The external anaerobic selector basin, ASB 1, and ASB 4 were constructed as part of the plant improvements in 2012. Flow from the selector basin flows to ASB 1. After exiting ASB 1, the flow is split and sent to ASB 2, 3, and/or 4.

4.2.8 Secondary Clarifiers

Four, 120-foot-diameter secondary clarifiers (330 Facility) comprise the last half of the secondary treatment process. Secondary Clarifiers No. 1 to No. 3 were constructed as part of the 1994 expansion. Secondary Clarifier No.4 was constructed during the 2012 plant improvements. These CIP concrete structures are mostly below grade with a CIP architectural arch roof structure

4.2.9 Oxygen Generation Facility

The Oxygen Generation Facility (210 Building) has been used as a maintenance storage location since the 2012 plant improvements. In 2022, the City begin construction on an on-site hypochlorite generation system in this renovated building. Construction is expected to be completed in November 2022.

4.2.10 Blower Building

The Blower Building (325 Building) was constructed as part of the 2012 plant improvements and houses the aeration blower system and large electrical room.

4.2.11 Chlorine Contact Basin

The Chlorine Contact Basin (420 Facility) provides contact retention time for chlorine prior to discharge of the treated effluent into Bellingham Bay. The Chlorine Contact Basins were constructed in 1974 and upgraded in 1994. The CIP concrete tanks are mainly located below grade.

4.2.12 Chlorine Buildings

The Chlorine Scrubber Building (420 Building) and Chlorine Gas Building (420 Building) provide storage for the gas/liquid chlorine used for disinfection of the secondary effluent. In 2022, the City will be phasing out the use of chlorine gas for disinfection at Post Point and replacing it with sodium hypochlorite generated on-site. These buildings are intending to be abandoned in place and only the east side of the Chlorine Gas Building will remain in use for existing electrical and instrument and control panels.

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4.3 Existing Solids Treatment Facilities

The following sections summarize the existing solids treatment facilities at Post Point.

4.3.1 Solids Treatment Process

Solids have been processed at Post Point on a 24-hour/7-days-per-week schedule since 2011. Primary and secondary solids are co-mingled and pumped to gravity belt thickeners (GBT) for co-thickening to about 6 percent solids. Polymer is injected upstream to condition the solids before entering the GBTs. Thickened solids are discharged to collection tanks below and pumped to centrifuges for dewatering to about 25 percent solids. Additional polymer is added upstream of the centrifuges to condition the solids. Dewatered solids cake and concentrated scum are pumped to one of two multi-hearth furnaces (MHFs); the resulting ash is landfilled. Figure 4-3 illustrates a simplified version of this process.

4.3.1.1 Solids Thickening

The solids thickening process uses two, 2-meter wide GBTs operating on a duty/standby basis. These units were placed in service in 1993 so are past the typical service life of 25 years.

4.3.1.2 Thickened Solids Storage

Thickened sludge generated at Post Point can be stored for improved operational flexibility and enables the facility to handle surplus capacity for peak and emergency events; however, unaerated sludge storage will result in endogenous decay, which generates volatile fatty acids and soluble organics that are recycled back to the liquid treatment process via the dewatering centrate.

4.3.1.3 Solids Dewatering

Two Alfa Laval G2-95 model centrifuges were installed in 2011 and are used to process up to 2,500 dry pounds per hour (lb/hr) of solids each. The centrifuges operate with a single-duty unit.

4.3.1.4 Solids Incineration

Post Point uses two MHFs to incinerate its biosolids with an approximate total capacity of 2,400 lb/hr. MHF 1 was installed in 1973 and MHF 2 was installed in 1993. The MHFs require regular repair and maintenance to the refractories, hearths, insulation, shell reinforcements, and to the programmable logic controllers (PLCs), all of which is becoming increasingly difficult and costly due to their age. The PLCs are over 30 years old and are no longer available from the original equipment manufacturer. With a typical life expectancy of 25 years, major maintenance on the MHFs in the future would likely require replacing the furnace firebrick and hearths, the wet scrubbing system (due to erosion and corrosion), and the center shaft drive mechanisms. The City is currently in the process implementing some of these maintenance repairs, which are anticipated to be completed for both incinerators in 2022.

The formation of slags and clinkers are reoccurring operation and maintenance problems that limit MHF performance. Slag is the accumulation of molten or fused ash that can stick to the MHF walls, rabble arms, or center shaft. Clinkers are hard or soft clumps of fused ash that can jam rabble arms or the ash-conveying system. Although some modifications to the MHF have reduced the occurrence frequency of slag and clinkers, they remain a maintenance challenge.

MHF operation is costly due to energy demands—they require approximately 25,000 to 60,000 cubic feet of natural gas per day, 2,500 megawatt hours per year of electrical power, and 3,300 gallons of diesel fuel. No energy or heat recovery system is currently used with either furnace to offset energy consumption.

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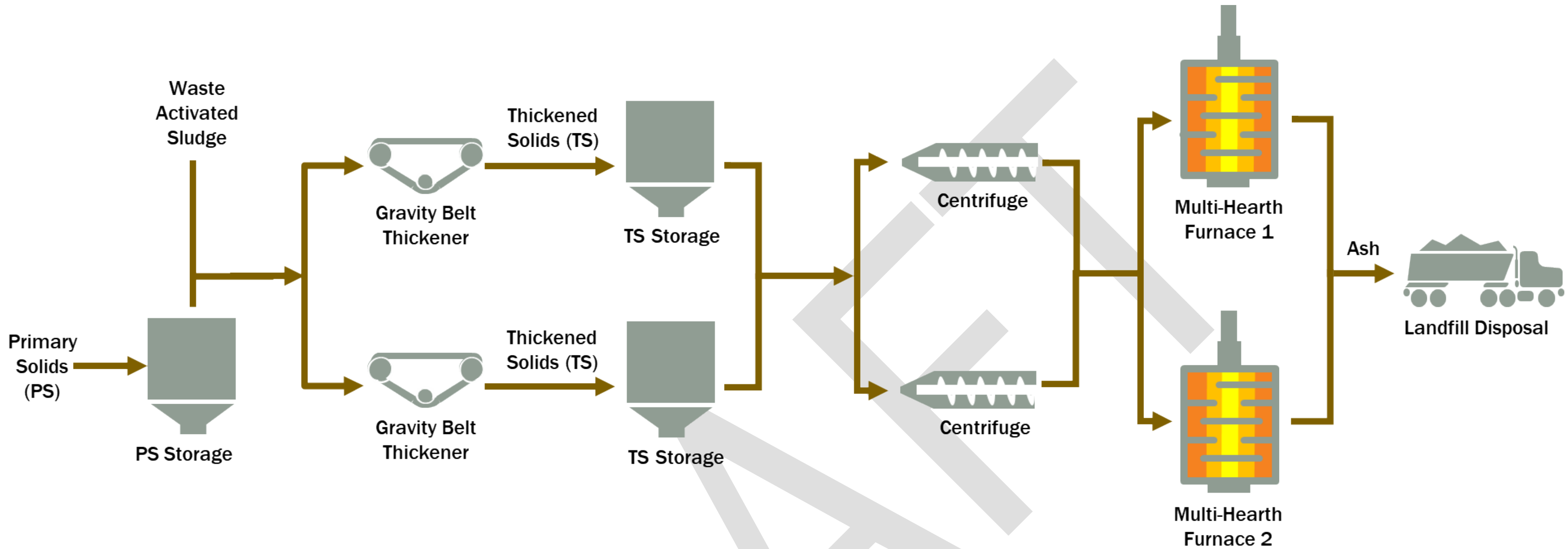

Figure 4-3. Post Point Simplified Process Schematic of the Existing Solids Treatment Process

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Emissions are controlled with a venturi wet scrubber, tray scrubber, mist eliminator, and wet electrostatic precipitator; however, increasingly stringent air quality regulations may require upgrades to the existing systems.

The old age and frequent maintenance requirements for the MHFs limits redundancy and reduce system reliability. Additionally, the current biosolids incineration with the MHFs does not comply with the City's desire to beneficially reuse its biosolids.

4.3.2 Solids Handling Facility

The original solids treatment process is housed in the multi-story Solids Handling Facility (510 Building) located on the northwest corner of Post Point. This building was constructed with the original plant and expanded during the plant improvements in 1994. The expansion included the addition of a west (520 Building) and east (530 Building) section. The west section houses polymer storage, Incinerator No. 2, and the ash loadout system. The main Solids Handling Facility contains Incinerator No. 1, the cake pumps, and primary sludge tank. The east section houses the thickening and dewatering equipment, odor control units, and thickened solids storage tanks. Figure 4-4 illustrates the layout of the combined Solids Handling Facility.

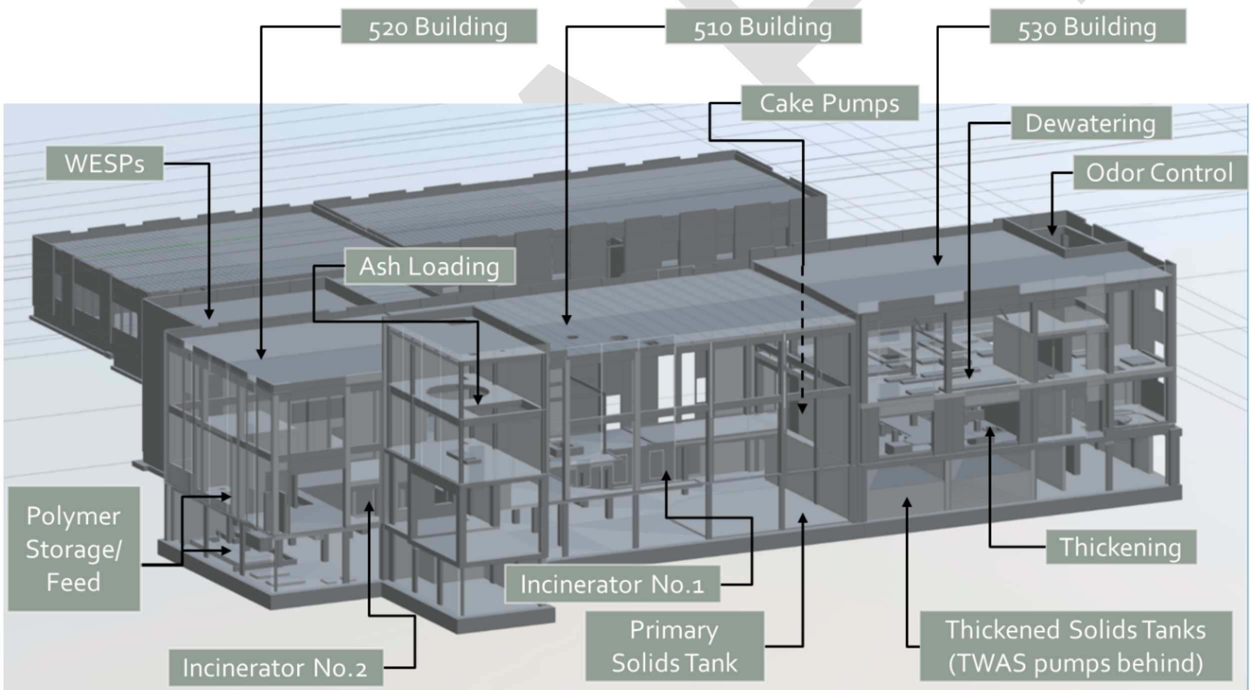

Figure 4-4. Solids Handling Facility Layout

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4.4 Existing Support Facilities

The following sections summarize the existing support facilities at Post Point.

4.4.1 Maintenance Shop and Administration/Laboratory Building

The Maintenance Building (720 Building) and the Administration/Laboratory Building (710 Building) are connected to the northern section of the Solids Handling Building. These facilities were built during the original Post Point construction and renovated in 1994. The Administration/Laboratory houses operations and laboratory staff. All plant testing is performed in the laboratory section of the building. Additional maintenance operations have been expanded to the existing buildings in the NW parcel.

Directly east of the Solids Handling Facility (520 Building) is the Storage Building (730 Building) which provides storage space for spare parts and other equipment. Other support facilities include the Emergency Generator Building (740 Building) which houses the equipment that provides backup power to Post Point.

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Section 5

Biosolids Management Alternatives Analysis

Section 5 summarizes the prior planning Phases 1 and 2 of the Project. TM 1 and TM 2 (Appendix A and B, respectively) provide more in-depth discussion related to those phases.

5.1 Biosolids Management Program Alternatives

As discussed in Section 1.3, the City has been considering alternative modes of solids treatment and management since 2010. The planning process explored solids stabilization, biogas utilization, and biosolids end-use opportunities for future solids management. The following sections describe the phased planning approach, including the alternatives considered and how the preferred alternative was selected. TM 1—Preferred Conceptual Alternative (Appendix A) and TM—2Final Alternative Selection (Appendix B) provide more details about Phase 1 and Phase 2 planning efforts.

5.2 Post Point Biosolids Planning Phase 1

In 2019, the Project Team completed Phase 1 of the Project, which included a comprehensive alternatives analysis that considered the "world of alternatives" available for different aspects of the Project. Phase 1 included the initial alternatives screening based on pass/fail criteria and the selection of a preferred conceptual alternative. The screening process included considerations of solids stabilization, biogas utilization, and biosolids end-uses. Table 5-1 provides the different alternatives considered for each category.

Table 5-1. List of Technologies and Alternatives

Solids Stabilization	Biogas Utilization	Biosolids End-Uses
• Aerobic digestion (X) • Anaerobic digestion (AD) (✓) • Alkaline stabilization (X) • Lagoons (X) • Raw solids composting (X) • Gasification (X) • Thermal hydrolysis + AD (X) • Incineration (X) • Pyrolysis (X) • Hydrothermal liquefaction (X) • Supercritical water oxidation (X)	• Flaring (X) • Boilers (✓) • Combined heat and power (✓) • Fuel cells (✓) • Gas turbines (✓) • Biogas upgrading (✓)	• Mine reclamation (✓) • Forestry (✓) • Agriculture (✓) • Landfill (X) • Biosolids composting (✓) • Soil blending (✓) • Dried fertilizer product (✓) • Dried fuel product (X)

(✓) Technologies and alternatives that passed the screening criteria
(X) Technologies and alternatives that did not pass the screening criteria

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Pass/fail screening criteria were developed to screen down each category to a shortlist of technologies for the evaluation. These pass/fail criteria were developed with the City's "core team" and were in part based on the City's 2009 Legacies and Strategic Commitments. Potential technologies that did not meet all the criteria were dropped from further consideration. Table 5-2 describes the pass/fail criteria for screening the "world" of alternatives.

Table 5-2. Pass/Fail Criteria for Preliminary Screening

Objective	Criterion	Importance	Legacy Goals	Strategic Commitments
Meets current regulatory requirements	Meets biosolids disposal permit and regulations.	Required by the state and federal government. Helps to protect the health of the environment.	Healthy environment	Protect and improve the health of lakes, streams, and bays.
	Meets air quality permit and regulations.		Healthy environment	Reduce contribution to climate change.
Uses a proven technology while allowing for innovation	Stabilization process technology meets "established" criteria. Non-critical components meet either "established" or "innovative" technology requirements. [1]	Allows for incorporation of innovative technology while minimizing risk of being a process that is not well understood without long-term performance data.	Quality, responsive City services	Deliver efficient, effective, and accountable municipal services.
	Stabilization process technology operates successfully in at least 5 similar-sized plants (average flow > 10 mgd) for more than 7 years in North America.			
Maintains reliable end-use options	Maintains a minimum of 1 end use or readily available backup alternative capable of handling the full biosolids flow under control of the City.	Reduces risk to the City of loss of market or disposal option for its biosolids.	Quality, responsive City services	Deliver efficient, effective, and accountable municipal services.
	Does not require importing materials (not including incidental chemicals, fuel) to site as part of the main stabilization treatment process.			
Maintains safe working environment	Does not require specialized licensing to operate the system beyond current wastewater operator license.	Protects worker and public health and safety.	Safe and prepared community	Prevent and respond to emergencies.
	Does not require hazardous chemicals or steam as an integral part of the stabilization treatment or energy recovery process.			
Meets climate action plan goals	Compared to current practice, reduces greenhouse gas emissions. Beneficially uses inherent biosolids nutrient and energy resources. Substantially reduces use of non-renewable resources compared to current practice.	Supports City's strategic climate action plan. Reduces global environmental impact.	Clean, safe drinking water	Use efficient, ecological treatment techniques.
			Healthy environment	Reduce contribution to climate change.
Minimizes social impacts	Compared to current practice, technology does not increase untreatable odors at the fence line.	Minimizes impacts to neighbors.	Sense of place	Support sense of place in neighborhoods.

1. The EPA has defined the following descriptions for current and upcoming treatment technologies:

- *Embryonic: developmental stage and/or tested at laboratory or bench scale; demonstrated viability overseas but not considered well-established there; high risk*
- *Innovative: tested at full scale in the United States; established technology overseas and some full-scale implementation in the United States (less than 5 years, less than 25 utilities); moderate risk*
- *Established: widely used (generally at least 25 utilities in U.S.); low risk*

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A shortlist of technologies was developed further into conceptual alternatives. Figure 5-1 provides a summary of the four main conceptual alternatives evaluated. Note that for all alternatives except Alternative 2, combined heat and power (CHP) was selected as the representative biogas end-use technology. Alternative 2 includes a dryer that would consume most of the biogas produced by the digestion process. Phase 2 of the project conducted a more detailed assessment of the shortlisted biogas alternatives (see Section 5.4).

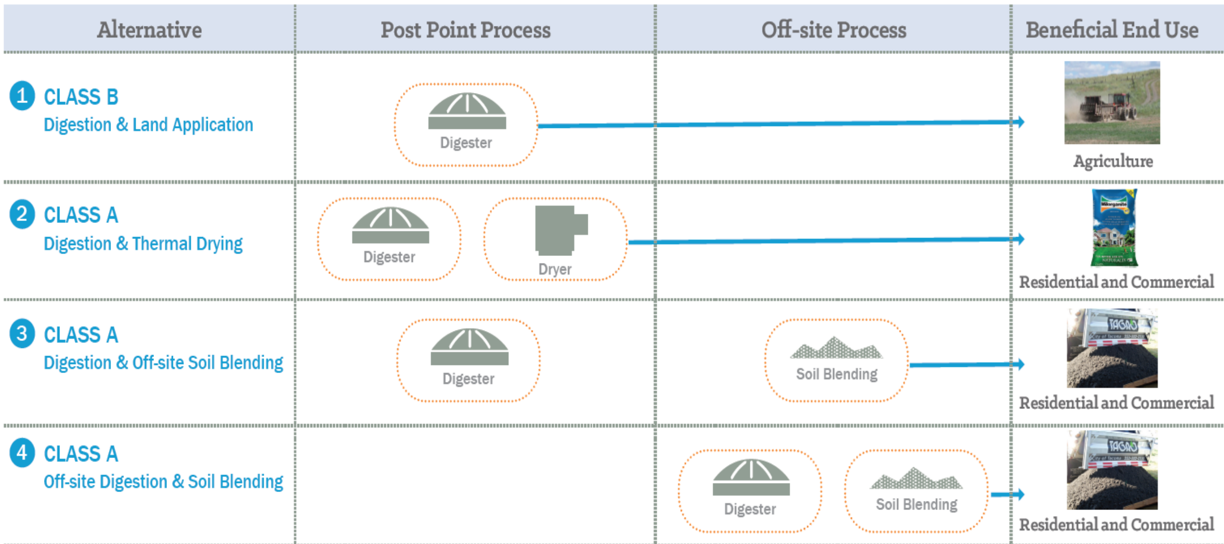

Figure 5-1. Summary of Conceptual Alternatives for Phase 1

The four conceptual alternatives are described below:

- **Alternative 1: Class B Digestion and Land Application**
  Solids from the liquid treatment would be co-thickened using the City's existing GBT. The co-thickened solids would be conveyed to mesophilic anaerobic digestion (MAD) for solids stabilization and then dewatered using existing centrifuges. Some of these systems may need additional or replacement processing units to handle future capacity. Biogas would be combusted in a CHP system to produce electricity and process and building heat. The Class B cake would be hauled to eastern Washington for application to agricultural land.
- **Alternative 2: Class B Digestion, Thermal Drying, and Dried Fertilizer Product**
  The solids process would be identical to Alternative 1 except the dewatered cake would then be fed to a belt dryer that would use much of the biogas from the digesters to dry the solids. It was assumed that no additional biogas would be available for beneficial reuse. The dried biosolids pellets would be sold as a bagged product for individual or bulk sale to fertilizer distributors.
- **Alternative 3: Class A Digestion at Post Point, Soil Blend Production Offsite**
  The solids process would be identical to Alternative 1 except that temperature-phased anaerobic digestion (TPAD) including Class A batch tanks would be used for solids stabilization to produce a higher-quality Class A biosolids product. Biogas would be combusted in a CHP system to produce electricity and process and building heat. After digestion, the dewatered Class A cake would be hauled to an offsite soil-blending facility to produce a topsoil product.

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- **Alternative 4: Offsite Class A Digestion and Soil Blend Production**
  Alternative 4 is a variant of Alternative 3 but with all the solids processing facilities located offsite. This would preserve available space at Post Point to be used for future liquid stream capacity or treatment process upgrades. This would also eliminate the need to truck solids from Post Point either to the biosolids end use (in Alternatives 1 and 2) or for final processing (Alternative 3). In Alternative 4, primary solids and WAS would be pumped together to an offsite location. Recycle streams from thickening and dewatering processes could be returned to Post Point through a dedicated pipe or through the existing sewer system.

5.2.1 Alternatives Evaluation

Each of the conceptual alternatives was evaluated to determine the mass quantities, energy use and generation, and greenhouse (GHG) emissions. A triple bottom line plus (TBL+) approach compared alternatives based on environmental, financial, social, and technical impacts. These criteria were derived from the City's Legacies and Strategic Commitments.

The City has a strong commitment to sustainability and has received awards for its Climate Protection Action Plan and "Green Government." These values are reflected in the City's Public Works Department's mission statement, which is to:

> *"Enhance Bellingham's quality of life through the construction and operation of a safe, effective physical environment; to protect public health & safety and the natural environment; and to provide our neighborhoods, our businesses, and our visitors with the efficient, quality services necessary to meet the demands of our growing, diverse community."*

To support this mission statement, the Bellingham City Council adopted and continues to implement the following nine Legacies and Strategic Commitments (summarized in Figure 5-2):

- Clean, safe drinking water
- Healthy environment
- Vibrant sustainable economy
- Sense of place
- Safe and prepared community
- Mobility and connectivity options
- Access to quality-of-life amenities
- Quality, responsive City services
- Equity and social justice

The 2009 Legacies and Strategic Commitments represent the values of the community and the City. In addition, the Bellingham City Council adopted several resolutions and programs that enforce these values and objectives, including:

- Environmentally Preferable Purchasing Program
- Cities for Climate Protection Program
- Resource Conservation Management Program
- Sustainable Buildings/Leadership in Energy and Environmental Design (LEED®)

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"We are working today so future generations will benefit from…"

Clean, Safe Drinking Water

- Protect & improve drinking water sources
- Limit development in Lake Whatcom watershed
- Use efficient, ecological treatment techniques
- Maintain reliable distribution system
- Promote water conservation

Healthy Environment

- Protect & improve the health of lakes, streams & bay
- Protect & restore ecological functions & habitat
- Reduce contributions to climate change
- Conserve natural & consumable resources

Vibrant Sustainable Economy

- Support a thriving local economy across all sectors
- Promote inter-dependence of environmental, economic & social interests
- Create conditions that encourage public & private investment
- Foster vibrant downtown & other commercial centers
- Preserve farmland & the agricultural economy

Sense of Place

- Support sense of place in neighborhoods
- Encourage development within existing infrastructure
- Preserve historic & cultural resources
- Protect natural green settings & access to open space
- Support people-to-people connections

Safe & Prepared Community

- Prevent and respond to emergencies
- Prevent and respond to crime
- Ensure safe infrastructure
- Increase community readiness and resilience

Mobility & Connectivity Options

- Provide safe, well-connected mobility options for all users
- Maintain & improve streets, trails & other infrastructure
- Limit sprawl
- Increase infrastructure for bicycles, pedestrians & non-single-occupancy vehicle modes of transportation
- Reduce dependence on single-occupancy vehicles

Access to Quality of Life Amenities

- Maintain & enhance publicly owned assets
- Foster arts, culture & lifelong learning
- Provide recreation & enrichment opportunities for all ages & abilities
- Ensure convenient access to & availability of parks & trails citywide

Quality, Responsive City Services

- Deliver efficient, effective & accountable municipal services
- Use transparent processes & involve stakeholders in decisions
- Provide access to accurate information
- Recruit, retain & support quality employees

Equity & Social Justice

- Provide access to problem-solving resources
- Support safe, affordable housing
- Increase living wage employment
- Support services for lower-income residents
- Cultivate respect & appreciation for diversity

Legacies and Strategic Commitments

Adopted by Bellingham City Council
July 13, 2009

City of Bellingham • Washington •

Figure 5-2. City Legacies and Strategic Commitments

Source: Bellingham City Council 2009.

5.2.1.1 TBL+ Evaluation Criteria

A TBL+ approach compares and evaluates alternatives based on the four considerations that impact any project or program delivered by a municipal utility: (1) environmental, (2) financial, (3) social, and (4) technical impacts. By including considerations for all four categories, the impacts to, and values of, a variety of stakeholders are included within the evaluation (e.g., ratepayers, neighbors, regulators, City staff, and others). The TBL+ approach has been implemented to successfully facilitate community input and communicate decisions in a clear and defensible manner for the City's largest public works projects in recent years.

For the evaluation of solids management alternatives at Post Point, TBL+ evaluation criteria were developed for each of the four categories based on the City's values (represented by the Legacies and Strategic Commitments). To facilitate the evaluation of the alternatives, each criterion identified is further defined by a corresponding parameter that serves as a qualitative or quantitative metric for achieving the criterion.

The following sections describe the criteria in further detail, organized by category (Figure 5-3). Although the number of criteria is different between the categories, the total number of points allowable for each category remains equal (i.e., 25 percent per category). This approach results in no single category having more weight or influence than another.

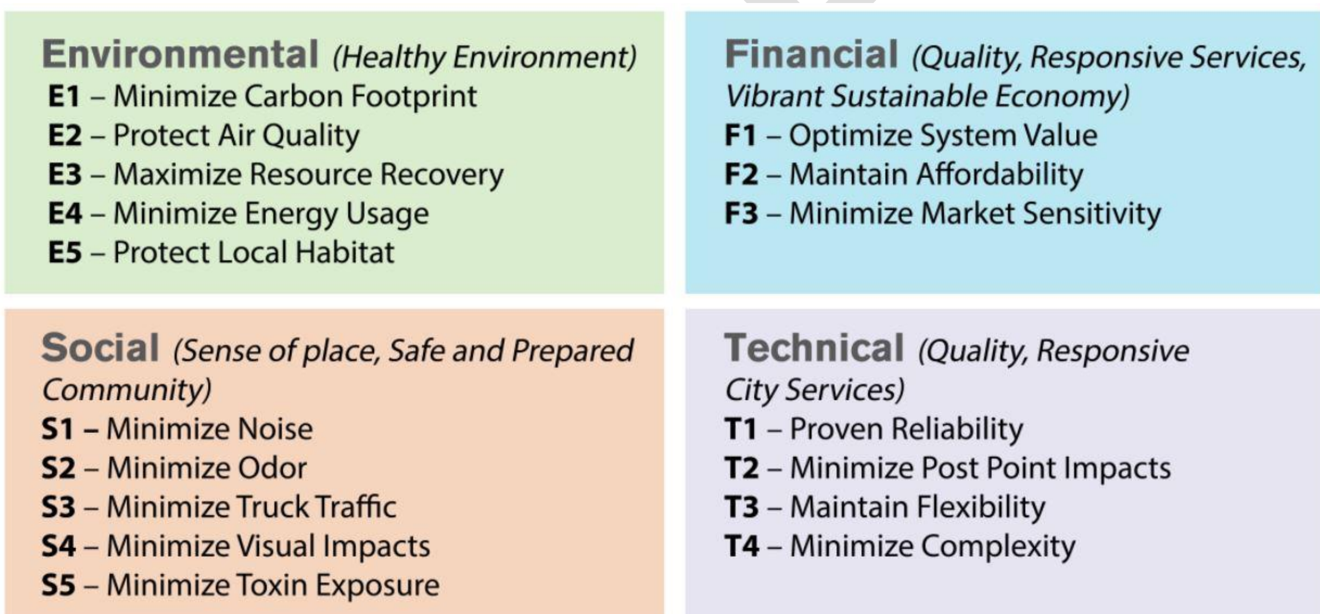

Figure 5-3. TBL+ Criteria

The results of the evaluation are reflected in Figure 5-4.

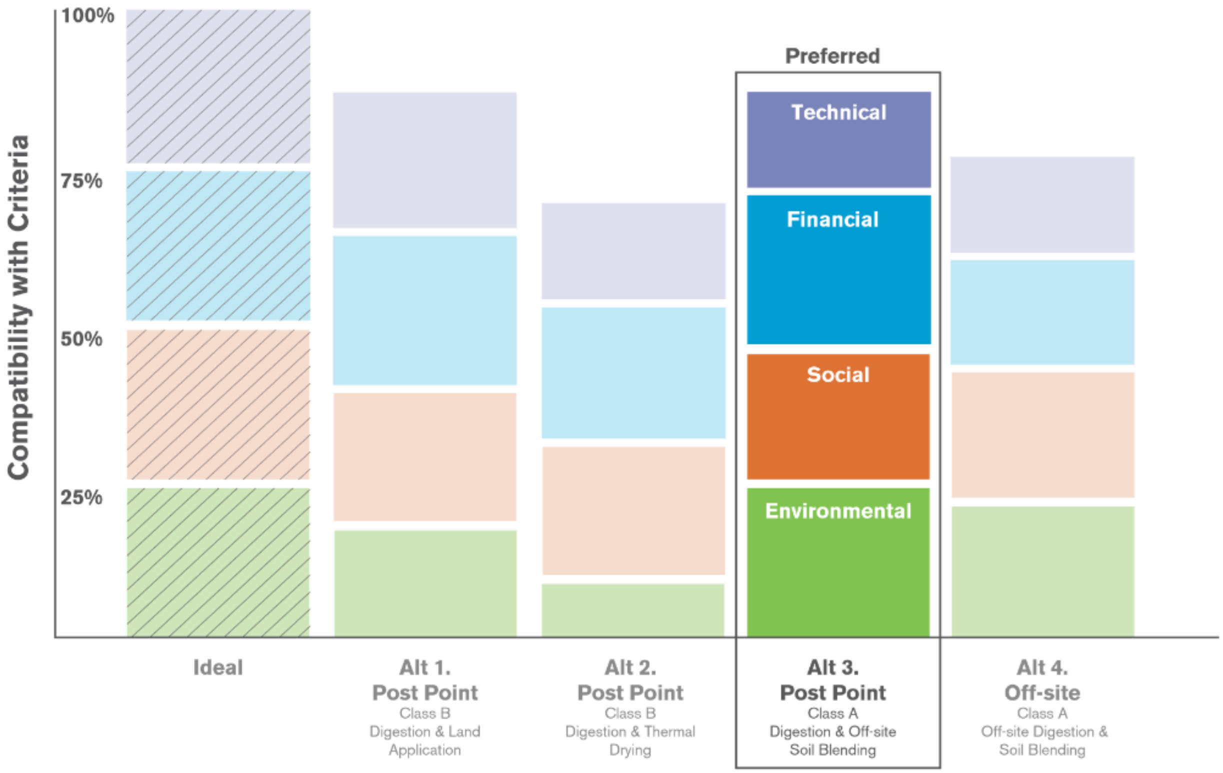

Figure 5-4. Post Point Biosolids Planning Phase 1 TBL+ Results

The results from the evaluation indicate that Alternative 2 scored the lowest. Alternatives 1 and 3 scored higher compared to the other alternatives, with Alternative 3 scoring slightly higher than Alternative 2. The methodology and results of the analysis were presented to the Bellingham community at a series of community workshops. The community feedback received at those workshops has been in concurrence with the evaluation criteria used and indicated support for an alternative that recovers resources, allows for local end-use of the biosolids resource, and improves the carbon footprint of the City's operations. Based on this process, Alternative 3 was selected as the preferred alternative. In addition to scoring the highest, the City saw the benefits of advancing a project based on a Class A product to maximize the flexibility for end-uses and provide the greatest opportunity for local end-use.

Below are additional conclusions that were developed for each alternative.

- **Alternative 1, Onsite Class B digestion with offsite land application**
  This is the least complex and least expensive alternative, but because a Class B product would be produced, the final product would require long-distance hauling to eastern Washington and likely could not be used locally.

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- **Alternative 2, Onsite Class B digestion with thermal drying to produce a dried fertilizer product**
  This alternative would have the advantage of producing a Class A product and the removal of almost all the moisture in the solids, resulting in little trucking from Post Point; however, the significant amount of energy required to thermally dry biosolids would result in a poor energy profile for this alternative compared to the others. In addition, the drying process is complex, expensive, and would take up a significant amount of space at Post Point, which would limit the City's ability to expand the plant in the future.
- **Alternative 3, Onsite Class A digestion with offsite soil blending**
  This alternative would produce a Class A product that could be distributed locally. Because Class A digestion is used, this alternative has the lowest GHG emissions and lowest net energy use. The drawback to this alternative is the need to acquire and site the soil-blending process at an offsite location due to space limitations at Post Point.
- **Alternative 4, Offsite Class A digestion with offsite soil blending**
  Like Alternative 3, this alternative would produce a Class A product that could be distributed locally and has a relatively good GHG emissions and energy use profile. Siting all the facilities at a new off-site location would also minimize the impacts to neighbors surrounding Post Point, allow for a future regional biosolids plant and/or the co-digestion of other imported materials, and preserve the greatest amount of space on-site at Post Point for future expansions. The off-site location would also come with new site acquisition and permitting risks, high costs associated with pumping solids from Post Point to the new off-site location, and increased costs for new administrative facilities and conveyance infrastructure.

Phase 1 concluded that anaerobic digestion was the solids stabilization process that best aligned with the City's values and commitments. In addition, it concluded that a process that produces a Class A biosolids material that could be beneficially used locally, with digestion performed at Post Point and final biosolids product manufactured at an off-site location, scored the highest when evaluated using the TBL+ criteria.

5.3 Fluidized-Bed Incinerator Conceptual Plan

Although incineration did not meet the City's pass/fail criteria, the City wanted to assess the cost and considerations of continuing with an incineration process to have a basis for comparing to anaerobic digestion. TM 1a—Bellingham Fluidized-Bed Incinerator Conceptual Plan (Appendix E) presents a conceptual plan and cost estimate for the installation of a new fluidized-bed incinerator (FBI) system to replace the existing MHFs.

The design capacity of the conceptual FBI system used the 2045 projected solids flow and loads presented in TM 1a—Bellingham Fluidized-Bed Incinerator Conceptual Plan (Appendix E). Assuming the existing thickened solids storage volume (110,000 gallons) was available either in the existing tankage or a like-sized new facility, the maximum day dewatered cake solids feed rate to the FBI system would be 36 dry tons per day (dtpd).

The City requested similar redundancy to the digestion-based alternative, so two FBI trains with a 36-dtpd capacity were assumed for this conceptual plan. Should the FBI system justify additional design effort, this capacity rating and redundancy requirement could be evaluated further.

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Predicted emissions from the FBI system, based on historical solids metal data and experience at other FBI facilities, require treatment to meet the Clean Water Act and Clean Air Act emissions limits. The Clean Air Act limits are typically the most stringent and commonly referred to as the maximum achievable control technology (MACT) limits. Air pollution control equipment that meet the "new FBI" category for MACT and the existing Clean Water Act and Northwest Clean Air Agency (NWCAA) limits, include:

- Nitrogen oxide (NO_x) ammonia or urea-based conversion system
- Multiple-venturi wet scrubber for particulate matter, acid gas, and metal removal
- Wet electrostatic precipitator for particulate matter and heavy metal polishing
- Granular activated carbon for mercury removal and provide polychlorinated dibenzo-P-dioxins and polychlorinated dibenzofurans removal

Based on the projected dewatered solids characteristics, processing 36 dtpd of dewatered solids generates about 500 pounds per hour of ash collected as a slurry in the multiple-venturi wet scrubber and wet electrostatic precipitators. The conceptual plan assumes that the slurry gets thickened in a gravity thickener and is then dewatered to 50 percent solids on a belt filter press (BFP). Typically, the ash gets landfilled, but some facilities are looking at beneficial reuse applications; one is working on getting the ash permitted for phosphorus fertilizer applications. The City indicated the current ash is considered "hazardous" and difficult to dispose and is interested in a system to separate toxins (i.e., metals) from the phosphorus. Several emerging technologies were identified in Europe and Japan that separate the toxins but have not yet established a reliable history of operation. Further investigation would be necessary to determine the potential reuse of the ash, ash characteristics, and additional treatment if required.

Figure 5-5 shows the base FBI system process schematic for one train. This analysis locates the new FBI facility in the open space to the east of the administration building for direct comparison to the digestion-based approach. The general footprint of the incineration facility is 11,700 square feet (ft^2) with a floor-to-ceiling height of about 60 feet. The footprint reflects the facility outline and does not include the area of intermediate floors within the building.

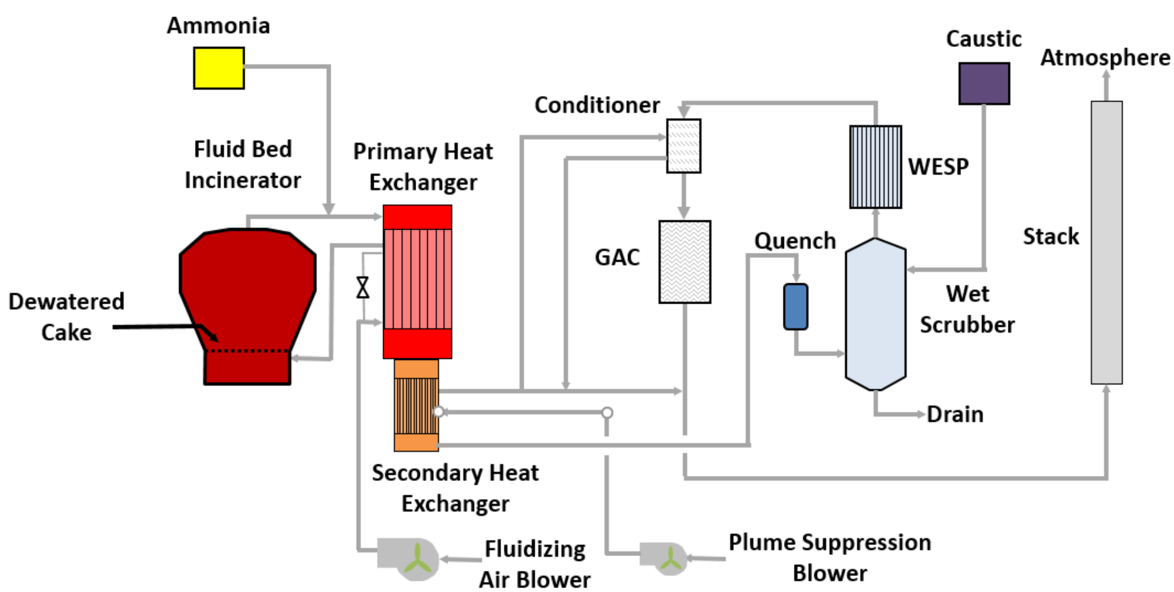

Figure 5-5. Base Alternative FBI Train Process Schematic

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For direct comparison with the digestion-based approach, the conceptual FBI facility includes solids thickening on GBTs, dewatering in centrifuges, and piston-type cake pumps with feed bins.

The City also requested that the conceptual plan consider an FBI system with an energy production alternative. This includes a waste heat boiler (WHB) that extracts heat from the flue gas to produce steam that drives a turbine generator. Based on the expected operating performance, about 0.5 megawatt of power generation is predicted. Figure 5-6 shows the process schematic of the system with the energy production features. The energy production increases the approximate building footprint to 14,300 ft^2 and height of 70 feet.

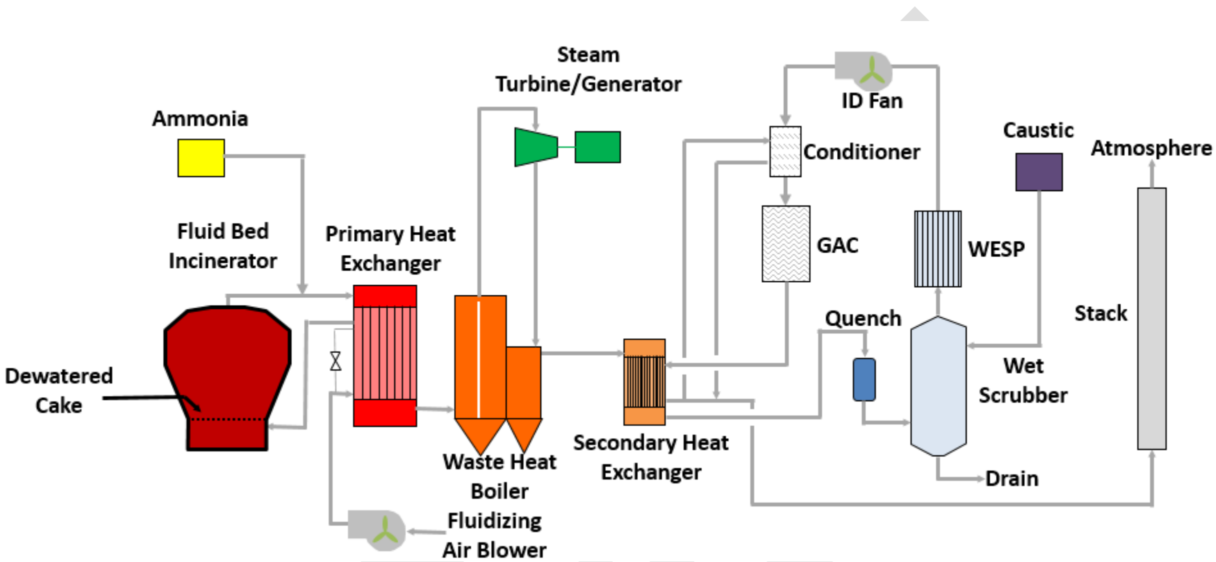

Figure 5-6. WHB Alternative FBI Train Schematic

This conceptual plan developed an opinion of probable costs for both FBI alternatives. Table 5-3 summarizes the cost for each. These costs do not include additional costs for ash treatment and beneficial use. Ash treatment technologies are just becoming commercialized overseas, and Post Point would possibly represent the first United States installation. As a result, there is a wide range of possible outcomes and costs, ranging from minimal costs if the ash is landfilled or regulators determine the ash is “clean” enough for fertilizer application to several million dollars if complex additional equipment and processing were required.

Table 5-3. Construction Cost Estimates for Incineration Alternatives (2023 dollars)

Alternative	Construction Cost
Base	$131,980,000
WHB/steam turbine	$160,950,000

The conceptual planning effort also produced a life-cycle cost estimate. Table 5-4 summarizes the results of a 20-year analysis.

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Table 5-4. Life-cycle Cost Estimates for Incineration Alternatives (2018 dollars)

Item	Base Alternative	WHB Alternative
Capital costs	$167,470,000	$204,230,000
Labor and materials	$37,940,000	$48,270,000
Utilities and chemicals	$6,090,00	$3,830,000
Ash disposal	$3,520,000	$3,520,000
Equipment and media replacement	$11,190,000	$10,530,000
Total	$226,210,000	$270,370,000

To fairly compare between the alternatives generated from Phase 1, upgrades and additional ancillary facility costs were added to the incineration alternative. The resulting costs for an incineration alternative was approximately the same when compared to the anaerobic digestion alternative. This information was important for City decision makers to confirm that sticking with the incineration technology wouldn't save significant costs. The fact that incineration didn't meet pass/fail and costs were slightly higher confirmed the City's decision to move ahead with anaerobic digestion.

5.4 Post Point Biosolids Planning Phase 2

In Project planning Phase 2, the preferred conceptual Alternative 3 (identified in Phase 1) was further developed; specific processes were evaluated, including pre-digestion, digestion, and post-digestion processes; and the preferred final alternative was identified. TM 2—Final Alternative Selection (Appendix B) provides more detail about the analysis. Phase 2 further refined the preferred conceptual alternative by selecting technologies for anaerobic digestion, solids handling, biogas end-use, and final product processing. The TBL+ and solids projections and sizing criteria that were used in Phase 1 were also used for Phase 2 to identify the preferred final alternative. Four new, expanded alternatives were developed based on the original conceptual Alternative 3 from Phase 1. The expanded alternatives include:

- **Alternative 1A/B: Class B Mesophilic Digestion and Composting**

  The first alternative would use MAD to produce a Class B cake. The cake would be transported to an off-site facility to be composted into a Class A final product for local beneficial use. Two variants of this alternative were considered to beneficially use digester gas: Alternative 1A would use the digester gas in a cogeneration (CHP) process to produce renewable electricity and heat, while Alternative 1B would use a biogas upgrading process to generate renewable natural gas (RNG) for use as a renewable vehicle fuel (distributed via the existing Cascade Natural Gas Corporation pipeline system).
- **Alternative 2A/B: Class B TPAD and Composting**

  Alternative 2 would also produce a Class B cake but would use a TPAD process instead of MAD. Like Alternative 1, the Class B cake would be transported to an off-site composting facility to generate a Class A compost. This alternative would give the benefit of increased volatile solids reduction and increased biogas generation but would not meet the standard for a Class A cake without the use of batch tanks. Space would be reserved at the site, however, for future construction of batch tanks should the City choose to implement Class A digestion.

  As with Alternative 1, two variants of Alternative 2 were considered to evaluate the difference between a CHP biogas utilization process (Alternative 2A) and a biogas upgrading process (Alternative 2B)

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- **Alternative 3A/B: Class A TPAD and Soil Blending**
  Alternative 3 is nearly identical to Alternative 2, except the batch tanks would be built with the TPAD system rather than being reserved for a future project. This would result in a Class A digestion process at Post Point. The Class A cake would not need to be further processed to meet EPA 503 Class A regulations. Instead, a soil-blending process would be used to produce a blended product that is more suitable for bagged and bulk sale to local consumers.

  As with the other alternatives, two variants were considered for the two biogas end-use options. Alternative 3A considers the use of a CHP facility to produce renewable electricity and heat from the plant's biogas while Alternative 3B considers the use of a biogas upgrading process to produce RNG.
- **Alternative 4: Class A Aerobic-Anaerobic Digestion and Soil Blending with Biogas Upgrading**
  Alternative 4 would use autothermal thermophilic aerobic digestion (ATAD) coupled with TPAD for the main stabilization process. This process generates a Class A biosolids product that would go to an off-site soil-blending facility rather than composting to produce a final Class A product for local end-use.

  The ATAD process would generate sufficient heat for process heating; therefore, consideration of a CHP facility for beneficial gas use was not appropriate. Instead, only one biogas end-use alternative was considered—a biogas upgrading process to generate RNG that would be injected into the Cascade Natural Gas Corporation pipeline.

5.4.1 Alternatives Evaluation

The evaluation methodology used in Phase 1 was repeated for Phase 2 to ensure consistent assessment of the alternatives. The sizing of equipment was based on projected 2045 flows and loads. Each alternative was evaluated to determine its mass quantities, energy generation, and GHG emissions. Average conditions based on 2035 solids flows and loads were used to determine mass, energy, and material quantities to reflect a mid-point operating condition.

Construction costs were developed based on major-item quantity estimates with percentage allowances for installation and support facilities. This approach combines aspects of cost-curve estimations and detailed quantity estimates and uses unit quantities developed for major cost items from similar projects. Construction costs include contractor-related costs, such as materials, labor, installation equipment, subcontractor costs, and indirect costs (i.e., contractor mobilization, demobilization, startup, commissioning, warranties, and sales tax). The expected level of accuracy for these cost estimates follows the Recommended Practice 18R-97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering 1998) designation as a Class 5 estimate with an expected level of accuracy of -50 to +100 percent.

Estimated construction costs were escalated to Year 2023, the mid-point of construction anticipated at the time of the analysis. Indirect construction cost factors include:

- Estimator's contingency (30 percent)
- Contractor general conditions (15 percent)
- Contractor overhead and profit (15 percent)
- Escalation to mid-point of construction (3 percent per year)
- Bellingham, Washington, sales tax (8.7 percent)

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Project costs include the sum of the construction and non-construction costs required to implement and support the Project. Non-construction costs include additional costs an owner must bear, such as engineering services, planning/management services, permitting and agency support, land acquisition, owner labor, project contingency, and initiatives. Non-construction costs were estimated as percentage allowances of construction costs as follows:

- Engineering, legal, and administration (25 percent)
- Owner's reserve for change orders (5 percent)
- Land acquisition for blending facility and biosolids storage ($1 million)

A TBL+ approach compared alternatives based on environmental, financial, social, and technical impacts. These criteria were derived from the City's Legacies and Strategic Commitments. Table 5-5 shows the cost evaluation results. The TBL+ evaluation is summarized in Figure 5-7.

Table 5-5. Estimated Construction and Project Costs (2023) in $ millions

Biosolids Project Element	Alt 1A	Alt 1B	Alt 2A	Alt 2B	Alt 3A	Alt 3B	Alt 4
	Class B Meso Compost Cogen	Class B Meso Compost Pipeline	Class B TPAD Compost Cogen	Class B TPAD Compost Pipeline	Class A TPAD Blend Cogen	Class A TPAD Blend Pipeline	Class A ATAD Blend Pipeline
Total Core Process	$ 56.0	$ 56.0	$ 57.9	$ 57.9	$ 56.8	$ 56.8	$ 68.9
Total Energy Recovery	$ 24.4	$ 11.8	$ 24.4	$ 11.8	$ 24.4	$ 11.8	$ 11.8
Total Ancillary Systems	$ 7.7	$ 7.7	$ 7.7	$ 7.7	$ 7.7	$ 7.7	$ 12.2
Post Point Site Work & Yard Piping	$ 17.3	$ 19.6	$ 17.3	$ 19.6	$ 17.3	$ 19.6	$ 18.4
Thickening & Dewatering	$ 19.3	$ 19.3	$ 19.3	$ 19.3	$ 19.3	$ 19.3	$ 19.3
Integrated Maintenance/Admin Bldg.	$ 29.3	$ 29.3	$ 29.3	$ 29.3	$ 29.3	$ 29.3	$ 29.3
Demolition & Site Remediation	$ 5.6	$ 5.6	$ 5.6	$ 5.6	$ 5.6	$ 5.6	$ 5.6
Total Estimated Construction Cost [a, b, c]	$ 159.5	$ 149.2	$ 161.4	$ 151.0	$ 160.3	$ 149.9	$ 165.2
Total Estimated Project Cost [d]	$ 208.4	$ 194.9	$ 210.9	$ 197.3	$ 209.4	$ 195.9	$ 215.9

a. Values shown are in 2023 dollars.

b. Estimates are planning level, Class 5 (per AACE International standards) with an expected accuracy range of -50/+100 percent.

c. Includes estimator's contingency (30%), general conditions (15%), overhead and profit (15%), escalation to mid-point (19.4% to 2023), and sales tax (8.7%).

d. Includes engineering, legal, and administration (25%), change order reserve (5%), land purchase for offsite facility at $1M for digestion.

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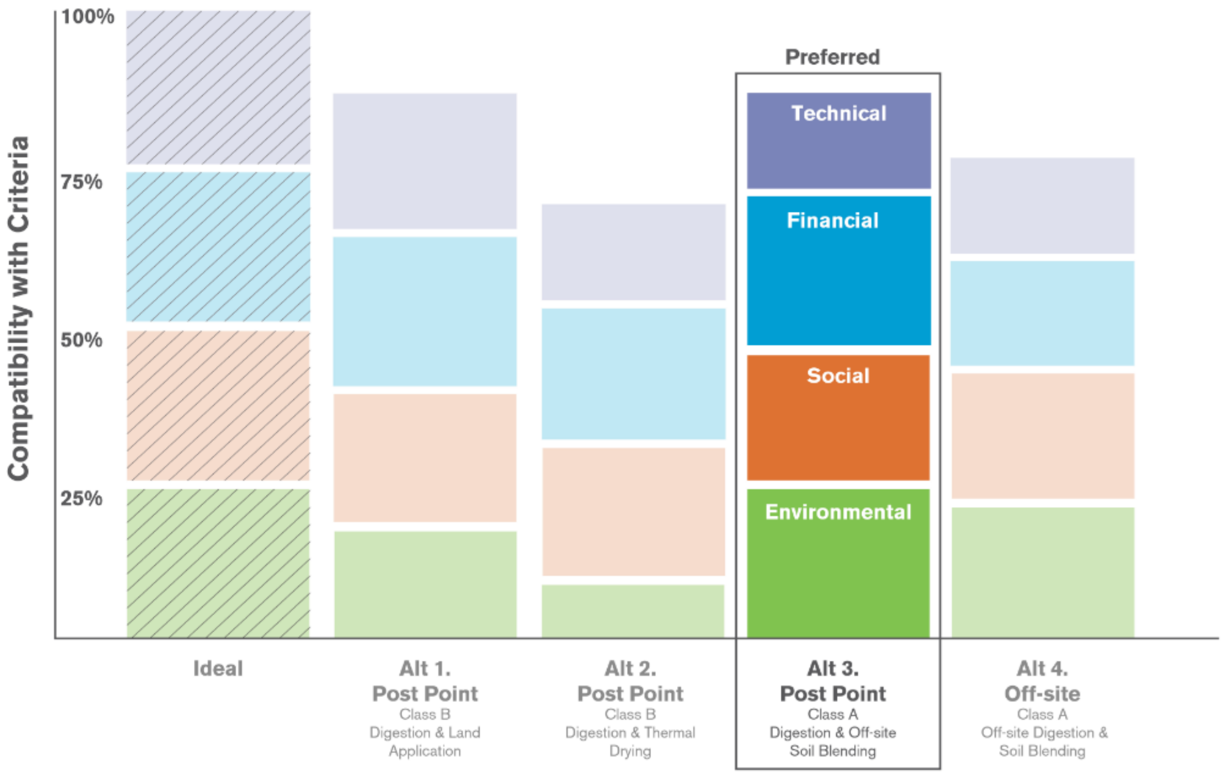

Figure 5-7. TBL+ Results of Phase 1 Alternatives

The preferred alternative was selected as Alternative 3B, which is to produce a Class A product using TPAD and then final processing of the biosolids through off-site soil blending. This allows the City to benefit from having a diverse amount of biosolids products to use locally in the community, which will improve the flexibility and adaptability of its program to market changes. Biogas generated from digestion would be upgraded to RNG and injected into the regional natural gas distribution pipeline. The upgrading of biogas to RNG provides the City with the best option to reduce its carbon footprint and maximize resource recovery.

Following the completion of the Phase 1 and Phase 2 evaluations, the City continues to evaluate alternatives the final end-use of the biosolids. The City reconfirmed commitment for the TPAD process and production of a Class A product selection as outlined herein. Evaluation of biosolids end-use technologies and applications is discussed in Section 7.1.

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Section 6

Final Alternative Post Point Biosolids and Biogas Basis of Design

Section 6 summarizes the Project Team's various analyses for the components of the preferred alternative for biosolids management and biogas handling at Post Point. This includes evaluations for the biosolids treatment, solids screening and thickening, digestion process, digested solids storage tank, solids dewatering and storage, biogas cleaning and utilization, heat recovery, odor control, noise control, and struvite mitigation and recovery. Additional details on biosolids disposition and biogas end-use can be found in Section 7. The supporting TMs for each are provided in the Appendices and referenced throughout the respective sub-sections.

6.1 New Biosolids and Biogas Treatment Train

The new biosolids treatment train involves new unit processes from solids screening and thickening to dewatered cake solids load out. Raw primary solids (PS) and waste activated sludge (WAS) will be combined in a blend tank before being pumped through a cylindrical type solids screen to remove small debris and trash. The screened solids will then be co-thickened using gravity belt thickeners. The co-thickened solids will then be pumped to an enhanced digestion process, Temperature Phased Anaerobic Digestion (TPAD) with Class A batch tanks. The solids will undergo thermophilic digestion and then be held in the batch tanks to meet US EPA Class A requirements for biosolids use before being cooled and conveyed to mesophilic digesters. The digested solids will be stored in digested solids storage tanks before they are pumped to dewatering centrifuges. Dewatered biosolids cake will be stored in hoppers prior to being trucked offsite for further processing and beneficial use. The high-nutrient liquid centrate from the dewatering process will be pumped to side stream ammonia treatment. A portion of the final dewatered cake will then be further processed by composting or soil blending to produce a more consumer-friendly product that has wider applications in urban or residential areas around the City. Biogas produced from the TPAD process will be recovered and cleaned to renewable natural gas (RNG) standards before being injected into the local natural gas pipeline. A process flow diagram of the new solids treatment process train is shown in Figure 6-1.

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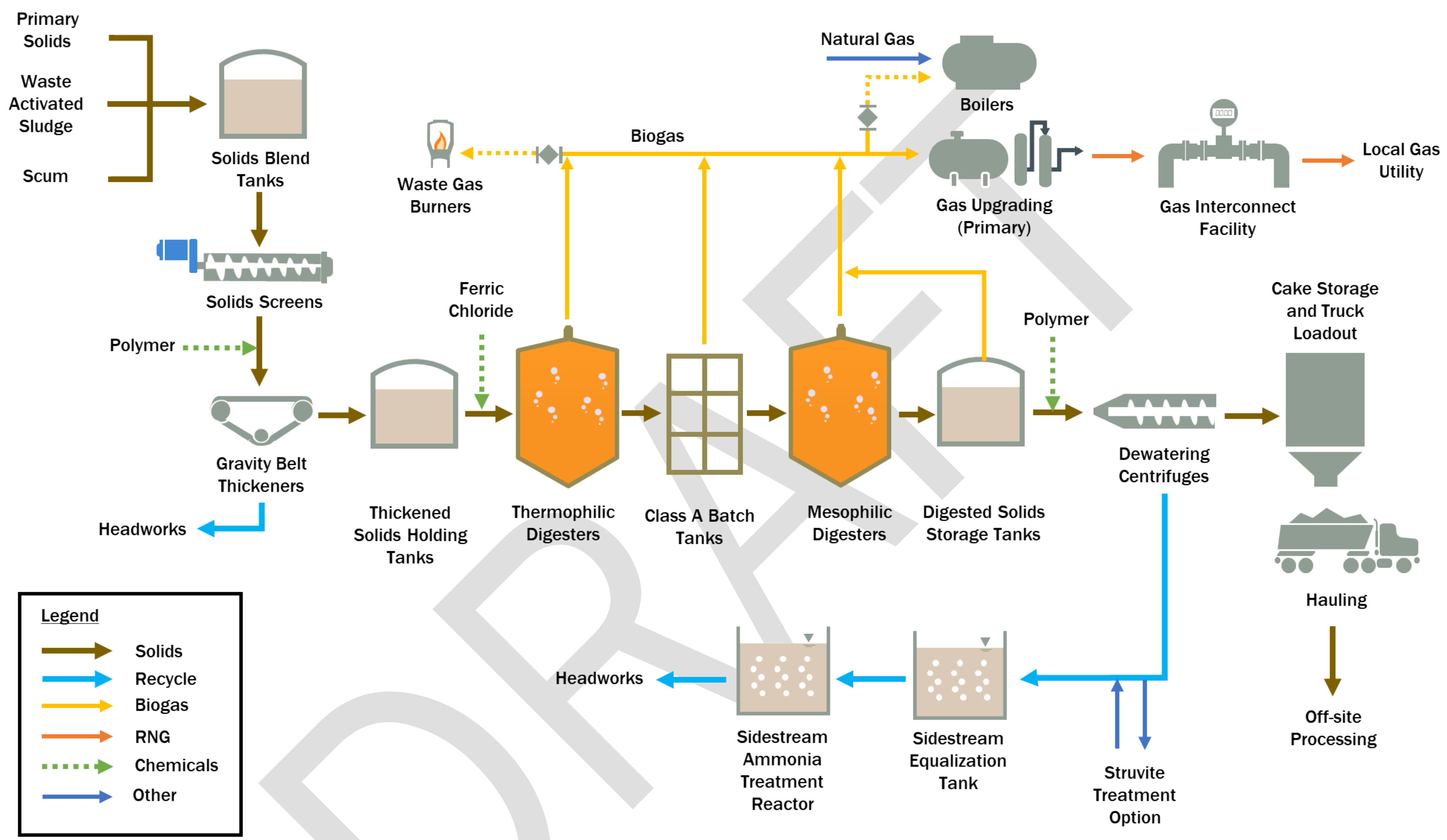

Figure 6-1. Process Flow Diagram of Post Point's New Biosolids Treatment Train

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6.1.1 New Facilities

The new biosolids treatment train and biogas upgrading systems will be sited mostly on the northeast corner of Post Point. This area was the former Homeport Properties and houses temporary facilities for Post Point. The existing Solids Handling Facility which houses the incinerators, thickening and dewatering processes will be modified to site new equipment. The new facilities are summarized in Table 6-1.

Table 6-1. Post Point New Biosolids Treatment Train and Biogas Upgrading System

Area ID	Facility Names	Facility Type	Descriptions
510/520	Solids Handling Facility – West	Existing	Facility for thickening equipment
530	Solids Handling Facility – East	Existing	Facility for dewatering equipment
540	Cake Loadout Facility	New	Dewatered cake hopper and truck loadout
550	Solids Screening Building	New	Existing Shop Building will be replaced with a new building for solids screening equipment
560	Solids Odor Control Facility	New	Odor control for all solids handling facility
570	Deammonification Facility	New	Side stream treatment for centrate from the dewatering process
610	Digestion Facility	New	Process facilities for the thermophilic and mesophilic digesters, Class A batch tanks, digested solids storage tanks, and ancillary equipment
620	Class A Batch Tanks	New	Batch tanks for TPAD process
630	Digested Solids Storage Tanks	New	Post digestion solids storage prior to dewatering
640	Heat Recovery Building	New	Heating and boiler equipment for process and building
650	Gas Upgrading Facility	New	Biogas cleaning and processing equipment
660	Waste Gas Burners	New	Waste gas burners and thermal oxidizer for waste gas flaring
670	Gas Interconnect Facility	New	Pipeline and metering for renewable natural gas injection to Cascade Natural Gas pipeline
710-730	Post Point Resource Recovery Center	New	Administration, laboratory, and maintenance facilities

A site map of the new biosolids treatment facilities are shown in Figure 6-2.

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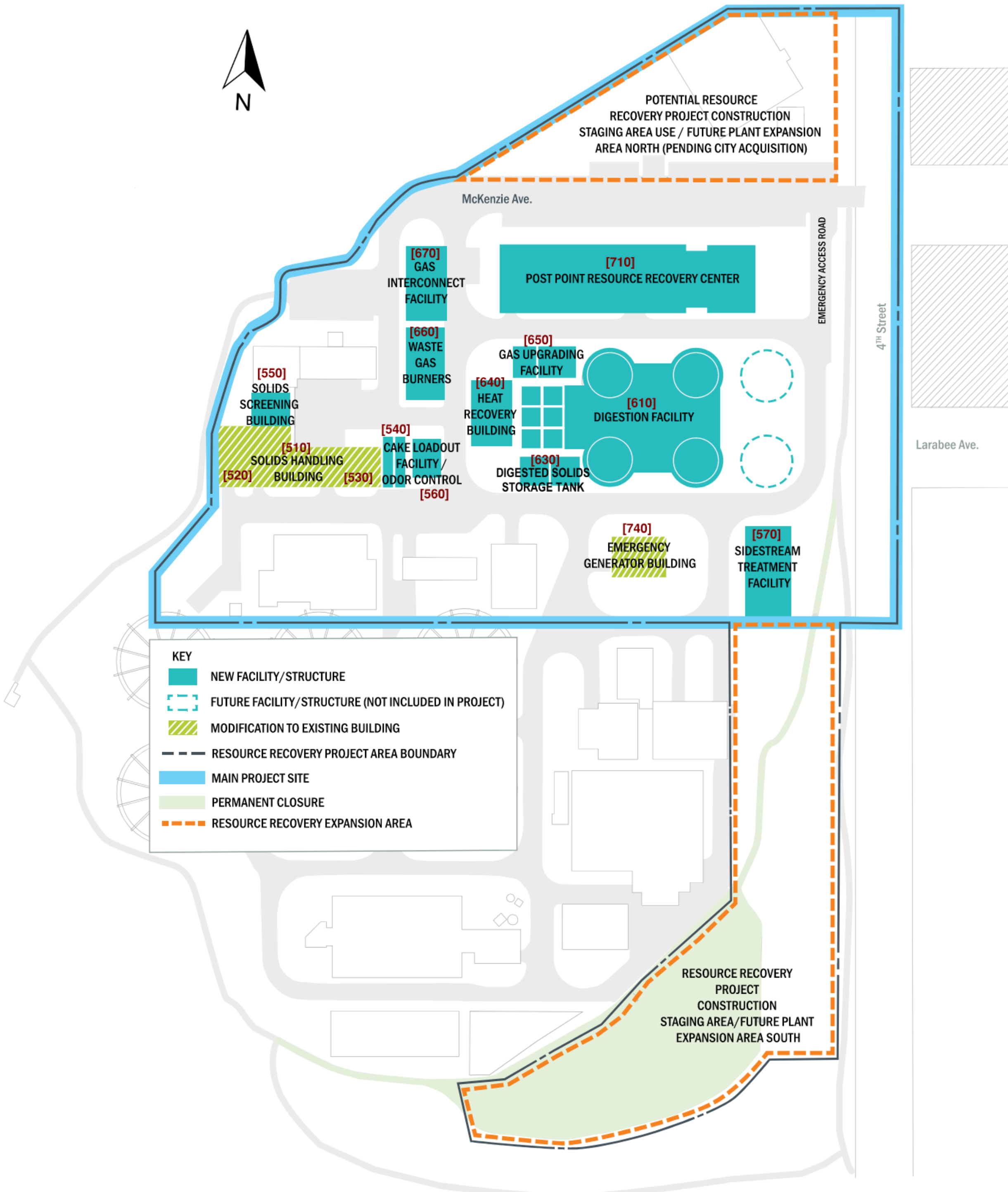

Figure 6-2. Post Point New Biosolids Treatment Facilities Site Map

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The modifications to the existing Solids Handling Facility are reflected in Figure 6-3 and discussed in the below sections.

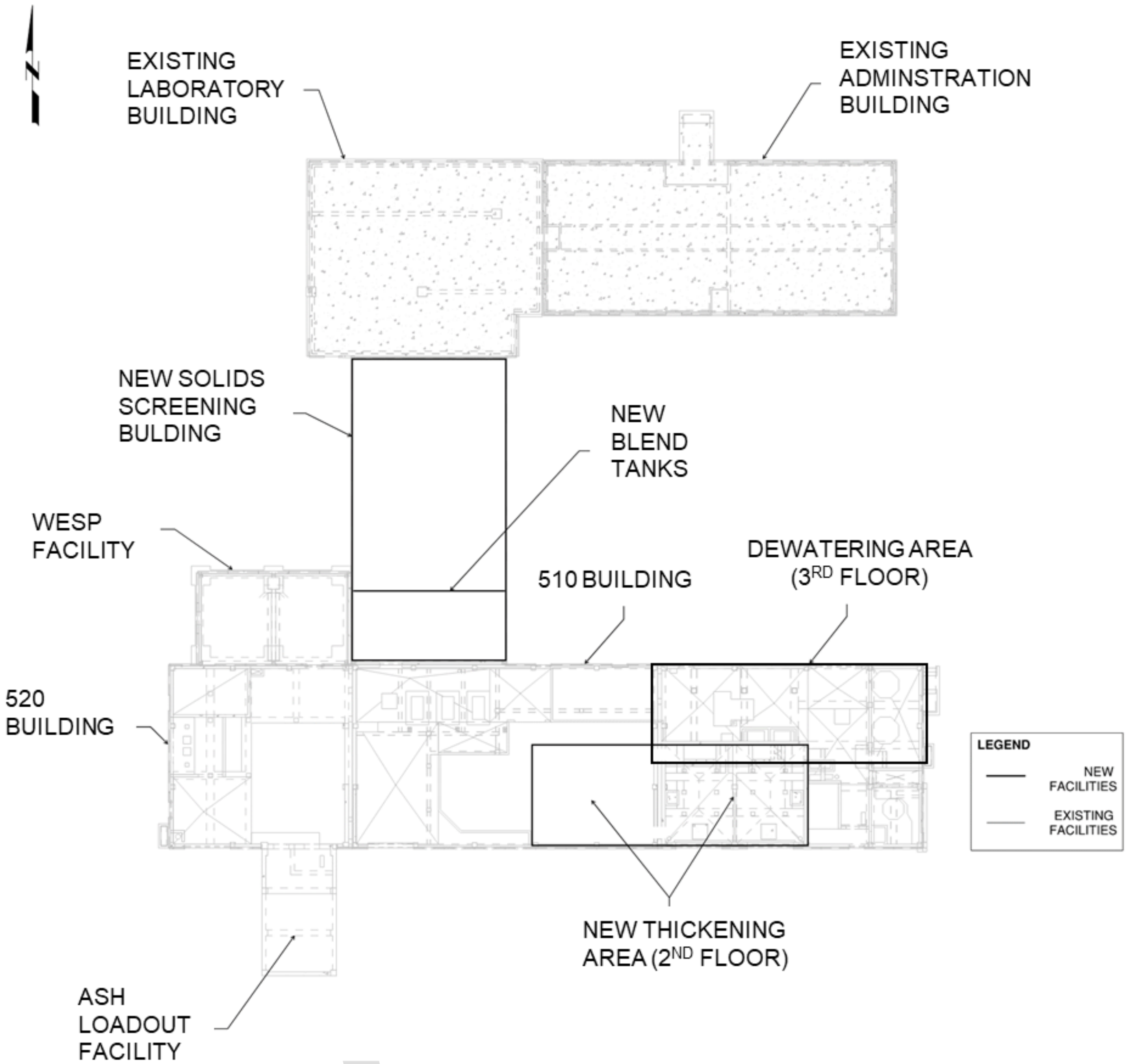

Figure 6-3. Modifications to Existing Solids Handling Facility

6.2 Solids Flows and Loads

The flows and loads for primary solids (PS) and waste activated sludge (WAS) were determined for 2020 and a design year of 2045. Flows and loads for 2025 were interpolated using the 2020 and 2045 values to characterize the start-up period for the solids treatment system. Detailed information on the methodology to determine the updated wastewater flow and loads can be found in Section 2.3 or TM 3—Flow and Load Projections (Appendix D).

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As part of the Phase 3 facility planning effort, additional wastewater sampling was conducted, and revised flows and loads were developed for the City's future solids treatment improvements. Future nitrogen limits are anticipated to be part of the next permit cycle and will require additional nutrient treatment. These potential nutrient reduction scenarios are expected to impact the liquid stream treatment processes and generate additional solids, therefore, increasing the flows and loads to the solids treatment processes. To account for the generation of the additional solids, the most conservative scenario was selected. This scenario would generate additional chemically-enhanced primary solids and filter backwash solids from biological aerated filters. The future solids flows and loads for a start-up year of 2025 and a design year of 2045 are summarized in Table 6-2.

Table 6-2. Wastewater Solids Loads to Solids Treatment, 2025 and 2045

Parameter	Units	2025	2045				
		Min Week	Annual Average	Max Month	Max 14-Day	Max 7-Day	Max Day
Primary Solids (PS)							
Total Solids Load	lb-TS/d	12,800	25,700	32,500	34,100	38,100	69,400
Volatile Solids Load	lb-VS/d	11,500	21,100	26,600	28,200	28,800	36,800
Solids Volatile Fraction	lb-VS/lb-TS	0.90	0.82	0.82	0.83	0.76	0.53
Solids Conc.	Percent	3.1%					
Solids Flow	gpd	49,400	99,300	125,600	131,700	147,200	268,100
Waste Activated Sludge (WAS)							
Total Solids Load	lb-TS/d	12,100	21,700	27,600	28,700	29,400	31,200
Volatile Solids Load	lb-VS/d	9,800	16,700	21,000	21,800	22,200	24,300
Solids Volatile Fraction	lb-VS/lb-TS	0.81	0.77	0.76	0.76	0.76	0.78
Solids Conc.	Percent	0.57%					
Solids Flow	gpd	254,200	455,900	579,900	603,000	617,700	655,500
Combined PS + WAS							
Total Solids Load	lb-TS/d	24,900	47,400	60,100	62,800	67,500	100,600
Volatile Solids Load	lb-VS/d	21,300	37,800	47,600	50,000	51,000	61,100
Solids Volatile Fraction,	lb-VS/lb-TS	0.86	0.80	0.79	0.80	0.76	0.61
Solids Conc.	Percent	0.98%	1.02%	1.02%	1.02%	1.06%	1.30%
Solids Flow	gpd	303,700	555,200	705,400	734,700	764,900	923,600

Note:

1. Abbreviations: d = day. gpd = gallons per day, lb = pound(s), TS = total solids, VS = volatile solids

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6.3 Solids Screening

WAC 173-308-205 (known as the inerts rule) requires the removal of manufactured inert material larger than 3/8-inch from biosolids prior to beneficial use. Biosolids must contain less than 1 percent by volume of recognizable manufactured inerts to be land applied. In addition, screening of recognizable debris is vital when developing a public market for the biosolids product. Screens are the most commonly applied physical barrier to achieve compliance with this requirement. Screening may occur at any point in the treatment process but must be applied to the entire process stream, including primary solids, secondary solids, and scum. The two most common screening locations are wastewater influent screening and solids screening.

Options for meeting this requirement at Post Point are described below along with a recommended approach.

6.3.1 Influent and Solids Screening Options

Post Point's current preliminary treatment process includes three automatic mechanical bar screens that screen raw wastewater through 5/8-inch openings and two manual backup screens. The City could replace the existing bar screens with a 3/8-inch or narrower bar spacing to comply with the biosolids inerts rule. There are several technologies available for mechanically cleaned fine screening, including rotary, step, rake, and perforated type screens. A multi-rake bar screen was selected as the basis of design for this analysis because it is similar to the current technology used at Post Point while providing a reduction in space and maintenance requirements.

Solids screens remove trash and other debris directly from a solids process stream. Inline solids screens allow pressurized flow through them while remaining enclosed. The solids screens on these units consist of a cylindrical screen, integral screw conveyor, and retention cone. Solids and scum are pumped into the solids screen via the solids inlet pipe. The screenings zone consists of a conical perforated mesh basket and the matching conical screen zone screw. Process solids pass through the screen and are discharged through the screened solids outlet pipeline. Debris and inerts larger than the screen perforations (1/4 inch assumed for this analysis) are retained inside the basket.

A Huber 430 unit and standard Hydro International unit were selected for preliminary sizing. Two duty and one standby solids screens are recommended to match the number of thickeners required for the facility.

6.3.2 Screening Comparison and Recommendation

A summary of advantages and disadvantages for each screening alternative are shown in Table 6-3. The advantages and disadvantages of each alternative are considered relative to each other.

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Table 6-3. Screening Option Non-Economic Comparisons		
Alternative	**Advantages**	**Disadvantages**
Replace Influent Screens	• Existing screens are approaching 30-years old and may be near the end of their service life, thus replacement may be needed soon • Narrower bar spacing protect the entire plant from rags and inerts, decreasing reactive maintenance throughout the plant • Maintains single screening collection location at screenings building, consolidating odor control and reducing O&M costs • Reduces inerts load to advanced treatment processes that may be added in the future • Screen replacement can likely occur concurrently with remainder of project	• Biosolids construction activities expand to screening building • Lower inerts capture than solids screens
Add Solids Screens	• Localizes construction to solids handling building, which simplifies mobilization and coordination issues during construction • Smaller screening aperture results in a higher quality biosolids • No land application restrictions if influent screens are bypassed	• Adds an additional mechanical process, requiring operator attention and long-term maintenance commitments • Second screenings dumpster location increases odor control requirements • Continued use of coarse influent screens maintain current level of reactive maintenance throughout the plant

Capital, O&M, and life-cycle costs for the solids screening technologies are shown in Table 6-4. Detailed cost estimates for the screening systems can be found in TM 12—Solids Screening, Thickening, and, Dewatering Technology Evaluation (Appendix F).

Table 6-4. Screening Options Cost Comparisons			
Alternative	**Capital Cost**	**O&M Cost**	**Life-Cycle Cost**
Replace Influent Screens	$11.6 million	No net change from existing	$11.6 million
Add Solids Screens	$10.2 million	$181,000/yr	$12.9 million

Life-cycle costs for both options are comparable, thus the screening technology selection should be based on non-economic factors. Although the influent screens would provide the most advantages for the facility overall, the remaining life of the screens is unclear, thus replacing them as part of this project may negate years of remaining service life. Solids screens would maximize inerts removal from the solids process, maximizing the protection of downstream assets and improving biosolids quality. If needed, the influent screens can still be replaced in the future with minimal impact to the solids system. Therefore, inline, pressurized solids screening is recommended for the biosolids upgrade project.

Two duty and one standby solids screens are recommended to match the number of thickeners required for the facility. The solids screening and thickening flows and loads are summarized in Table 6-5.

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Table 6-5. Solids Screening and Thickening Flows and Loads, 2025 and 2045							
Parameter	Units	2025	2045				
		Min Week	Annual Average	Max Month	Max 14-Day	Max 7-Day	Max Day
Solids Screening/Thickening Feed [a]							
Total Solids Load	lb-TS/d	24,900	47,400	60,100	62,800	67,500	100,600
Volatile Solids Load	lb-VS/d	21,300	37,800	47,600	50,000	51,000	61,100
Solids Volatile Fraction	lb-VS/lb-TS	0.86	0.80	0.79	0.80	0.76	0.61
Solids Conc.	Percent	0.98%	1.02%	1.02%	1.02%	1.06%	1.30%
Solids Flow	gpd	303,700	555,200	705,400	734,700	764,900	923,600

Recommended design criteria for a solids screening system are shown in Table 6-6.

Table 6-6. Solids Screening System Design Criteria	
Parameter	Value
Number of Units (duty + standby)	3 (2 + 1)
Operation	24 hours/day, 7 days/week
Design Flow per Unit	650-700 gpm
Feed Solids Concentration	1.0% TS

6.3.3 Solids Screening Layouts

The existing shop building would be removed and replaced with a solids screening building. A preliminary plan and profile of the solids screening building are shown in Figure 6-4 and Figure 6-5, respectively. The solids screening building will be approximately the same footprint as the existing shop building and will be the same height as the existing solids handling buildings. It will contain the solids screening equipment, raw solids blend tanks, and storage space. Solids screens and supporting equipment will be located on the second floor of the solids screening building.

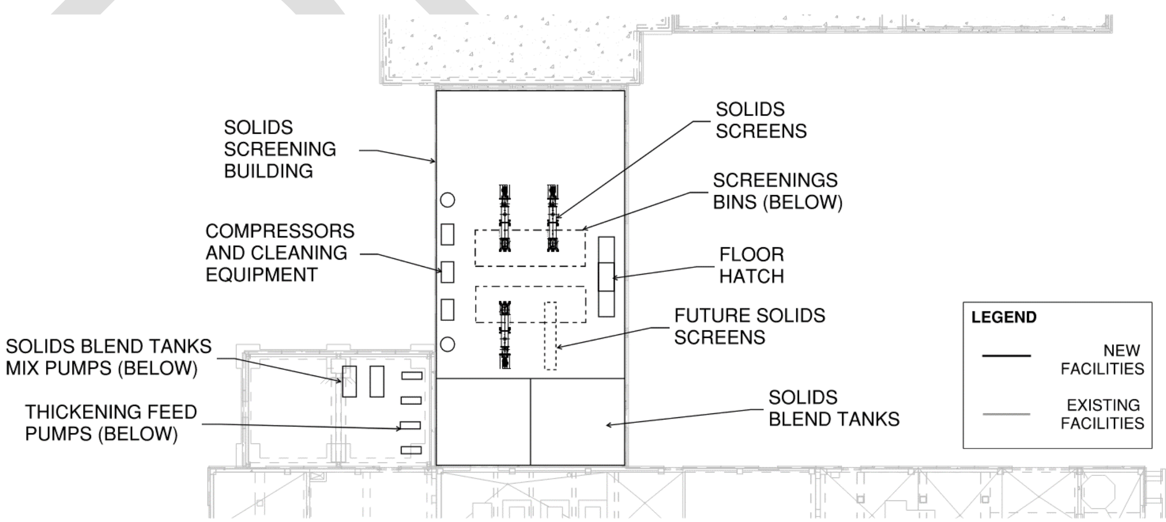

Figure 6-4. Solids Screening Building Plan

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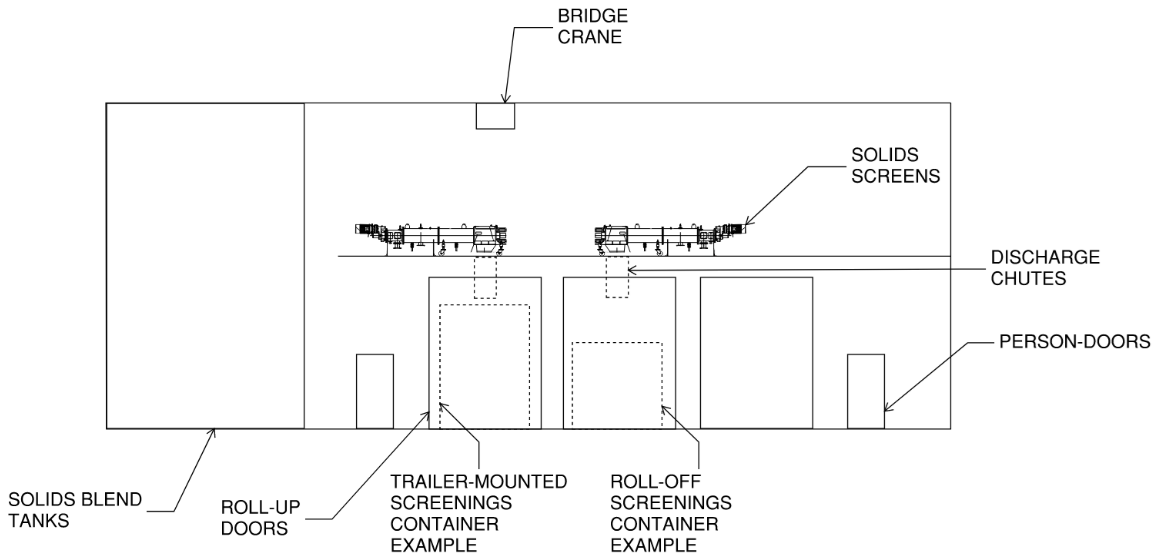

Figure-6-5. Solids Screening Building Profile

6.4 Solids Thickening

Solids thickening removes water from raw solids to optimize capacity for downstream storage and processing. Primary and secondary solids are currently co-thickened to 6.0 percent TS or higher in the existing 2-meter gravity belt thickeners. The existing GBTs are near the end of their useful life and will not provide enough capacity through the design period. Therefore, replacement of the GBT process is recommended to provide reliable performance through the design period.

In Phase 2 of the Project, several thickening technologies were evaluated, including dissolved air flotation thickeners, centrifuge thickeners, gravity belt thickeners, gravity thickeners, membrane thickeners, and rotary drums thickeners. Centrifuge thickeners, gravity belt thickeners, and rotary drum thickeners were selected for further evaluation (see TM 2—Final Alternative Selection [Appendix B]). Detailed information, descriptions, sizing of each technology and can be found in TM 12—Solids Screening, Thickening, and Dewatering Technology (Appendix F).

6.4.1 Thickening Comparison and Recommendation

A summary of the advantages and disadvantages for each thickening alternative are shown in Table 6-7. The advantages and disadvantages of each alternative are considered relative to each other.

Table 6-7. Solids Thickening Non-Economic Comparison

Technology	Advantages	Disadvantages
Centrifuge Thickener	• Low odor (enclosed) • Low polymer demand	• Large motor sizes and relatively high power consumption • Sophisticated maintenance requirements • Moderately difficult to operate • Noise and vibration require special design provisions • Maintenance difficult due to limited headspace • Primary solids increase maintenance (grit can be abrasive)

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Table 6-7. Solids Thickening Non-Economic Comparison		
Technology	Advantages	Disadvantages
Gravity Belt Thickener	• Simple operation • Proven at facility • Low power use • High solids capture	• Potential for odor if not enclosed • Open belt and discharge increases housekeeping and potential for corrosion • Hot water spray required to prevent blinding
Rotary Drum Thickener	• Low power use • High solids capture • Odor containment (enclosed)	• Does not fit well within available footprint • Highest polymer demand • Moderately difficult to operate • Hot water spray required to prevent blinding

Capital, O&M, and life-cycle costs for the solids thickening technologies are shown in Table 6-8. Detailed cost estimates for the thickening systems are shown in TM 12—Solids Screening, Thickening, and Dewatering Technology (Appendix F).

Table 6-8. Solids Thickening Options Cost Comparisons			
Alternative	Capital Cost	O&M Cost	Life-Cycle Cost
Centrifuge Thickener	$9.3 million	$446,000/yr	$15.9 million
Gravity Belt Thickener	$6.0 million	$262,000/yr	$9.9 million
Rotary Drum Thickener	$6.5 million	$369,000/yr	$12.0 million

Capital and operating costs of centrifuge thickeners are considerably higher than both RDTs and GBTs, thus centrifuge thickeners are not recommended for Post Point. Capital costs for RDTs and GBTs are comparable, but the life-cycle cost of GBTs is lower due primarily to a lower polymer demand. As noted above, there are several challenges with the layout of RDTs in the existing thickening room. GBTs provide several advantages compared to RDTs:

- The GBT equipment layout provides the best maintenance access around the equipment and does not require the roll-up door to observe operation
- The Plant's operation and maintenance teams are familiar with GBT technology
- GBTs have a long history of successful use at Post Point

Therefore, continued use of GBT technology is recommended for Post Point.

This recommendation differs from the Phase 2 recommendation due to changes in the proposed locations for the solids blend tank. In the original layout, RDTs were the only technology that reasonably fit within the space available in the 530 building. By relocating the solids blend tanks, additional space for thickening equipment is available in the 510 building. As a result, continued use of gravity belt thickening technology is recommended.

The flows and loads to the solids thickening process were conservatively estimated to be the same as the flows and loads to the screening process and are summarized in Table 6-5 (above). All thickening units evaluated are expected to be hydraulically limited, thus solids loadings were not included in this evaluation. The thickening system was sized to process the max day 2045 flow.

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Thickening is planned to operate continuously, 24 hours (hr)/day, 7 days/week, throughout the design period.

Recommended design criteria for a solids thickening system are shown in Table 6-9.

Table 6-9. Thickening System Design Criteria	
Parameter	Value
Number of Units (duty + standby)	3 (2+1)
Operation	24 hours/day, 7 days/week
Design Flow per Unit	500 gpm
Feed Solids Concentration	1.0% TS
Capture Efficiency (%)	95%
Thickened Solids Concentration	6.5% TS

6.4.2 Thickening Equipment Layouts

A preliminary layout and profile of the GBTs are shown in Figures 6-6 and Figure 6-7. New GBTs would replace the existing GBTs in the 530 building and a third unit would be installed in a thickening room extension into the 510 building. If needed in the future, a fourth thickener could be installed in the thickening room extension.

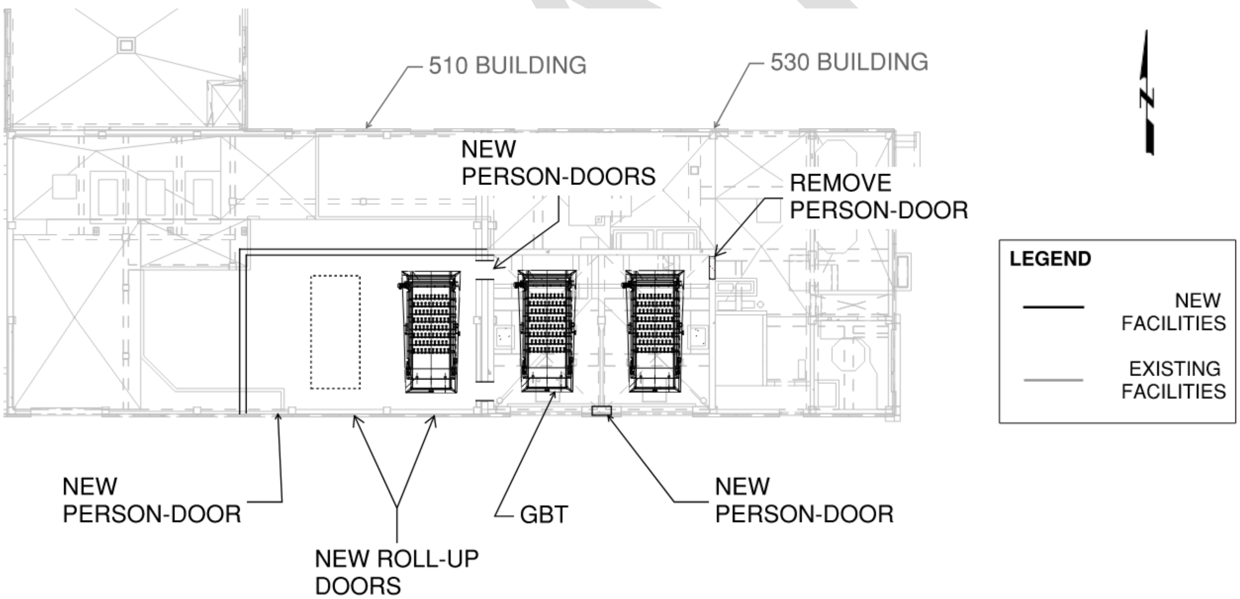

Figure 6-6. Gravity Belt Thickener Layout

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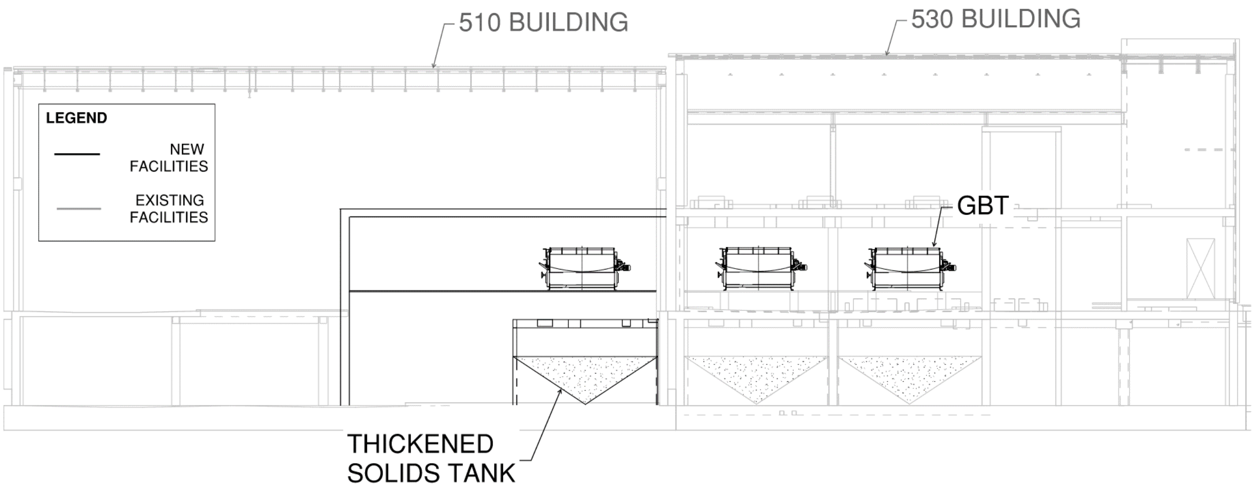

Figure-6-7. Gravity Belt Thickener Building Profile

The estimated capital cost of a GBT system includes a demolition allowance for the existing thickeners and three GBT units. Annual operating and maintenance costs for the GBT system include power, operation and maintenance labor, polymer, and equipment parts.

6.5 Anaerobic Digestion

The solids stabilization process will employ an enhanced digestion process, temperature phased anaerobic digestion (TPAD) with batch tanks to meet the requirements of the WAC-173-308 and Part 503 (see Section 3), specifically to achieve a Class A designation for beneficial use of the biosolids. Different digestion processes were evaluated during Phase 1 and Phase 2 of the Project and details on the comparisons can be found in TM 1—Preferred Conceptual Alternative (Appendix A) and TM 2—Final Alternative Selection (Appendix B).

TPAD utilizes digesters in series with a first stage thermophilic digestion followed by mesophilic digestion in the second stage. Two thermophilic anaerobic digesters will operate at 131 to 135 degrees Fahrenheit (°F) with solids retention times (SRT) of at least 5 days. The elevated temperatures increase biochemical reactions and result in high-rate solids reduction and increased pathogen destruction.

To prevent short-circuiting and pathogen counts above the Class A criterion, the digesting solids from the thermophilic digesters will be pumped to one of six rectangular batch holding tanks (fill cycle) and held (hold cycle) at nominally the same temperature as the thermophilic digesters, at least 131 °F, for 24 hours (per Part 503 Class A requirements). After completing the appropriate hold cycle, a batch tank will draw down as the solids are pumped through cooling heating exchangers before being pumped to the two mesophilic digesters which will operate at an SRT of at least 7 days.

Figure 6-8 represents a process flow diagram of the TPAD system.

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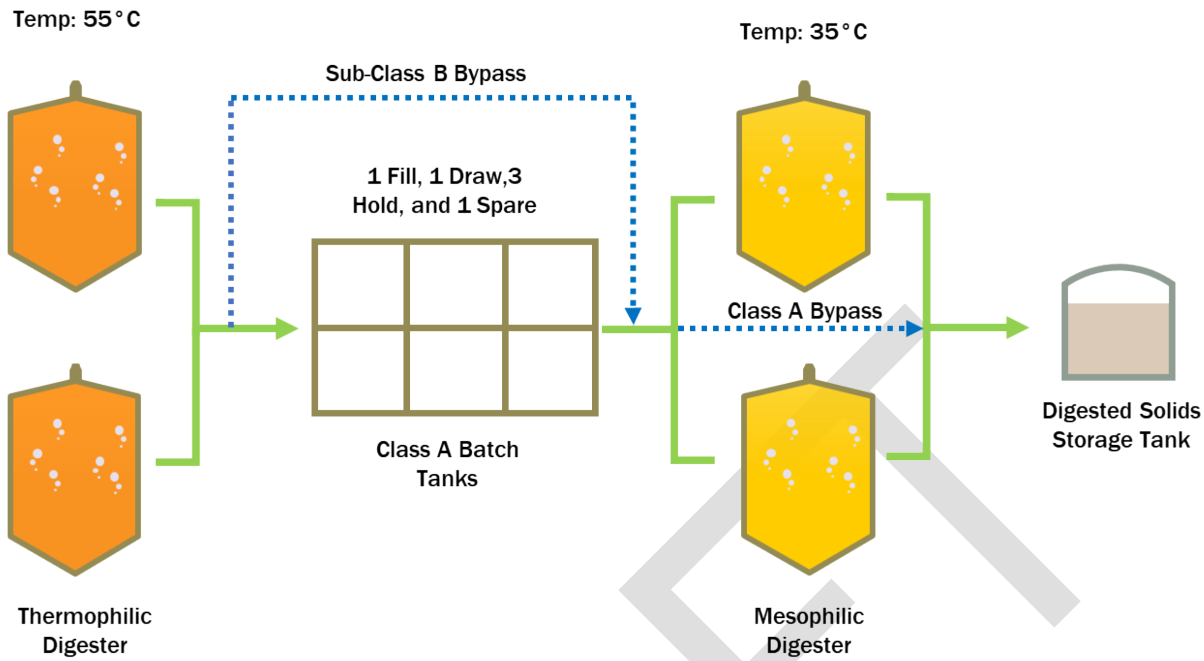

Figure 6-8. TPAD Process Flow Diagram

The flows and loads to the TPAD system is summarized in Table 6-10.

Table 6-10. TPAD Flows and Loads, 2025 and 2045

Parameter	Units	2025	2045				
		Min Week	Annual Average	Max Month	Max 14-Day	Max 7-Day	Max Day
TPAD Influent Feed							
Total Solids Load	lb-TS/d	24,300	46,200	58,600	61,200	65,800	98,100
Volatile Solids Load	lb-VS/d	20,800	36,900	46,400	48,800	49,700	59,600
Solids Volatile Fraction,	lb-VS/lb-TS	0.86	0.80	0.79	0.80	0.76	0.61
Solids Conc.,	Percent	6.0%	6.0%	5.5%	5.0%	5.0%	5.0%
Solids Flow,	gpd	48,500	92,300	127,600	146,659	157,600	234,900

6.5.1 Thermophilic Digestion

The elevated temperature of the thermophilic phase allows the process to operate at higher organic loading rates (OLR) and shorter retention times than mesophilic digesters. The OLR is defined as the mass of volatile solids (VS) load per digester unit volume per day, normally expressed in pounds of VS per cubic foot per day (lb VS/ft^3-day). A maximum OLR criterion of 450 lb-VS/1,000 cubic feet (ft3/day) is recommended based on Brown and Caldwell (BC) experience for design organic loading conditions of full-scale facilities.

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The thermophilic digester was designed to meet a service condition that reflects one digester in service and a flow and loads that represent the 2045 annual average plus 15 percent additional. Table 6-11 summarizes the criteria used to evaluate the process tankage requirements for the thermophilic phase of the digestion process.

Table 6-11. Thermophilic Digester Design Criteria

Criterion	Unit	Service Condition [a]	Peak Condition [b]
HRT, minimum	d	5	7
OLR, maximum	lb-VS/ft^3/d	0.45	0.40

[a] 115% of annual average solids flows and loads. One digester out of service.

[b] Max 7-day solids loading and max 14-day flows. All digesters in service.

Based on the thermophilic digester design criteria, the design characteristics of the thermophilic digester is summarized in Table 6-12.

Table 6-12. Thermophilic Digester Design Characteristics

Parameter	Value
Number of Thermophilic Digesters	2
Diameter, ft	60
Wall Height, ft	32.4
Cone Dimensions	-
Depth, ft	14
Cone Slope, %	25
Cone Volume per Digester, gal	98,600
Design Volume per Digester, gal	783,000
Active Volume per Digester, gal [a]	684,000
Total Design Volume, gal	1,090,000

6.5.2 Class A Batch Tanks

The application of batch tanks fulfills the requirements codified in WAC-173-308 Alternative 1 (time and temperature) where each gallon of digesting sludge must be held for 24-hours at temperatures in excess of 131 °F. A minimum of a 3-tank fill/hold/draw system is required for batch operation. By increasing the number of batch tanks in the "hold" phase, the total volume of batch tanks can be reduced. The hold period does not include tank filling or emptying to meet the Class A requirements.

The Figure 6-9 shows schematically how this approach would generally work with a six-tank option; a 2-by-3 pod of batch tanks is operated using a fill-hold-hold-hold-draw sequential operation to achieve the required 24 hours with three 8-hour cells–and one spare for redundancy. To minimize complexity, provide more understandable and simple operation, and reduce the risk of sub-Class A material associated with inadequate batch times, it is recommended that the batch tanks be designed and operated with a 24-hour hold time for all operating conditions regardless of the operating temperature.

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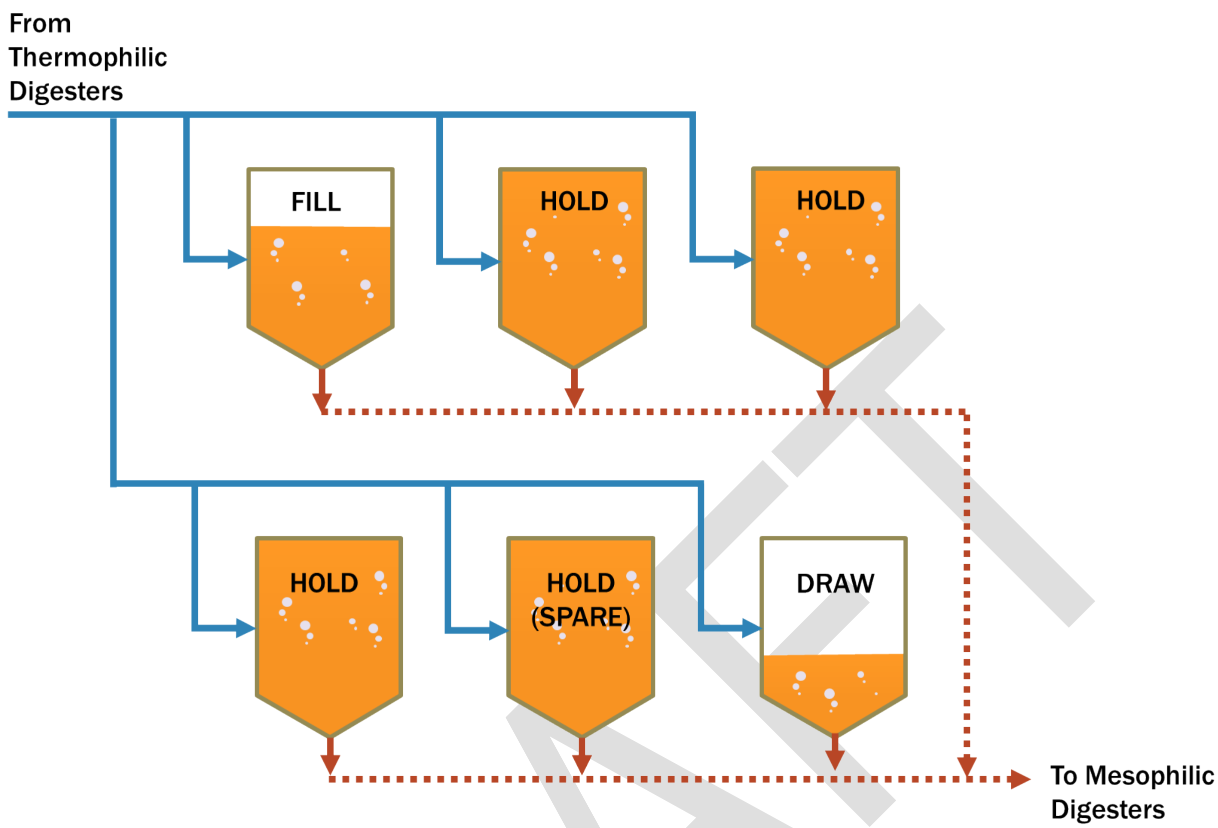

Figure 6-9. Batch Tank Fill, Hold, Draw Sequence

Along with this is the ability to bypass Class A thermophilically-digested biosolids around the mesophilic process while still maintaining Class A biosolids product and allowing the mesophilic reactor to be taken off line for maintenance.

The batch tanks were sized to accommodate the 2045 max day flow plus 50 percent additional capacity for future expansion of the system. It is anticipated that the digestion system will expand from four digesters to six digesters for future buildout. Based on the max day sizing and tank configuration, three tanks would be in service and the spare tank would act as a standby tank allowing at least one tank to be out of service at all times and still able to handle max day flows for buildout conditions. Table 6-13 summarizes the design criteria for the Class A Batch Tanks

Table 6-13. Class A Batch Tank Design Criteria

Design Parameter		Design Flow (gpd)	Minimum Required "Hold" Batch Tanks in Service	Typical Condition [a]	Service Condition [b]
				Minimum HRT (hrs)	
Class A Batch Tanks	Design Peak Day Flow, 2045	235,000	2	24	24
	Design Peak Day Flow, Buildout [c]	352,400	3	24	24

[a] *All batch tanks in service.*

[b] *One batch tank out of service.*

[c] *Assumes 150% of 2045 design peak day flow.*

Table 6-14 provides a summary of the Class A Batch Tank characteristics.

Table 6-14. Class A Batch Tanks Design Characteristics	
Parameter	Value
Number of Batch Tanks	6
Tank Configuration (Fill/Draw/Hold/Spare)	1/1/3/1
Batch Tank Dimensions	-
Width and Length, ft	22
Wall Height, ft	46
Additional Freeboard, ft	2
Cone Dimensions	-
Depth, ft	4.4
Cone Slope, %	25
Cone Volume per Tank, gal	7,800
Design Volume per Tank, gal	181,600
Total Design Volume, gal	1,090,000

6.5.3 Mesophilic Digestion

The mesophilic phase in the TPAD system provides many benefits including the increase of VSR and gas production, reduction of odors, further stabilization of the biosolids, and improvements in dewatering. Although most of the VSR is expected to occur in the thermophilic phase, the mesophilic phase OLR and SRT need to be considered to assure process stability. Table 6-15 summarizes the criteria used to evaluate the process tankage requirements for the mesophilic phase of the digestion process.

Table 6-15. Mesophilic Digester Design Criteria			
Criterion	Unit	Service Condition [a]	Peak Condition [b]
HRT, minimum	d	7	7
OLR, maximum	lb-VS/ft^3/d	0.18	0.18

[a] 115% of annual average solids flows and loads. One digester out of service.

[b] Max 7-day solids loading and max 14-day flows. All digesters in service.

The mesophilic digesters will be designed to be identical to the thermophilic digesters, the design characteristics of the mesophilic digester is summarized in Table 6-16.

Table 6-16. Mesophilic Digester Design Characteristics	
Parameter	Value
Number of Mesophilic Digesters	2
Diameter, ft	60
Wall Height, ft	32.4

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Table 6-16. Mesophilic Digester Design Characteristics	
Parameter	**Value**
Cone Dimensions	-
Depth, ft	14
Cone Slope, %	25
Cone Volume per Digester, gal	98,600
Design Volume per Digester, gal	783,000
Active Volume per Digester, gal [a]	684,000
Total Design Volume, gal	1,090,000

6.5.4 Ferric Chloride Dosing

Struvite will be controlled via ferric chloride dosed to the thermophilic digesters. A single FRP storage tank will store bulk chemical delivered by a local chemical supplier. The storage tank is located outdoors on the south side of the Digester Control Building within a containment area sized to accommodate the contents of the tank as well as the accumulated rainfall from a 25-year storm event. The metering pumps are located within the containment area. There are three peristaltic metering pumps, two duty one standby. The two duty pumps each feed one of the thermophilic digesters. Table 6-17 summarizes the design criteria for the ferric chloride system sizing.

Table 6-17. Ferric Chloride Dosing Criteria		
Criteria	**Unit**	**Value**
Chemical Concentration	%	38
FeCl Dose	Lbs-FeCl/ton TS	75
Storage Duration	Days	20

6.6 Heat Utilization

The TPAD process planned for Post Point will require a means of heating the thermophilic digesters and cooling the mesophilic digesters. The simplest and most common heating and cooling strategies at plants with TPAD processes are gas-fired boilers for sludge heating and plant effluent for sludge cooling, which are suitable for Post Point. However, integrating either electric or absorption heat pumps could recover the heat from the sludge leaving the batch tanks prior to the mesophilic digesters for heating the thermophilic digesters and thereby reduce Post Point's energy consumption, lower GHG emissions, and reduce operating costs. This section summarizes the planning-level approach to setting heating/cooling design criteria, evaluating available heating and cooling alternatives, the associated technologies for each alternative, and provides a recommended alternative based on qualitative analysis.

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A central heating system is required to provide process heat for the thermophilic digesters, batch tanks, and space heat to maintain occupied spaces, equipment rooms, and passageways at comfortable temperatures. The new TPAD process, will heat thickened sludge from wastewater temperatures (55–80 deg F) to thermophilic temperatures (131 deg F), maintain that temperature in the batch tanks, then cool the sludge to 98 deg F for mesophilic digestion (see Figure 6-9). The digester control building and adjacent buildings and tunnels will require space heat to maintain equipment rooms at comfortable temperatures for operations and maintenance staff. A cooling system will be required to reduce the sludge temperature from thermophilic (131 deg F) to mesophilic (98 deg F) as well as cooling the digester gas upgrading equipment, such as compressors and gas coolers.

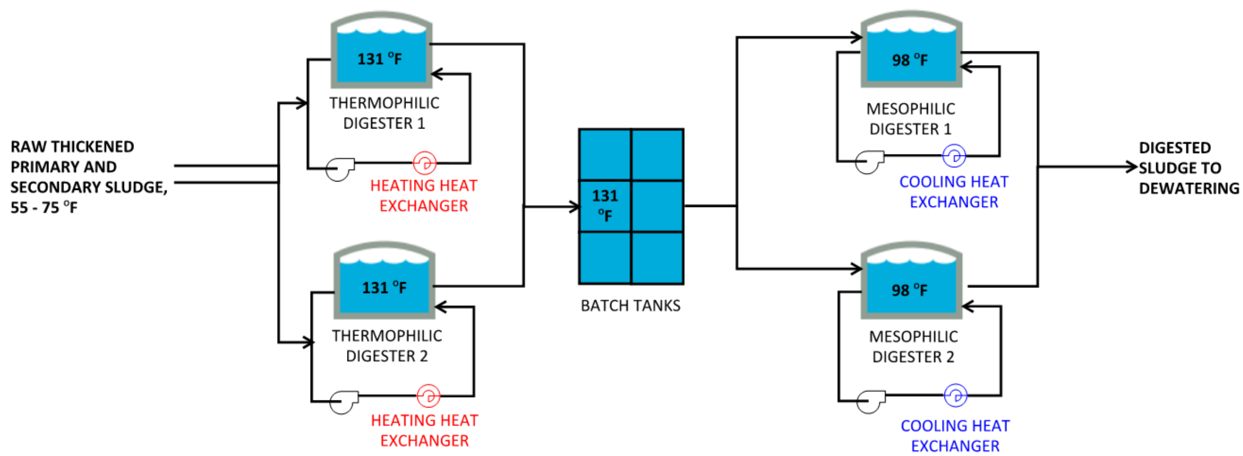

Figure 6-10. Heating and Cooling Diagram of TPAD System

6.6.1 Heating and Cooling Criteria

The following sections discuss the heating/cooling criteria for Post Point based on the projected digestion process flows and temperature requirements. Detailed information on the heating and cooling considerations are documented in TM 5—Sludge Heating and Cooling (Appendix G).

6.6.1.1 Process Heating and Cooling Requirements

Table 6-18 summarizes the projected minimum, average, and peak process heating requirements for Post Point. The minimum and peak heat demand values are used for sizing the heat system while the average heat demand is used for assessing mean operating costs and resources. Process heat is required to heat the sludge from wastewater temperatures (expected to be 55–75 deg F) to thermophilic digestion temperatures (131 deg F). The flow rate of sludge will vary depending on plant influent and liquid stream operation. The digesters would be insulated but would still lose some heat through the walls and covers. This heat loss is considered part of the process heating demands.

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Table 6-18. Process Heating Requirements Summary					
Demand	Sludge temperature, °F	Sludge flow rate, gpd	Sludge heating demand, MMBtuh	Digester shell loss, MMBtuh	Total process heating demand[a], MMBtuh
2045 peak week	55	153,400	4.0	0.9	4.9
2035 average	65	91,300	2.1	0.7	2.8
2025 minimum week	75	74,600	1.5	0.5	2.0

a. Assumes thermophilic digesters are maintained at 131 °F.

Abbreviations: gpd = gallons per day, MMBtuh = million British Thermal Units per hour

Table 6-19 summarizes the projected minimum, average, and peak process cooling requirements for Post Point. Sludge at 131 deg F or higher from the batch tanks will be transferred to the mesophilic digesters, which would operate in the temperature range of 95–105 deg F. To maintain the digesters within this temperature, the mesophilic digester sludge would be circulated through cooling heat exchangers.

Table 6-19. Process Cooling Requirements Summary				
	Sludge flow rate, gpd	Sludge cooling demand, MMBtuh	Digester shell loss, MMBtuh	Total process cooling demand[a], MMBtuh
2045 peak week	153,400[a]	1.8	0.2	1.6
2035 average	91,300[a]	1.0	0.4	0.6
2025 minimum week	74,600[b]	0.9	0.5	0.4

a. Assumes thermophilic digesters are maintained at 131 °F and mesophilic digesters are maintained at 98 °F.

The heat exchangers are recommended to be cooled using close-loop cooling to eliminate biofouling on the cooling sides of the sludge heat exchangers.

6.6.1.2 Space Heating

The new solids processing facility will include a new Digester Control Building, dewatering, screening, thickening, and gas upgrading buildings. It is assumed that all these buildings will be heated from the central heating system. Based on the preliminary building layout, typical height of these buildings, and required air changes per hour, the peak building space heat demand was estimated to be 3.6 MMBtuh through 2045. Other facilities, such as those associated with the liquid stream, and tunnels and galleries were assumed to be heated separately and were not considered in this estimate.

It was assumed occupied areas would need to be heated to 70 deg F in the winter while storage and process areas would only need to be heated to 55 deg F in the winter. Reasonably sized heating coils could be provided for all these spaces with entering water temperatures as low as 130 deg F.

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6.6.1.3 Equipment and Space Cooling

Equipment for the gas upgrading process will require compressor oil cooling and gas cooling. A closed-loop cooling process is recommended to be used where possible. For the purposes of the Facility Plan, compressor and gas cooling demands in the range of 0.2 to 0.5 MMBtuh is assumed based on the flow rate of digester gas as indicated in TM 6—Biogas Upgrading Technology Alternatives (Appendix H). For space cooling, the Facility Plan assumes electrical rooms and occupied spaces are cooled using individual air conditioning systems.

6.6.2 Heating and Cooling System Alternatives

TM 5—Sludge Heating and Cooling (Appendix G) describes in detail the different technologies available for Post Point's heating and cooling systems. This includes technologies for sludge heat exchangers, steam injectors, space heating, boilers, electric heat pumps, absorption heat pumps, and other technologies.

The alternatives considered for heating and cooling systems include:

- Alternative 1A: Hot water boilers, plant effluent sludge cooling
- Alternative 1B: High pressure steam boilers, plant effluent sludge cooling
- Alternative 2: Alternative 1B with heat recovery heat exchangers
- Alternative 3A: Heat pumps for heat recovery with hot water boilers
- Alternative 3B: Electric heat pumps for heat recovery with high pressure steam boilers
- Alternative 4: Electric heat pumps only
- Alternative 5: Absorption heat pumps for heat recovery with hot water boilers

Alternatives 2 and 4 were eliminated from further consideration due to the risk of and/or poor operating experience at other facilities. Upon receiving input from Post Point staff, alternatives that used steam systems were eliminated from consideration (Alternatives 1B and 3B).

Table 6-20 summarizes the heating and cooling alternatives considered for Post Point and, for each alternative, indicates the heating source, cooling source, the approach to digester heating, digester cooling, space heating, and biogas compressor and gas cooling.

Table 6-20. Heating and Cooling System Alternatives Summary

Alternative	1A	1B	2	3A	3B	4	5
Heating Source	Hot water boilers	High pressure steam boilers	High-pressure steam boilers and sludge heat recovery	Electric heat pumps and hot water boilers	Electric heat pumps and high-pressure steam boilers	Electric heat pumps	Hot water boilers and absorption heat pumps
Cooling Source	Plant effluent	Plant effluent	Plant effluent and sludge heat recovery	Electric heat pumps/plant effluent	Electric heat pumps/plant effluent	Plant effluent	Absorption heat pumps/plant effluent
Digester Heating	Sludge heat exchangers	Direct steam injection	Direct steam injection/sludge heat exchangers	Sludge heat exchangers	Direct steam injection/sludge heat exchangers	Sludge heat exchangers	Sludge heat exchangers
Digester Cooling	Sludge heat exchangers						
Space Heating	Hot water coils	Steam coils	Steam coils	Hot water coils	Steam coils	Hot water coils	Hot water coils
Compressor/ gas cooling	Closed loop with plant effluent cooling			Chilled water loop		Air coolers	Chilled water loop

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6.6.3 Alternatives Comparison

Alternatives were compared on both an economic and non-economic basis. Economic factors included the lifecycle costs such as capital cost, 20-year O&M costs, and net present value (NPV) for each of the four heating system alternatives. Non-economic factors included environmental impacts and operational considerations. For details about the alternative comparison and approach to evaluating the economic and non-economic factors, refer to TM 5—Sludge Heating and Cooling (Appendix G).

Table 6-21 summarizes the economic factors for the five evaluated alternatives.

Table 6-21. Economic Summary of Evaluated Alternatives

Alternative	Description	Capital Cost[a,b]	Annual O&M Cost[a,c]	20-yr NPV[a]
1A	Hot water boilers, plant effluent cooling	$1,570,000	$254,000	$5,440,000
1B	Steam boilers, plant effluent cooling	$2,500,000	$252,000	$6,270,000
3A	Hot water boilers and electric heat pumps, closed loop cooling	$3,210,000	$269,000	$7,130,000
3B	Steam boilers and electric heat pumps, closed loop cooling	$3,610,000	$273,000	$7,570,000
5	Hot water boilers and absorption heat pumps, closed loop cooling	$3,720,000	$192,000	$6,440,000

[a]All values provided are in 2021 US Dollars.

[b]Capital cost includes equipment costs plus major future equipment replacement costs.

[c]O&M costs includes electricity, natural gas, and potable water consumption costs, and annual maintenance contracts.

Non-economic factors for the alternatives were also evaluated. These include environmental factors (energy and water consumption, GHG emissions) and operational factors (e.g. footprint, operational risks, equipment and design commonality, system complexity, flexibility to meet future, unanticipated operating conditions, maintenance requirements, and process safety hazards). Table 6-22 and Table 6-23 summarize the environmental and operational factors of the non-economic comparison, respectively, for the five alternatives. Refer to TM 5 for additional discussion of how the environmental and operational factors compare across alternatives considered.

Table 6-22. Environmental Comparison of Evaluated Alternatives

Alternative	1A	1B	3A	3B	5
Electricity consumption, kWh/yr[a]	250,000	80,000	1,760,000	1,760,000	400,000
Natural gas consumption, MMBtu/yr[b]	39,000	40,000	19,000	19,000	25,000
Total factored energy consumption, MMBtu/yr[c]	40,000	39,000	32,000	33,000	27,000
GHG emissions, MT CO_2 equivalent/yr[d]	2,050	2,100	1,200	1,200	1,350

a. Includes electricity consumption by boiler burners, heat pumps, and hydronic pumps.

b. Assumes boilers exclusively use natural gas; digester gas is used fully for upgrading.

c. Total factored energy consumption is the equivalent total thermal energy consumed as natural gas assuming consumed electricity is generated by natural gas at an efficiency of 40%.

d. Includes GHG emissions from burning fossil fuels and refrigerant leakage at 33% per year with a GWP of 1410. No GHGs are associated with the electricity consumed.

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Table 6-23. Heating and Cooling Systems Alternatives Operational Comparison					
Alternative	1A	1B	3A	3B	5
Criteria	Hot water boilers, effluent cooling	Steam boilers, effluent cooling	Hot water boilers and electric heat pumps, effluent cooling	Steam boilers and electric heat pumps, closed loop cooling	Hot water boilers and absorption heat pumps, closed loop cooling
Footprint	+	++	-	●	●
Risk	++	++	-	-	●
Equipment and design commonality	++	+	●	-	-
Heating/cooling systems complexity	+	++	--	-	-
Future flexibility	-	●	+	++	++
Maintenance requirements	●	●	--	--	-
Process safety hazards	++	+	●	--	●
Median score	+	+	-	-	-

Key: [--] Significantly Unfavorable [-] Unfavorable [●] Neutral [+] Favorable [++] Significantly Favorable

6.6.4 Summary and Conclusions

The TPAD process planned for Post Point will require a means of heating the thermophilic digesters and batch tanks and cooling the mesophilic digesters. The Project Team recommends carrying forward Alternative 5 – absorption heat pumps for heat recovery with hot water boilers with a closed cooling loop – in the Post Point planning process and later preliminary design. Table 6-24 summarizes the advantages and disadvantages of Alternative 5.

Table 6-24. Recommended Heating and Cooling System Alternative (Alternative 5) Advantages and Disadvantages	
Advantages	Disadvantages
• Lower GHG emissions and energy consumption • Low plant effluent cooling water flow during normal operation • Multiple heating and cooling options • Absorption heat pumps and boilers can generate hot water up to 170 °F for better struvite control in the thermophilic heat exchangers	• Large capital and space requirements for equipment • Complicated control strategies to coordinate heat pumps and boilers • Anaerobic digester heat addition is limited by size and condition of the heat exchangers • Numerous hydronic pumps

Alternative 5 is more capital-intensive and would be more operationally burdensome compared to the other alternatives due to the additional equipment, maintenance, and complexity. However, the NPV and environmental benefits of Alternative 5 are more favorable than the boilers-only alternatives.

6.7 Digested Solids Storage Tank

The Digested Solids Storage Tanks (DSST) provides storage of digested solids prior to dewatering to improve operational flexibility, system reliability and dewatering operations. The amount of storage of the DSSTs depends on the operational configuration of the dewatering system, cake storage capabilities, and transportation schedule of the biosolids. Table 6-25 summarizes the design criteria for the DSSTs.

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Table 6-25. Digested Solids Storage Tanks Design Criteria				
Design Parameter		Design Flow (gpd)	Typical Condition [a]	Service Condition [b]
			Minimum Storage (day)	
Digested Solids Storage Tank	Design Max 7-Day Flow, 2045	157,600	2	NA
	Design Max 7-Day Flow, Buildout [c]	236,500	2	NA

[a] *All DSST in service.*

[b] *One DSST out of service.*

[c] *Assumes 150% of 2045 design Max 7-day flow.*

6.8 Solids Dewatering

Dewatering increases the solids content of a digested solids stream to 15% TS or higher. Increasing the solids content reduces transportation and beneficial use costs. The dewatered biosolids product is commonly referred to as "cake". In Phase 2, several dewatering technologies were evaluated, including belt filter presses (BFPs), dewatering centrifuges, rotary presses, screw presses, and volute presses. BFPs, dewatering centrifuges, and screw presses were selected for further evaluation in Phase 3 (see TM 2—Final Alternative Selection [Appendix B]).

6.8.1 Solids Dewatering Comparison and Recommendation

A summary of advantages and disadvantages for each dewatering alternative are shown in Table 6-26. The advantages and disadvantages of each alternative are considered relative to each other.

Table 6-26. Dewatering Technology Non-Economic Evaluation		
Technology	Advantages	Disadvantages
Belt Filter Press	• Low power use • Lowest polymer consumption • Simple operation • High solids capture • Pathogen regrowth not widely documented	• No room for future expansion • Potential for odor if not enclosed • Potential for belt blinding with grease or polymer • Sensitive to changes in solids conditions • High operator attention • Highest washwater consumption
Dewatering Centrifuge	• Proven technology at Post Point • High cake dryness • Low odor within building (enclosed)	• High power consumption • High noise • High vibration • High polymer demand • Potential for regrowth/reactivation
Screw Press	• Low power use • Simple operation • Low odor within building (enclosed) • Pathogen regrowth not widely documented	• High polymer demand • Potential for plug loss within unit (several hours required to rebuild plug) • Plugging or blinding of screens with debris possible

Capital, O&M, and life-cycle costs for the solids dewatering technologies are shown in Table 6-27. Detailed cost estimates for the dewatering systems are shown in TM 12—Solids Screening, Thickening, and Dewatering Technology Evaluation (Appendix F).

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Table 6-27. Solids Dewatering Cost Comparisons			
Alternative	Capital Cost, million	O&M Cost, million/yr	Life-Cycle Cost, million
Belt Filter Press	$8.7	$1.47	$30.6
Dewatering Centrifuge	$7.4	$1.46	$29.1
Screw Press	$9.3	$1.36	$29.5

The life-cycle costs of all options are comparable; thus the dewatering technology selection should be based on non-economic criteria. Centrifuges provide a drier cake than the other technologies, contain odors, fit well within the existing dewatering building, and the operators are familiar with the technology. Additionally, dewatering technology selection can affect the quality of the biosolids product, including biosolids odor, rheology, and total solids content, which can impact the City's beneficial use program. The biosolids beneficial use program is expected to be composting or soil blending. A higher cake solids content equates to less water to be hauled and processed, which results in less cost as tipping fees are typically on a wet ton basis. Further, the cake solids content will impact the amount of bulking agent and amendment needed for composting or soil blending, which can reduce risks and cost to the City. Dewatering centrifuges may be the most compatible with the planned biosolids beneficial use program and would likely result in the lowest processing cost.

Some Class A processes have shown to be susceptible to pathogen regrowth and reactivation after using high shearing processes such as centrifuge dewatering. The mechanisms for regrowth or reactivation are not well understood and it is unclear why some facilities experience the phenomenon while others do not. More information on regrowth and reactivation is available in TM 2—Final Alternative Selection (Appendix B).

Because the likelihood of experiencing regrowth or reactivation is unknown at this time, the dewatering recommendation for this project involves a monitoring program after the TPAD system is commissioned to determine the appropriate dewatering technology. The existing dewatering centrifuges located in the East – Solids Handling Building were installed in 2012 and have years of remaining life available. Centrifuges have numerous advantages over the other technologies and are economically preferable. Therefore, it is prudent to continue using the existing centrifuges after the digester process is commissioned. During this time, the City should monitor for pathogens in the cake to determine if regrowth and reactivation occurs. If regrowth or reactivation is not observed, replacement of the existing centrifuges with new centrifuges is recommended. If regrowth or reactivation is observed and cannot be corrected through other means, replacing the existing centrifuges with screw presses is recommended. BFPs and screw presses have comparable life-cycle costs, but screw presses fit better within the existing building and contain odors better.

Pathogen regrowth/reactivation monitoring can be performed for approximately 6 months after the digesters are commissioned. The City has expressed a preference for retaining one of the existing incinerators in operational standby mode for this time to provide backup solids processing capacity in case the digesters experience an upset during startup. After the digesters have successfully operated for 6 months, the incinerator can be removed. Therefore, a 6-month pathogen monitoring period before replacing the dewatering equipment is not expected to delay the overall construction schedule for this project.

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6.9 Dewatered Cake Storage and Loadout

Dewatered cake from the cake hoppers will be loaded into semi-tractor trailers through either conical-shaped hoppers with slide gates or a rectangular-shaped hopper with a live bottom screw conveyor system that extends the length of the semi-tractor trailer. Conical-shaped hoppers require steep side slopes on all four sides, thus they provide less storage capacity compared to live bottom hoppers that only require two sloped sides. In addition, live bottom conveyors can provide better control of loading rate to the trailers and more even distribution in the trailers when provided with multiple gated discharge openings. Therefore, two rectangular hoppers with live bottom screw conveyors are recommended.

The hoppers will be sized to provide an effective storage volume of approximately 180 cubic yards dewatered cake per hopper. This volume would provide at least 2 days of storage at 2045 maximum month solids loadings with one hopper out of service.

6.10 Biogas Cleaning and Utilization

This section summarizes the biogas upgrading technology alternatives analysis and provides preliminary selection of the preferred alternative for upgrading biogas to RNG. TM 6—Biogas Upgrading Technology Alternatives (Appendix H) provides more details about the analysis.

6.10.1 Background

Biogas produced from the anaerobic decomposition of wastewater sludge within the digesters will be collected and treated to remove carbon dioxide (CO_2), moisture, and gaseous contaminants. The product gas, comprised primarily of methane (CH_4), will be of a quality suitable for injection into the natural gas pipeline.

Due to its high CH_4 content, biogas is combustible and suitable for use as fuel (cogeneration and vehicle fuel) and as a natural gas substitute (or supplement). See Section 5.4 and TM 2—Final Alternative Selection (Appendix B) for the Project Team's earlier conceptual evaluation of Post Point's biogas utilization alternatives. TM 2—Final Alternative Selection (Appendix B) concluded that converting Post Point's biogas to RNG was the most cost-effective and environmentally beneficial solution.

6.10.2 Basis of Analysis

The criteria used to compare biogas upgrading technologies, including Post Point's projected raw biogas quantity and quality assumptions and anticipated RNG quality specification, are described in this section.

Key criteria used to evaluate biogas upgrading alternatives include:

- Estimated biogas production
- Assumed raw biogas quality
- Required capacity and turndown of the biogas upgrading system
- RNG quality requirements defined by Cascade Natural Gas Corporation (CNGC)
- CH_4 recovered from the raw biogas for upgrading to RNG (high methane capture rate)
- CH_4 content of the upgraded RNG (high methane content)

The following sections describe the design criteria further.

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6.10.2.1 Raw Biogas Production

Anticipated biogas production rates from the new Post Point anaerobic digesters were used to develop preliminary sizing of candidate biogas upgrading systems. Biogas production estimates for Post Point were based on a combination of solids production estimates and historical plant operating data. Table 6-28 provides biogas production estimates. The Project's final design stage will consider expansion of the new biogas upgrading system to treat biogas flows that may occur at buildout conditions beyond 2045.

Table 6-28. Biogas Upgrading System Preliminary Sizing Criteria

Criterion	Biogas Production, scfm	Required System Turndown Ratio
Year 2025, minimum week	175	–
Year 2045		
Average annual	290	1.7:1
Maximum month	360	2.1:1
Maximum week [a]	370	2.1:1
Maximum day	425	2.4:1
Anticipated buildout condition	540	3.1:1

a. Note that the max week biogas production is less than the max month value in the solids mass balance due to an estimated drop of 5 percent in VSR. This VSR reduction results from a shorter SRT from higher solids loading. The max month value was adjusted to be representative of a max week and max month biogas production scenario.

scfm–standard cubic feet per minute

Maximum month biogas production is the recommended design condition as this will capture all biogas produced under most conditions. Sizing for maximum day biogas production would result in underutilized equipment capacity for most of the project life. Conversely, sizing for average annual biogas production would result in continuously flaring excess biogas during significant portions of the year and thereby reduce the return on the capital investment.

Biogas upgrading systems provided by various manufacturers may not be available with specific capacities and turndown tailored explicitly for Post Point. Some manufacturers have standard product offerings only. Therefore, some flexibility in selecting the final design values is warranted.

6.10.2.2 Raw Biogas Quality

Raw biogas quality is a key design criterion for the biogas upgrading system. Post Point does not yet operate anaerobic digesters and thus does not produce biogas, therefore anticipated raw biogas quality is based on conservative assumptions. Table 6-29 presents the assumed biogas composition, which is based on typical anaerobic digesters used for municipal wastewater sludge stabilization.

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Table 6-29. Assumed Post Point Biogas Composition		
Criteria [a]	Typical	Range
Methane, dry, mole %	60	55 - 65
CO_2, dry, mole %	39.5	35 - 45
Nitrogen, dry, mole %	0.5	0.25 - 0.75
H_2S, ppm_v [b]	600	100 - 1,000
Total siloxanes, mg Si/Nm^3 [c]	25	5- 50

[a] Raw biogas, as produced, has a relative humidity of 100%.

[b] mg Si/Nm^3–milligrams silicone per Normal cubic meter

[c] ppm_v–parts per million by volume

Once the new anaerobic digesters have been fully commissioned, the City should immediately implement a sampling program to determine the actual biogas composition. Actual biogas composition, as determined by laboratory analysis, is not expected to impact the results of this alternatives analysis but will be important for determining the type of pre- and post-treatment systems needed to remove H_2S and siloxanes, along with the costs associated with these systems.

6.10.2.3 RNG Quality Specification

The new biogas upgrading system will be required to produce RNG that meets the gas quality requirements set forth by CNGC. Based on experience with other RNG upgrading projects, a draft agreement with CNGC will likely outline specific constituent concentrations as well as monitoring, testing, reporting, and recordkeeping requirements. Table 6-30 summarizes the anticipated RNG quality requirements based on the City's discussion with CNGC to date.

Table 6-30. CNGC Gas Quality Specification		
Parameter	Minimum Value	Maximum Value
Heating value (BTU/SCF)	985	–[a]
Wobbe number (BTU/SCF)	1,290	–[a]
Temperature (°F)	35	100
Carbon dioxide (%)	–	2
Nitrogen (%)	–	2[a]
Total inerts + oxygen (%)[c]	–	3[b]
Oxygen (%)	–	0.20[d]
Hydrogen sulfide (grain/CCF)	–	0.25
Total sulfur (grain/CCF)	–	5
Moisture (lb/MMSCF)	–	7
Hydrocarbon dew point (°F) at delivery pressure	–	15

a. *The Company may establish maximum heating and Wobbe number values if biomethane is enriched with other hydrocarbons.*

b. *The Company may establish higher nitrogen and/or total inert levels at its discretion.*

c. *Inerts are defined here as nonhydrocarbon gases including, but not limited to, carbon dioxide, nitrogen, and oxygen.*

d. *All parties agree to exercise every reasonable effort to keep the gas completely free of oxygen.*

Abbreviations:
BTU/SCF = British thermal units–standard cubic feet
CCF = 100 standard cubic feet
MMSCF = One million standard cubic feet

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In addition to complying with the RNG quality requirements summarized in Table 6-30, periodic sampling will be required to confirm several other gas constituents are below specified limits. A polishing step is recommended for all biogas upgrading alternatives to capture any remaining siloxanes that may have passed through the upgrading process. Refer to TM 6—Biogas Upgrading Technology Alternatives (Appendix H) for more information.

6.10.3 Biogas Upgrading Alternatives

Several biogas upgrading technologies were considered during the conceptual screening phase. This section is a summary of the alternatives considered. For more information about the biogas upgrading technologies, detailed technology descriptions, evaluation criteria and approach for technology screening, vendor and manufacturer specifics, criteria comparison, and cost evaluation information, refer to TM 6—Biogas Upgrading Technology Alternatives (Appendix H).

TM 6—Biogas Upgrading Technology Alternatives (Appendix H) includes a conceptual-level technology evaluation that includes four biogas upgrading alternatives. The alternatives included:

1. Amine-based systems
2. Water scrubber systems
3. Membrane systems
4. Pressure swing adsorption (PSA) systems

The screening of these alternatives focused on the ability of the proposed systems to meet CNGC's RNG quality requirements and capital and operating costs. Refer to TM 6—Biogas Upgrading Technology Alternatives (Appendix H) for information about how the alternatives were ranked and scored against specific criteria.

The conceptual-level technology screening resulted in the short-listing of membrane and PSA systems. Amine systems were eliminated due to lack of experience within the United States in the size range required for the Project. Water scrubber systems were eliminated from further evaluation due to difficulty in meeting CNGC's RNG quality requirements. Membrane and PSA systems were carried forward for cost estimating.

6.10.4 Summary and Recommendations

Based on the analysis, two of the technologies considered are appropriate for Post Point's design conditions and can comply with CNGC's RNG requirements. The short-listed technologies that warrant further evaluation are membrane and PSA systems. The Project Team evaluated and developed preliminary scoring of the manufacturer systems that represent membrane and PSA technologies. Preliminary scoring was based on the relative rank of the systems' technical performance and ability to comply with CNGC's requirements and the criterion's assumed importance to the City. The Project Team performed technology scoring using weighted importance factors such capital costs, operations and maintenance costs, CH_4 recovery, CH_4 concentration in product gas, and system availability (time the system is operational). PSA systems received the highest technical score (average score 707) followed by membrane systems (average score 622).

For purposes of the Biosolids Facility Plan, a PSA system was selected for inclusion in the total project cost estimate.

Table 6-31 summarizes the range of CAPEX and annual OPEX costs for the biogas upgrading alternatives. The CAPEX range is between approximately $2.3M and $5.6M. The OPEX costs account for power, fuel, chemicals and other consumables, and labor. The OPEX range is between approximately $155,000 and $1M.

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Table 6-31. Biogas Upgrading System Cost Summary

Technology	CAPEX	OPEX/yr
PSA	$2,274,000 - $5,265,000	$154,200 - $544,500
Membrane	$3,640,000 - $5,595,000	$345,600 - $990,900

6.10.5 RNG Interconnect Facility

Custody of RNG will be transferred to CNGC at a new interconnection facility located at Post Point. It is anticipated that CNGC will provide all necessary interconnection equipment and operate the facility. The interconnect facility would primarily include a gas chromatograph, various isolation and automatic shutoff valves, an odorizer, and flow and sales meters.

The gas chromatograph will continuously analyze the incoming RNG from the Post Point upgrading facility. In the event that the RNG does not meet the CNGC gas quality requirements, an automatic shutoff valve will close and thus divert the RNG back to the Post Point gas upgrading facility for further treatment or for disposal at the waste gas burners.

The interconnect facility will include an odorizer to automatically inject small amounts of mercaptans (odorous, sulfur-based molecules) into the RNG. Because natural gas is odorless, industry standard is to add odorant to the gas so that it can be smelled in the event of a leak.

The interconnect facility will also include flow and sales meters to totalize the amount of RNG received from Post Point and injected into the natural gas pipeline.

6.10.6 Additional Considerations

Following the biogas treatment technology short-listing, additional discussions with membrane and PSA system suppliers revealed that multiple suppliers offer both membrane and PSA systems. All suppliers that offer both technologies recommended PSA systems for the Project. The suppliers' reasons for recommending PSA systems include:

- PSA systems remove nitrogen (N_2) and oxygen (O_2) which results in greater flexibility complying with RNG requirements as specified by CNGC. These systems can more easily comply with the Total Inerts + Oxygen requirements. Additionally, the removal of N_2 and O_2 produces a gas product that more easily complies with the high heating value (HHV) and Wobbe number requirements (Table 6-30). Conversely, membrane systems do not remove N_2 or O_2, which results in these constituents becoming more concentrated in the RNG.
- PSA systems have lower OPEX costs due to having a much lower operating pressure and lower pressure loss through the system. PSA systems operate at approximately 150 psig, whereas membrane systems operate at about 250 psig. Pressure loss through a PSA system is about 15 psig compared to 50 psig for membrane systems.
- While a degree of moisture removal is required for all technologies, PSA systems are more tolerant of small amounts of moisture due to their ability to continuously regenerate their media and thus reject some moisture trapped in the media.
- PSA media can be tailored to specific raw gas constituents.

Based on the conceptual technology evaluation results and consistent feedback from suppliers, the Project Team recommends the selection of PSA technology for biogas upgrading at Post Point.

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Procurement of the biogas upgrading equipment is another consideration for the City. Given the complex nature of biogas upgrading systems and the degree of variability amongst systems proposed by the candidate manufacturers, even within the same technology category, the City should consider procuring the biogas upgrading system as a complete package with all necessary pre- and post- treatment equipment and compression equipment under a single scope of supply.

6.11 Odor Control

This section presents a high-level planning evaluation of odor control requirements and a preliminary design of the Post Point solids handling odor control system as discussed in TM 13—Odor Control Evaluation (Appendix I).

6.11.1 Existing Odor Control Systems

Odor-producing substances found in domestic wastewater and solids handling processes are small, relatively volatile molecules that are usually formed by anaerobic decomposition of organic matter containing sulfur and nitrogen. Most of these compounds have a low odor DT (detection threshold), defined as the concentration at which the average human nose can barely detect the presence of an odor. Hydrogen sulfide (H_2S) is the most recognizable and prevalent odorous gas associated with domestic wastewater collection and treatment systems. It has a characteristic rotten egg odor and is directly corrosive to metals and indirectly corrosive to concrete when oxidized to sulfuric acid.

Post point is currently equipped with several odor control systems that are used to reduce H_2S concentrations and odor D/T (dilutions-to-threshold) in plant odor source emissions, including:

- Air from the screen and grit facilities is captured and treated in a chemical scrubber followed by carbon adsorption.
- Chlorine is fed to the plant influent to mitigate odor and H_2S emissions from the headworks and primary clarifiers.
- Air from the anoxic/anaerobic zone of AB No. 1 is captured and treated in a biofilter.
- Air from the aerated sections of AB No. 1 is exhausted through dispersion fans, which simulate 40-ft stacks; the fans were installed to improve dispersion and dilution of the collected foul air.
- Air from the Primary Effluent Pump Station is captured and treated in a deep bed carbon adsorber
- Air from various processes within the solids handling building is captured and treated in chemical scrubbers followed by carbon adsorption.
- The incinerator exhaust is passed through a scrubber and a wet electrostatic precipitator and then discharged through one of two stacks on the roof of the building.

Figure 6-11 shows a current aerial photograph of Post Point with major processes identified.

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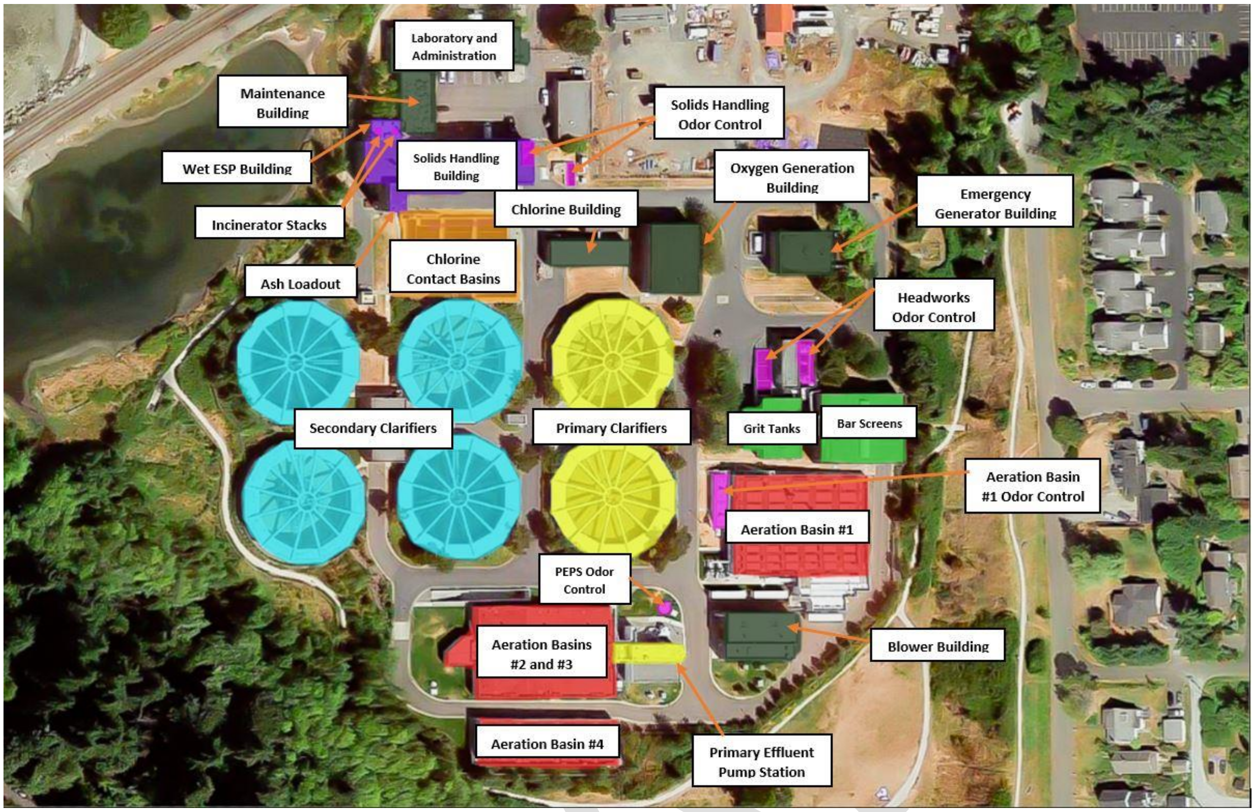

Figure 6-11. Post Point Aerial Photograph

Webster Environmental Associates conducted field sampling, laboratory analysis and a community odor survey to quantify current odor emissions at Post Point. Odor sampling and field testing procedures and results are discussed in Section 2 of TM 13—Odor Control Evaluation (Appendix I). These results were used to develop an odor control design criteria for Post Point.

6.11.2 Odor Control Design Criteria

The new biosolids treatment train involves new unit processes from thickening to dewatered cake solids load out. The goal of the new odor control system is for the new biosolids facilities to cause no increase in off-site odors.

Design airflow rates depend on the foul air volume to be evacuated and the selected air change rate. Air change rates were determined based on odor control guidance in the Water Environment Federation Manual of Practice No. 25 (2004), other literature documents, and from the Project Team's experience. The Project Team calculated how much foul air should be drawn from each process of the proposed biosolids facility and conveyed to odor control. Airflow rates to odor control should be lower in the new system because much of the generated gas will be collected and treated in other processes. Based on these airflow rate calculations, the odor control system for the proposed biosolids facility should be sized to treat 33,000 cfm. The contributing source airflow rates are summarized in Table 6-32.

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Table 6-32. Proposed Solids Handling Airflow Rates to Odor Control			
Location	Source Air Volume (ft^3)	Design Air Changes (ACH)	Airflow Rate (cfm)
Solids blend tanks			600
530 Building (thickening, dewatering, cake management)			9,000
Solids screening building			13,800
Cake storage and truck loadout			9,000
510 Building (other equipment)			0
Centrifuge discharge cake chute and conveyor			600
Proposed new Solids Handling Odor Control System design airflow rate			33,000
Side stream pretreatment and EQ tank	1,283	12	260
Ammonia treatment reactors			1,000
Total air conveyed to existing Headworks Odor Control System			1,260 [a]

a. The side stream pretreatment, EQ tank, and ammonia treatment reactors are close to the existing headworks odor control system and distant from the solids handling area; therefore, 1,260 cfm of air is proposed to be added to the existing odor control system at the headworks.

The estimated H_2S and odor DT emissions for the solids handling processes being ventilated to odor control in the new Post Point facility are listed in Table 6-33. For the existing solids handling processes, odor data was used when available. Where new solids handling processes are being installed, data from similar facilities in the literature were used.

Table 6-33. Proposed Solids Handling Design Odor Loads			
Location	Airflow Rate (cfm)	H_2S Concentration (ppmv)	Odor (D/T)
Solids blend tanks	600	100 [a]	38,000 [b]
530 Building (thickening, dewatering, cake management)	9,000	1 [c]	2,000 [b]
Solids screening building	13,800	1 [c]	4,000 [b]
Cake storage and truck loadout	9,000	0.5 [c]	3,900 [b]
Centrifuge discharge cake chute and conveyor	600	10	34,000 [d]
Total odor loading (flow-based composite of all sources)	33,000	2.8	4,600

a. Based on similar blend tanks in other projects where primary sludge and WAS are mixed.

b. Source: McGinley, 2008.

c. Because this air stream is extracted from an inhabited room, H_2S concentrations need to regularly be in the range of 0 to 2 ppmv for safety. This will be transferred to the odor control system.

d. McGinley (2008) BFP category used and multiplied by 10 to account for higher odor emissions using centrifuges.

6.11.3 Odor Control Alternatives

Potential odor control technologies for the new solids handling area odor control system were evaluated and several options were initially eliminated for reasons discussed in TM 13—Odor Control Evaluation (Appendix I). The three technologies evaluated for further consideration are biofiltration, bioscrubbers, and dry media (carbon) adsorption.

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Biofiltration uses naturally occurring microorganisms that grow on organic or engineered media to oxidize odorous compounds to carbon dioxide, waster, biomass, and other benign by-products like chloride and sulfate. Moisture levels must be controlled in the biofilter media and in the foul air, and pH levels are often self-regulating, but the reaction products from H_2S treatment include sulfuric acid, which acidifies drain water. Thus, biofilter designs must include corrosion protection for concrete components and other downstream facilities.

Bioscrubbers are similar to chemical scrubbers in that they typically use artificial media and closed-vessel construction in a tower shape, with treated air exiting at the top of the vessel through a stack. The bioscrubbing process involves intermittent spraying or recirculating biologically active, nutrient-rich scrubbing solutions over a media bed while odorous air is forced upward through the media. Bioscrubbers are designed almost exclusively for the removal of inorganic compounds, particularly H_2S. Bioscrubbers are a sustainable, proven technology in many wastewater treatment odor control applications, although O&M requirements and costs can be significant because they require continuous nutrient-rich water feed and recirculation and pH monitoring.

With dry media (carbon) adsorption, air is forced through an activated carbon bed and odorous compounds are transferred from air to the surface of the carbon, which has a complex pore structure with a very large surface area. When the compound and the carbon come into contact, there is a physical attraction which results in bonding (adsorption). Compounds in the air stream will continue to adsorb onto the surface of the carbon until all the pore space in the carbon is used up, at which point odors will breakthrough and the carbon must be replaced or regenerated. These systems are relatively easy to operate and maintain, but the cost of replacement carbon can make other treatment options more cost-effective. There are many types of carbon and other dry media available depending on the compounds to be removed. Extruded coal-based carbon (ECC) provides a low pressure drop compared to granular activated carbon and can be specifically manufactured to have a high capacity for removing H_2S. For this analysis, carbon with a high adsorption capacity for H_2S is referred to as high-capacity (HC) carbon.

From these technologies, four odor control alternatives were developed:

- Alternative 1 – Centralized biofilter
- Alternative 2 – Centralized two-stage system (bioscrubber/carbon adsorber)
- Alternative 3 – Split treatment: Two-stage system (bioscrubber/carbon adsorber) for solids blend tanks and GBTs); Dry media adsorber for screening building, truck bay, and centrifuges.
- Alternative 4 – Centralized, single-stage, dual-layer dry media adsorbers

Initial alternatives screening eliminated Alternative 1 due to limited site footprint and Alternative 2 due to space availability and lack of cost-effectiveness.

Alternative 3 (spit treatment) employs the strategy of treating only the 9,600 cfm air stream from the sludge blend tanks and Building 530 (GBTs) through a two-stage odor control system, leaving the remaining, higher airflow and lower odor air stream to be treated only by a single-stage carbon adsorber. Following treatment in the bioscrubber, the 9,600-cfm air stream combines with the other source air streams and then it is divided up into three 11,000-cfm capacity carbon adsorbers.

Alternative 4 was developed to evaluate whether a single stage odor control system could be sufficient for treatment if two types of dry media were in the same single-stage adsorber. This would extend the dry media life, thus lowering annual O&M costs associated with media replacement. Two dry media combinations were evaluated: (A) an ECC layer followed by a layer of potassium permanganate impregnated dry media and (B) a HC carbon media layer followed by a layer of potassium permanganate impregnated dry media.

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6.11.4 Capital and O&M Costs and Comparison of Odor Control Alternatives

Capital and operating cost estimates were prepared for proposed Odor Control Alternatives 3 and 4. Additionally, Alternative 4 was divided into Alternative 4A and 4B to distinguish between the two dual-layer media combinations. For Alternative 4A, the first dry media layer is 20 inches depth of ECC. For Alternative 4B, the first dry media layer is 20 inches depth of HC carbon. The second layer for both 4A and 4B is 10 inches depth of potassium permanganate impregnated dry media.

Table 6-34 provides design criteria comparisons of the three alternatives, including estimated media life, annual media replacement costs, and advantages/disadvantages of each.

Table 6-34. Odor Control Alternatives Design and Cost Comparison

Criterion	Alternative 3 (Split Treatment)	Alternative 4A (Single-Stage Dry Media Adsorbers)	Alternative 4B (Single-Stage Dry Media Adsorbers)
Odor control processes	Solids blend tanks and Building 530: 2-stage treatment (bioscrubber/activated carbon) Solids screening building, truck bay, and centrifuges: single-stage activated carbon adsorbers	Centralized single-stage dual-layer dry media adsorbers (ECC and potassium permanganate impregnated media layers)	Centralized single-stage dual-layer dry media adsorbers (HC carbon and potassium permanganate impregnated media layers)
Media life	5.0 years	1.3 years	4.4 years
Annual media replacement cost	$60,000	$229,000	$80,000
Advantages	• Bioscrubbers are an efficient and cost-effective technology for removal of H_2S. • Lower annual media replacement costs than using the same activated carbon without the upstream bioscrubber. • Effective for peak odor loadings • Activated carbon adsorption is effective as a second stage	• Smaller space requirement • Odor control systems located in one area • Dry media adsorption provides a broad range of odorous compound capture • Only one type of odor control unit for the solids handling facilities	• HC carbon has a longer life than ECC due to its higher H_2S adsorption capacity • Smaller space requirement • Odor control systems located in one area • Only one type of odor control unit for the solids handling facilities
Disadvantages	• The 12-ft diameter bioscrubber takes up more space than single-stage dry media only • Flushing water is required but plant reuse water is preferred	• Additional labor and cost required to replace dry media yearly due to higher H_2S loading without the upstream bioscrubber	• HC carbon can convert methyl mercaptan to DMDS, which may reduce odor removal efficiency

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Table 6-34. Odor Control Alternatives Design and Cost Comparison			
Criterion	Alternative 3 (Split Treatment)	Alternative 4A (Single-Stage Dry Media Adsorbers)	Alternative 4B (Single-Stage Dry Media Adsorbers)
Expected performance	• 95% H_2S reduction through the first stage bioscrubber treating the combined solids blend tanks and Building 530 (GBTs) foul airflow of 9,600 cfm. • 75% odor (as measured in D/T) reduction through the first stage bioscrubber treating the combined solids blend tanks and Building 530 (GBTs) foul airflow of 9,600 cfm. • 99% H_2S reduction through all three carbon adsorbers. • 90% odor (as measured in D/T) reduction through all three carbon adsorbers	• 99% H_2S reduction through all three dry media adsorbers • 90% odor reduction through all three dry media adsorbers	• 99% H_2S reduction through all three dry media adsorbers • 90% odor reduction through all three dry media adsorbers
Footprint	Estimated 600 to 800 ft^2	Estimated 400 to 600 ft^2	Estimated 400 to 600 ft^2

Table 6-35 provides a capital and O&M cost comparison and the 20-Year NPV for the three alternatives.

Table 6-35. Alternatives 3 and 4 Capital and Rating Cost Comparison			
Capital Costs	Alternative 3	Alternative 4A	Alternative 4B
	3-Stage System Bioscrubber ECC/PPI	2-Stage System ECC/PPI	2-Stage System HC/PPI
Total Capital Costs	$2,470,000	$1,740,000	$1,780,000
Total O&M Costs	$113,000	$187,000	$120,000
O&M 20-yr Present Worth	$2,146.000	$3,551,00	$2,279,000
Total 20-yr Present Worth	$4,616,000	$5,291,000	$4,059,000

a. Equipment costs obtained from ECS email proposal dated August 26, 2021.

b. Assumed cost for labor and equipment to replace media in the carbon adsorber is $30,000 per replacement.

c. Assumed 8 hrs/wk at $40/hr for Alternative 3 and 6 hrs/wk for Alternative 4.

6.11.5Summary and Recommendations

Atmospheric dispersion modeling was used to assess odor emission impacts in the community, before and after completion of the Project, with proposed odor mitigation measures. Refer to TM 13—Odor Control Evaluation (Appendix I) for description of the modeling and results. Preliminary results indicate that odor emissions will be reduced, and any off-site impacts can be improved with this “high level” planning effort for odor control of all new sources incorporated into the Biosolids Facility Plan.

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Of the odor control alternatives developed and evaluated, Alternatives 3, 4A, and 4B are all viable alternatives with specific advantages and disadvantages. Alternative 4A has the highest 20-year NPV by about $1.2 million because virgin carbon media has a low saturation rate for H_2S, and therefore would require frequent replacement. The bioscrubber in Alternative 3 reduces this H_2S loading, such that this option is still a reasonable long-term solution. However, due to cost and other considerations, Alternative 4A is not carried forward in this analysis.

Compared to Alternative 4B, Alternative 3 has an additional treatment step with a bioscrubber treating the highest levels of H_2S from select processes, thereby extending the longevity of the carbon in the polishing stage. The pretreatment of H_2S in a bioscrubber allows the carbon in the polishing stage to be virgin or extruded coal-based, which is a lower unit cost than high-capacity carbon required in Alternative 4B. Based on our analysis, pretreating with a bioscrubber would reduce the total Odor Emission Rate by about 20 percent because the odor in the exhaust from the carbon adsorber would be 366 versus 460 D/T with carbon treatment only. Bioscrubbers are highly effective, proven technologies, and this approach of pretreating the highest sources of H_2S and odors in a targeted fashion matches the best technology with the level of odor treatment required for this project. This provides a layer of protection and redundancy to the treatment of odors.

The estimated 20-year NPV for Alternatives 3 and 4B are very close, with most of the cost difference coming from the higher initial capital costs for Alternative 3. As shown in the modeling, there is no significant difference in off-site odors between Alternative 3 and 4B. Thus, the bottom line over-all community impacts are about equal between the two options. Finding space in the Solids Building would apparently be difficult and is the only major drawback of this approach.

Therefore, in consideration of all the above factors, Alternative 3 is the recommended Odor Control Facility Plan if space can be found to locate the bioscrubbers.

6.11.5.1 Summary of Proposed Facility Plan for Odor Control

It is recommended that air from the Blending Tank and the Gravity Thickener Room be combined and treated in a preliminary treatment bioscrubber. The composite loading to the bioscrubber from these sources would be 9,600 cfm with an average inlet H_2S concentration of 7.2 ppmv and an odor of 4,250 D/T. The remaining odor sources would be treated in single-stage carbon adsorbers and combined with the outlet air from the bioscrubber, for a total of 33,000 cfm of air treatment.

The preliminary sizing of vessels for this recommended approach would be one 12-ft-diameter bioscrubber and three 10-ft diameter carbon adsorbers. Effluent water should be considered as supply water for the bioscrubber because of the nutrients available in this water. Blowdown water from the bioscrubber will be low pH so handling this water in corrosion resistant pipes is important but the low pH water would have no impact on the plant influent wastewater.

Following are the Alternative 3 design H_2S and odor removal efficiencies that were assumed:

- 95 percent H_2S reduction through the first stage bioscrubber treating the combined solids blend tanks and Building 530 (GBTs) foul airflow of 9,600 cfm.
- 75 percent odor reduction through the first stage bioscrubber treating the combined solids blend tanks and Building 530 (GBTs) foul airflow of 9,600 cfm.
- 99 percent H_2S reduction through all three carbon adsorbers.
- 90 percent odor reduction through all three carbon adsorbers.

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Three radial flow carbon adsorbers, each with 20-inches of high-capacity carbon and 10-inches potassium permanganate impregnated media, are the recommended Odor Control polishing technology, with a total capacity to treat 33,000 cfm of air from all the biosolids sources. The adsorber vessels would be sized to treat 11,000 cfm each during normal operation but are capable of treating 16,500 cfm each if one of them has to be taken out of service for carbon changeout or other repairs. The adsorbers are 10 feet in diameter and about 16 feet high. Because of expected low hydrogen sulfide loading to the three carbon units, the media inside the adsorbers can be virgin or extruded coal-based carbon. A mist eliminator/grease filter would be placed upstream of each vessel. Additional redundancy is recommended by providing a 33,000 cfm duty and standby fan. This would help assure continued operation if one of the fans fails or has to be taken out of service. The layout of the fan/carbon adsorber systems could be as shown on Figure 6-13, with two redundant fans, and three mist eliminators and three carbon adsorbers. The bioscrubber would likely be located elsewhere. The carbon adsorber outlet should be less than 400 D/T and less than 2 ppb H_2S. Figure 6-13 below shows a flow diagram of Alternative 3.

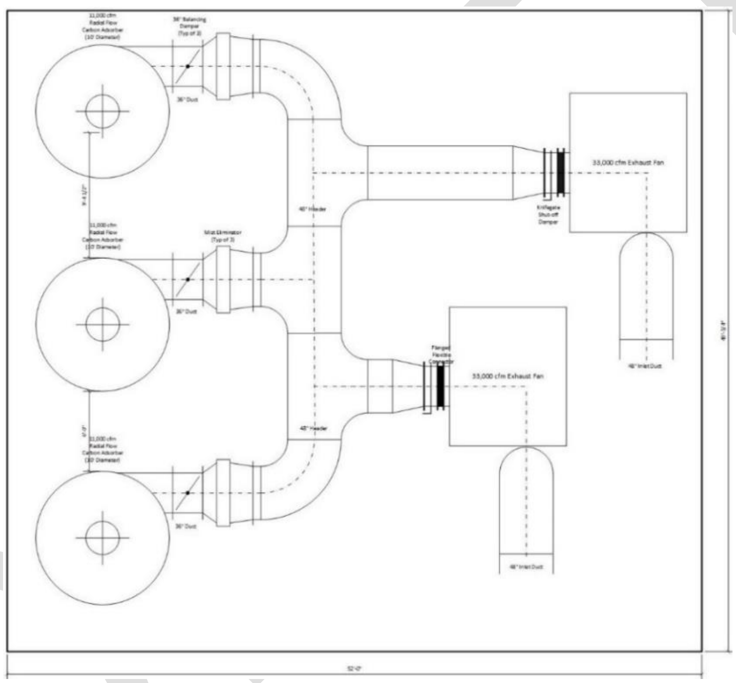

Figure 6-12. Proposed Alternative 3 Layout

The odor emissions from this scenario were modeled in comparison to baseline conditions for peak odor levels and frequency of occurrence. There is an improvement in peak odor levels as the contours are brought closer to the plant as a result of eliminating the incinerator complex and treating all the sources in the recommended odor control system for the new Biosolids Facility. In addition, and significantly, the frequency at which low levels of odor are detected in the community is reduced more than two-fold. The recommended odor control system meets the goals for the Project.

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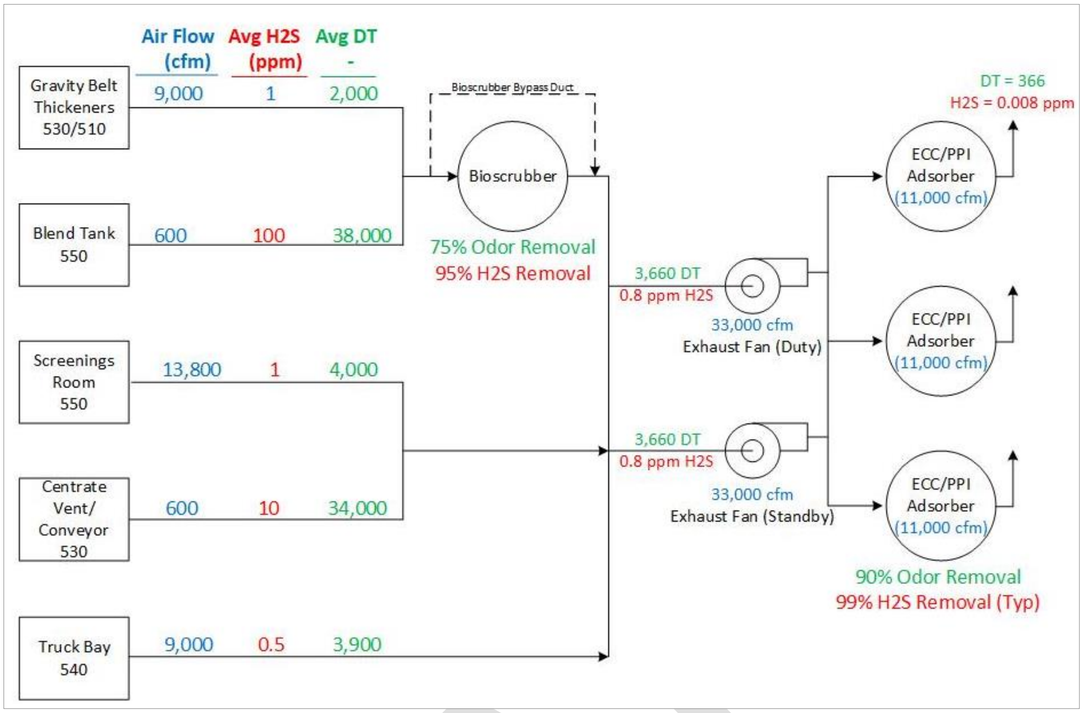

Figure 6-13. Flow Diagram of Alternative 3 with Bioscrubber and Carbon Adsorbers

6.12 Noise Control

This section presents recommended design criteria and noise mitigation measures to minimize impacts form sound produced by the new equipment and operations proposed at Post Point. Refer to TM 14—Noise Control (Appendix J) for more detailed information such as regulatory criteria, existing sound levels, noise modeling analysis and results.

6.12.1Summary and Recommendations

Washington Administrative Code (WAC) regulates noise and quantifies maximum permissible environmental sound levels at Post Point and surrounding properties. A daytime and nighttime sound limit of 50 dBA is recommended as the Post Point design criterion at residential land use properties during future operating conditions, which is more stringent than WAC requirements. This recommendation is designed to minimize noise complaints based on current noise conditions being below WAC limits. These recommended design criteria are anticipated to be achievable based on preliminary noise modeling efforts. However, to reduce sound emissions from the future equipment to within the design criteria, silencers will likely be needed on the future odor control fans. Additional mitigation may be identified as the design progresses.

Noise from construction of the new facilities is exempt from codified sound limits under WAC 173-60-050 3.A. However, the Post Point Great Blue Heron colony is in a forested area southwest of the Project and is subject to Department of Fish and Wildlife (WDFW) regulations. Sound levels at the Post Point Blue Heron colony were predicted to determine whether sounds produced during construction and operation of the completed facility will be within the Washington WDFW regulations. Operation noise is predicted to comply with WDFW regulations. Pile driving will likely be necessary during construction and is anticipated to be the loudest construction activity.

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To determine the potential sound levels produced during this activity, an impact-type pile driver was positioned (in the model) at a location nearest to the heron rookery where pile driving would occur. Although the predicted sound levels were below WDFW criteria in the model results, construction noise should be reevaluated as the design progresses and construction methods are further defined to ensure WDFW limits are met.

6.13 Struvite Mitigation and Recovery

Struvite is a common precipitate at wastewater treatment facilities. The likelihood of nuisance struvite formation at Post Point will increase after the biosolids upgrade because nutrient concentrations in the thickening and dewatering return streams will also increase. However, the severity of nuisance struvite formation varies by facility, and it is difficult to accurately predict the location or quantity of struvite formation at Post Point. Struvite formation is a complicated process affected by the concentrations of key constituents (magnesium, ammonia, phosphorus), equipment geometry, temperature, pH, and the activity of other ions in solution. Therefore, struvite mitigation planning is often based on empirical observations of struvite formation in the field.

Struvite impacts on maintenance vary depending on the location and severity of formation. Struvite can be particularly problematic when it forms within piping, rotating equipment, or other critical plant processes. Struvite commonly forms on the inside of heat exchangers that cool digested solids from thermophilic to mesophilic temperatures, such as those planned for the TPAD process at Post Point. In contrast, struvite can also be a beneficial precipitate if it is formed within the digester and remains in the biosolids. When retained in the biosolids, struvite can be a valuable fertilizer that increases the nutrient content of the biosolids product, a benefit to the resource recovery process.

It is impossible to accurately predict the severity of struvite formation at Post Point after Project. Biological and chemical wastewater treatment models have not been shown to be effective at accurately predicting the fate and behavior of metals like magnesium. Dedicated struvite precipitation models are available, but require field measurements of nutrient concentrations, which won’t be available until after the digesters are installed. Even if struvite formation potential could be accurately predicted, discerning between nuisance struvite formation and formation in the biosolids would likely not be possible.

This section summarizes struvite formation, management, and recovery at Post Point as discussed in TM 15—Struvite Management Alternatives (Appendix K).

6.13.1 Struvite Management Alternatives

Section 4 of TM 15—Struvite Management Alternatives (Appendix K) describes in detail the different struvite management alternatives for Post Point. This includes preventative design measures, reactive maintenance, chemical management, and controlled precipitation (including Ostara Pearl® and Centrisys MagPrex™ processes).

Table 6-36 summarizes struvite control mechanisms with their description, relative cost, and recommendation.

Table 6-36. Comparison of Struvite Control Mechanisms			
Technology	Description	Relative Cost	Recommendation
Preventative Design	Design piping and other equipment to minimize nuisance struvite formation	$	Include in biosolids upgrade project
Reactive Maintenance	Remove nuisance struvite from affected piping and equipment after it has formed	$-$$$, depending on severity	Perform reactive maintenance until the impacts of struvite formation can be characterized
Chemical Management	Manipulate chemical characteristics of process fluid to minimize struvite formation	$-$$$	Include chemical management techniques in biosolids upgrade project
Controlled Precipitation	Dedicated struvite precipitation reactor	$$$	Consider use if nuisance struvite formation is substantial

6.13.2 Summary and Recommendations

Struvite formation potential at Post Point after the Project is unknown at this time. Therefore, it is prudent to establish a struvite management plan that can match the severity of nuisance struvite observed at the facility. Preventative engineering measures will be incorporated into all stages of the biosolids upgrade design, including the following items:

- Redundant raw solids pipelines from the solids handling building to the digesters.
- Redundant digested solids pipelines from the digesters to the dewatering equipment.
- Cleanouts and long-radius elbows on all new solids and return liquid piping.
- Glass-lined or epoxy-lined filtrate and centrate pipe.

Additionally, tanks will be included in the digester facility for chemical management options via iron salts, alum, or other chemicals. Other TPAD systems in North America have experienced substantial nuisance struvite formation and have managed with iron salt addition and periodic heat exchanger cleaning, thus a chemical management option will be provided.

After the Project, nuisance struvite formation can be handled by a combination of chemical management and, if needed, reactive maintenance such as manual or chemical removal. After the costs and non-economic impacts of those management methods have been accurately characterized, controlled precipitation could be considered.

A preliminary sizing analysis shows that both an Ostara Pearl FX system and a Centrisys MagPrex system will fit within the existing 520 Building. The MagPrex reactor can be provided as a single tank if the building is modified and access to the top of the MagPrex reactor tank is provided via the roof. Two MagPrex tanks would fit within the existing building, albeit at a higher cost and larger equipment footprint.

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Section 7

Biosolids and Biogas End-Use

Section 7 summarizes the Project Team's evaluations for biosolids and biogas end-uses, including a discussion of biosolids production quantities, product marketing, considerations for future transition, backup land application, and landfill plans as well as the biomethane sale evaluation.

Given recent concern about emerging contaminants, the end-use of the biosolids from Post Point has not been selected by the City. The City will be performing a public education and selection process of the biosolids end-use and any off-site processing in the coming years. End-use of the biosolids in this section focuses on land application. As indicated herein, alternative end-uses to be further studied prior to the selection of the biosolids' end-use.

7.1 Biosolids End-Use

Beneficial use of biosolids is the predominant biosolids end-use approach in Washington with over 80 percent of biosolids sent for agricultural land application. The City would like to recover biosolids as a local resource that can benefit the community as part of their Legacies and Strategic Commitments and based on feedback from community workshops. The Class A biosolids produced from the proposed TPAD process would not have any restrictions on its use or application. However, the form of these biosolids (referred to as a dewatered "cake") is more conducive to large-scale agricultural land application than for residential applications.

Further processing of biosolids into amended products such as soil blends and composts can create a more consumer-friendly product that has fewer odors and is easier to handle, making them similar to the soil amendments found in retail stores and nurseries. Amended products are typically mixed with organic and inorganic material to improve soil characteristics such as soil texture, permeability, porosity, drainage, water retention, nutrient balance, carbon-to-nitrogen ratio, appearance, and electric conductivity. These changes typically allow amended products to be more versatile in applications from gardens to lawn care.

Due to the space limitation at Post Point, this type of additional processing step would need to be accomplished at an off-site location where Class A dewatered biosolids would be blended or processed with organic and inorganic amendments. This off-site processing step could be accomplished by the addition of City-owned facilities, or by establishing service agreements with private entities (or a combination). This effort, known as the Off-Site Facilities Delivery Evaluation, will use an open procurement process to allow the vendor community to propose options for further processing of biosolids from Post Point.

The City may also consider alternative disposition options as a contingency plan related to recent local concerns about emerging contaminants. The disposition options will explore innovative and embryonic technologies to treat and process biosolids to potentially reduce or eliminate the presence of emerging contaminants. These technologies would be downstream of the digestion process at an off-site location.

7.1.1 Biosolids Products and Quality

The City will have the potential opportunity to generate a diverse number of biosolids products for both suburban (i.e., landscaping) use and rural/agricultural use.

The City can use biosolids products for various needs including municipal applications in landscaping, parks and recreation, civil and site work, athletic fields, land rehabilitation, and revegetation/reforestation as well as for public distribution. The different biosolids products can serve different needs for the City. However, the use of an amended product will require further processing, which will likely result in increased cost to the biosolids management program. The City can benefit from identifying uses for the Class A dewatered cake which would reduce the amount of material that needs to be further processed and/or generate revenues capable of partially offsetting processing costs. Defining the quantities and quality of biosolids products available to different end use markets, including Class A dewatered cake, compost, and soil blend products, will require coordination with the different City departments including the City Parks and Public Works

7.1.1.1 Class A Dewatered Cake

The average annual production of Class A biosolids that will be generated from the TPAD process and subsequently dewatered to 20 percent total solids (TS) are estimated to be 33 wet tons (WT) per day in 2025 and 55 WT per day in 2045, summarized in Table 7-1. The 20 percent TS represents a conservatively low value resulting in more biosolids produced and trucks than may ultimately be generated. It is anticipated that dewatering performance may be closer to 25 percent TS which would reduce biosolids produced by 20 percent.

Table 7-1. Biosolids Product Production

Parameter	Flows and Loads 2025		Flows and Loads 2045, Digestion with Tertiary Nitrogen Treatment						
	Min Week	Average Annual/wk	Min Week	Average Annual/wk	Max 30-Day	Max 14-Day	Max 7-Day	Max 3-Day	Max Day
Biosolids Production									
Dewatered Cake, (lb-TS/day)	9,951	12,982	15,613	22,229	28,775	32,255	36,068	44,593	61,478
Solids Concentration, (%)	20%	20%	20%	20%	20%	20%	20%	20%	20%
Dewatered Cake, (wet lb-TS/day)	49,753	64,908	78,063	111,144	143,876	161,276	180,338	222,967	307,390
Dewatered Cake, (WT-TS/day)	25	33	39	56	72	81	90	111	154
Bulk Density, (lb/cf)	59.3								
Dewatered Cake, (cf/day)	840	1,095	1,317	1,876	2,428	2,722	3,043	3,763	5,187
Dewatered Cake, (cy/day)	31	41	49	69	90	101	113	139	192
Hauling and Transportation									
Truck Option 1 Capacity, (WT/truck)	16								
Number of Trucks	1.6	2.0	2.4	3.5	4.5	5.0	5.6	7.0	9.6
Truck Option 2 Capacity, (WT/truck)	28								
Number of Trucks	0.9	1.2	1.4	2.0	2.6	2.9	3.2	4.0	5.5

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7.1.1.2 Class A Dewatered Cake Quality

Heavy metals data from Post Point's existing dewatered cake from May 1, 2017, to April 3, 2018, indicate that the pollutants regulated under Title 40, Code of Federal Regulations Part 503 (Part 503) are well below the most stringent requirements contained within that regulation and that the biosolids would likely meet the Exceptional Quality (EQ) standards. Because digestion reduces volatile solids, the concentrations presented in Table 7-2 would be expected to slightly increase once digestion is implemented, however, still meet EQ standards. The addition of organic and inorganic amendments has the potential to decrease concentrations. Routine monitoring of these heavy metals will be integrated into the City's biosolids program following startup and commissioning.

Table 7-2 summarizes the regulations and average pollutant concentrations from Post Point's existing dewatered cake. Note that not all the monitored pollutants are subject to Part 503, but certain end users may have unique interests or concerns regarding these heavy metals.

Table 7-2. Post Point Existing Biosolids Pollutant Concentrations

Pollutant	Column 1[b] Ceiling Concentration Limits (mg/kg, dry weight)	Column 2 Cumulative Pollutant Loading Rate (kg/ha, dry weight)	Column 3[c] Limit Monthly Average (mg/kg, dry weight)	Post Point Average Solids Sample Test (5/1/17 - 4/3/18) (mg/kg, dry weight)
Arsenic	75	41	41	**1.0**
Cadmium	85	39	39	**1.2**
Chromium [a]	-	-	-	**16.0**
Copper	4,300	1,500	1,500	**158**
Cyanide [a]	-	-	-	**8.3**
Lead	840	300	300	**11.0**
Mercury	57	17	17	**0.2**
Molybdenum	75	-	-	**1.4**
Nickel	420	420	420	**8.6**
Selenium	100	100	100	**3.7**
Silver [a]	-	-	-	**1.5**
Zinc	7,500	2,800	2,800	**278**

a. Pollutant not subject to 503 regulation

b. Class B Pollutant requirement

c. Exceptional Quality pollutant requirement

kg/ha = kilograms per hectare

mg/kg = milligrams per kilogram

7.1.1.3 Nutrients Profile

The nutrient content of the future dewatered cake will be an important property that will help to determine its value as a soil amendment and fertilizer but is difficult to project at this time. The nutrient content will also impact the requirements for final processing. Depending on the desired product characteristics, the soil blending could change feedstock quantities needed for composting or soil blending. Estimations of the nutrient content of the biosolids were derived from the BioWin process model and will be verified through testing following startup and commissioning.

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Table 7-3 summarizes the estimated nutrient content for the Class A dewatered cake. These estimated nutrient values will be verified once the new biosolids management train is operational.

Table 7-3. Class A Dewatered Cake Estimated Nutrients Profile		
Parameter	Flows and Loads 2025	Flows and Loads 2045, Digestion with Tertiary Nitrogen Treatment
	Average Annual	Average Annual
Class A Dewatered Cake		
Total Organic Carbon Content, (%)[1]	33%	33%
Total Nitrogen Content, (%)	3.4%	3.2%
Carbon:Nitrogen Ratio	9.7	10.3
Total Phosphorus Content, (%)	3.9%	3.4%
Potassium [2]	-	-

Notes:

1. *Total organic carbon content was assumed to be 50 percent of the volatile solids.*
2. *Potassium has not been sampled.*

7.1.2 Final Processing

A consumer biosolids product will require further processing to improve marketability. The two processes that have been considered at this time are composting and soil blending. Detailed information on biosolids composting and soil blending quantities can be found in TM 18—Product Quantity Projections (Appendix M).

7.1.2.1 Biosolids Composting

Class A dewatered cake can be composted with organic waste or other feedstocks to create soil amendments with greater ranges of use than dewatered biosolids alone. Composting biosolids can further reduce odors, decrease particle size, increase the bioavailability of micro- and macronutrients, and improve soil characteristics. Compost is widely used for applications such as gardening and landscaping where it can improve soil aeration and drainage in areas where the soil is compacted and limit the growth of weeds. Compost as a potting mix can replace potting soil. Some feedstocks that can be composted with biosolids include sawdust, wood chips, yard clippings, food waste, manure or crop residues, or food processing wastes. While these materials have traditionally been viewed as waste, they can play a valuable role in returning carbon to the soil while restoring soil health in the local community. Composted biosolids products can not only provide nutrients and organic matter but sequester carbon, thereby conserving resources and combating climate change. Compost products were estimated to be 31,000 WT per year (85 WT per day) or 68,800 cubic yards (CY) per year (188 CY per day) in 2045 if all biosolids were composted.

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7.1.2.2 Soil Blending

While Class B biosolids may be composted to produce a Class A material with certain technologies, producing manufactured soils is a specialized class of biosolids product development. Manufactured soils require processing Class A biosolids cake with clean or sterilized amendments to generate a stable end product. Class A biosolids are blended with organic or inorganic amendments to adjust the characteristics for a product that can be publicly distributed in bag or bulk form. Soil blending is different than composting because there is no active processing of the material that allows for a high-rate stabilization or maturation of the product. Manufactured soils can be custom-tailored to meet certain applications such as gardening, landscaping, agriculture, golf, or turf. For example, the City of Tacoma produces a range of products under their TAGRO brand which includes potting soil, green roof blend, and classic topsoil blend. Soil blend products were estimated to be 40,100 WT per year (110 WT per day) or 61,700 CY per year (169 CY per day) in 2045 if all biosolids were soil blended.

7.1.3 Biosolids Product Marketing

As part of this project, a survey was developed to collect information on the existing market for soil amendments and the different entities that generate, market, and sell them. The intent was to determine the demand for soil amendments, the level of interest for biosolids, and to determine the feasibility and timeline for services. Additionally, the survey was used to investigate the degree of interest from private entities in partnering with the City for off-site final processing, marketing, and distribution of the final biosolids product. This information will help inform next steps in strategies and procurement of land, facilities, or service agreements.

Nineteen soil generators, municipalities, and other entities were identified through general web searches, contacts, and from the previous study. Each entity was interviewed by phone or via email. The survey captured details on current available capacity, interest, and plans for developing additional future capacity. Additional questions on the number of sites and/or facilities, capacity of each site, expansion plans, biosolids experience, and contractual agreements. The results are summarized in TM 7—Product Production and Marketing Contractor Assessment (Appendix N).

7.1.3.1 Biosolids Product Market

The surrounding northwestern Washington region beneficially uses both Class A or Class B biosolids in large-scale agriculture and residential applications. The biosolids are mainly produced and processed by municipalities and are available directly to the public (Class A) or are contracted for land application (Class B/Class A).

The pacific northwest region is home to dozens of soil blenders, composters, and organic materials companies. These service providers are largely multidimensional and provide several different functions including operations, processing, marketing, suppliers, and end-users of soil amendments. Many of these service providers currently do not process biosolids or have little experience processing biosolids. However, the survey indicated that there is significant interest to partner with the City from local, regional, and national private service providers to develop a biosolids program to further expand biosolids reuse in the area. Nine of the ten service providers expressed interest in future conversations about partnerships. Five of the service providers have experience with biosolids, but only three service providers are currently working with biosolids: Barr-Tech (composter), Boulder Park (land application), and Elysian Fields (composting and land application). The other service providers work with organic wastes such as yard, food, agricultural, and wood wastes.

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No existing national biosolids management firms or operators have established composting and soil blending operations in the State of Washington. Several national biosolids management firms and operators provide a wide array of biosolids operation, maintenance, and program services to hundreds of municipalities throughout the United States. These types of organizations have a diverse background of experiences and significant capabilities in types of biosolids projects. They can offer flexible contract structures to fit the needs of each municipality but tend to require longer contracts.

Only some mild interest was expressed from local and regional municipalities and were only interested in participating in a City established and led regional biosolids management program.

7.1.3.2 Biosolids Product Market Conclusions

Private partnerships with existing local and regional soil generators could be advantageous for the City's biosolids program. Tapping into the existing local and regional soil generator markets could provide the City with market experts that could help to successfully implement the program. Using their understanding of the regulatory and product market could allow the City to transition to a local/regional beneficial use program more quickly. Local and regional soil generators conveyed significant interest in advancing the discussion around partnerships at this planning level of evaluation.

The public municipalities in the area expressed some interest in being part of a program that the City develops with a private service provider. This may have some benefits by sharing the initial capital investment and operations cost of such a program. Based on the survey, the likelihood of a direct public partnership with area municipalities to develop a program seemed less probable given the level of interest and urgency for the other municipalities to modify their current operations. Additionally, implementation of a regional biosolids management program requires the consideration of intergovernmental agreements, facility ownership and maintenance, and typically long planning periods.

Partnerships with national biosolids management firms is a possibility that the City could pursue. National private partnerships potentially offer lower risk due to the wider berth of expertise but may elicit higher overall program costs.

Based on these survey results of the area biosolids market and operations and the favorable outlook for establishing a partnership for off-site processing and marketing of a biosolids product, it is recommended to move on to the next phase of study to develop procurement strategies. This effort would develop strategies for determining which alternatives for off-site biosolids processing and marketing would best achieve the City's goals and interests.

7.1.4 Off-Site Facilities and Procurement

The City is exploring contracting with one or more service provider(s) to further process the biosolids into a beneficial product that is appropriate for local use (e.g., compost or soil blend). Due to the space constraints at Post Point, the additional processing will need to be accomplished at an off-site location. As part of the Facility Plan development, an off-site facility evaluation focused on investigating options for procuring services for future biosolids processing and distribution, comparing procurement strategies, and developing an action plan for delivering the Biosolids Beneficial Use Program. The City prefers to have a single Service Provider for the full range of required services, including loading and transportation of biosolids from Post Point to a proposed processing site (or sites), further biosolids processing to Class A quality, marketing of the finished product, and product distribution (preferably within Whatcom County). The assessment process and major conclusions are discussed below.

7.1.4.1 Procurement Process Overview

The City is in the process of conducting a multi-phase procurement effort with the goal of selecting one or more teams to provide the desired services. In October 2021 the City issued Phase 1 of the procurement process, i.e., the Biosolids Beneficial Use Services Request for Proposals (RFP). Phase 1 was intended to enable the City to collect information from Proposers to inform key decisions regarding the scope, allowable technical approaches, and preferred business arrangements for the required services. Based on the results and market interest observed in Phase 1, the City will decide whether there is adequate competition such that a single party could be responsible for the full range or desired services, and whether or not new sites/facilities would probably be necessary to be developed to provide services. The Phase 1 process is anticipated to conclude in Fall 2022.

Should the City elect to continue with the procurement process, Phase 2 will involve the City issuing one or more RFPs for the desired services. The timeframe for issuing the Phase 2 RFP(s) depends on whether or not new facilities and sites will likely need to be developed to provide the required services. Phase 2 would commence following the City's selection of a preferred biosolids end-use.

7.1.5 Transition and Backup Land Application and Landfill Strategy

Prior to implementing the long-term biosolids management plan described previously, a strategy must be developed to cover management of the City's biosolids during startup and commissioning, at a minimum. The transition and backup land application/landfill strategy is intended to provide a temporary disposition solution for City's biosolids during that time and potentially provide a transition period during which a local market for the biosolids will be developed. It is unlikely that the local and regional biosolids market will be available immediately with the startup of the biosolids program and likely will not be able to accept significant amounts of biosolids products. The service provides may need their own transition period in which alternative end-uses are implemented. The strategy will include a backup plan and end-use contract(s) that will provide program contingencies to mitigate the risks resulting from unforeseen circumstances, including seasonal demand fluctuation within the local product market, process upsets at Post Point, and service interruptions.

The potential conditions during commissioning and start-up of the new solids treatment train could include:

- The commissioning and startup of the TPAD process may produce a portion of the biosolids that may not meet WAC 360-180 requirements for beneficial use for land application and would be unclassified solids that will require disposal in a municipal solid waste landfill. Once placed in a landfill, the unclassified solids are considered solid waste. The unclassified solids may be used as daily cover but not intermediate or final cover as those are considered beneficial use applications. The potential to continue to use the existing MHF during the commissioning and startup period is also a possibility.
- The commissioning and start-up of the TPAD system may produce Class A or Class B biosolids that may be land-applied for large-scale agriculture applications in Eastern Washington. The large demand for soil amendments in Eastern Washington to support the large agricultural sector provides a major route for the beneficial use of biosolids. Dozens of utilities in Western Washington already contract to send their biosolids for land application in Eastern Washington.
- The commissioning and start-up of the TPAD system may produce Class B biosolids that may be processed into Class A biosolids by the service provider.
- The commissioning and start-up of the TPAD system may provide Class B or Class A biosolids that may be temporarily incinerated.

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The backup strategy and contract is intended to provide reliable alternative outlets for the City's biosolids in the event that the primary end-use pathways are disrupted. These could include:

- Temporary large-scale agricultural land application of Class A or Class B biosolids in Eastern Washington.
- Temporary landfilling of unclassified, Class A, and Class B biosolids.

7.2 Biomethane Sale Evaluation

During Phase 2, an evaluation of gas utilization strategies was conducted between pipeline injection and co-generation. Although pipeline injection of renewable natural gas (RNG) has a higher risk of end-use market sensitivities it was selected over co-generation as it provided the lower greenhouse gas (GHG) emissions and the higher financial incentives. The conceptual development of the gas upgrading system for the pipeline injection alternative is discussed in Section 6. This section summarizes the registration and ongoing compliance and operational requirements that must be completed in order to generate revenue from the sale of environmental attributes under the programs associated with biomethane pipeline injection. This section also includes a financial feasibility update and describes how revenue is generated from ongoing RNG injection. TM 11—Biomethane Sale Evaluation (Appendix O) provides more details about the analysis.

7.2.1 Federal and State Incentive Programs

Biomethane used as a transportation fuel in the United States is eligible for financial incentives under the Environmental Protection Agency (EPA) Renewable Fuel Standard 2 (RFS). The RFS mandates that fuel refiners and other obligated parties must obtain renewable fuel credits called Renewable Identification Numbers (RINs) to meet a minimum percentage of renewable fuel production. RINs are tradable commodities with monetary value. In addition, biomethane that is used as a transportation fuel in California or Oregon is eligible for financial incentives under the California Air Resources Board's Low Carbon Fuel Standard (LCFS) program or Oregon Department of Environmental Quality's Clean Fuels Program (CFP). Additionally, Washington is developing its own Low Carbon Fuel Standard to target reducing transportation emissions. It is anticipated that HB 1110 will offer a similar market incentive like California and Oregon.

In order to become a registered renewable fuel producer for the pipeline-injected biomethane that will ultimately be produced at Post Point for use as transportation fuel, the City would be responsible for registering for these programs and meet ongoing compliance requirements. Specialty firms can support the City in navigating the low-carbon marketplace through managing compliance, hiring all necessary third parties, and brokering the sale of the fuel and environmental attributes. The City will still need to account for staff time to gather data, prepare contracts, and upload reports.

7.2.2 Energy Utility and Infrastructure Utility Contracts

In addition to regulatory and compliance costs, the City will also incur costs from the natural gas energy utility and infrastructure utility. The natural gas energy utility, Cascade Natural Gas Corporation (CNGC), is contracted to schedule, or balance, and control the flow of biomethane between pipelines and the distribution schedule, compliant with schedules and demands. The infrastructure utility owns the transmission and distribution system along with the natural gas injection equipment.

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The City would also be subject to CNGC's March 2020, Distribution System Transportation Service Schedule No. 663 (Schedule 663) and would need to report estimated gas supply requirements for the upcoming month at least by the 15th of the current month. The City (or a hired third-party) would also be required to report estimated gas requirements daily to CNGC's gas scheduling department at least 32 hours prior to the beginning of each gas day (considered the daily nomination). Additional details can be found online at the following link: Distribution System Transportation Service Schedule No. 663, CNGC

7.2.3 Credit Sales

RIN and LCFS credit sales are performed at the discretion of the City and are typically scheduled based on market pricing and number of credits available. There are numerous methods to structure the bids for credit sales, three of the common approaches include 1) annual or bi-annual request for bids solicitation, 2) 5-year contract with obligated party based on volume-weighted average price, and 3) City hires a broker to market and sell credits.

7.2.4 Basis of Analysis

Anticipated biogas production rates from the new Post Point biomethane system are used to develop revenue from the sale of RINs, LCFS/CFP credits, and RNG and costs for regulatory compliance. Biomethane production estimates for Post Point, as described in Section 6, are based on a combination of solids production estimates, historical plant operating data, typical gas production rates from anaerobic digestion, and typical gas upgrading performance. Average annual biogas production is estimated to increase from 218 standard cubic feet per minute (scfm) in 2026 to 290 scfm in 2045.

The increase in biomethane production is considered in this evaluation and is summarized in Table 7-4.

Table 7-4. Biomethane Basis of Evaluation Criteria

Criterion	Value (Therms/yr)
Biomethane production, higher heating value (HHV), therms/yr[a]	
Year 2026	662,000
Year 2045	899,000

a. *Based on raw biogas containing 60% methane by volume, methane HHV of 1,011 Btu/cf, biogas upgrading system methane capture and equipment uptime of 95% (net methane recovery).*

Given the variability in cost and revenue inputs used to develop the evaluation and the potential impact on financial planning, a sensitivity analysis was performed to establish a range for the net value of biomethane. Average, low, and high scenarios were analyzed to estimate a more probable near-term average benefit and provide worst case and optimistic values for planning.

The analysis assumed all RINs are classified as D3 since the City does not co-digest any high strength organic (food waste, etc.) feedstocks. LCFS values were assessed using a CI score of 35 gCO_2e/MJ against the 2020 standard, combined with a trading value of $198/ton. Table 7-5 presents the RIN and LCFS pricing assumptions used in the evaluation.

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Table 7-5. RIN and LCFS Pricing Assumptions		
Characteristic	D3 RIN Value, per RIN	LCFS Credit Value, per MT CO_2e
Average (current)	$2.25	$198
Low	$1.50	$150
High	$3.00	$220

BC solicited third-party vendor quotes from five companies for LCFS and RFS compliance services to develop a range of potential costs for compliance services and are summarized in Table 7-5.

Table 7-6. Regulatory and Compliance Assumptions		
Parameter	One-time Costs	Annual Costs
LCFS Compliance		
Average	$43K	$30K
Low	$34K	$22K
High	$55K	$45K
RFS Compliance		
Average	$14K	$15K
Low	$8K	$20K
High	$23K	$25K
Optional RFS–QAP		
Average		$40K
Low		$35K
High		$45K
City Effort ($150K annual salary)	$7K	$6K

Table 7-7 summarizes the infrastructure-utility, energy-utility, and broker/offtaker cost assumptions that were used in the evaluation. These costs are based on third party vendor quotes specific to wastewater biomethane facilities without co-digestion. Quotes were solicited in the second half of 2020. Broker and offtaker fees (as a percentage of revenue) for RNG have been on the rise due to low RINs market values and offtakers knowing the producer cannot capitalize on credits without contracting for the vehicle fuel's use.

Table 7-7. Key Cost Assumptions		
Parameter		Cost, $/therm
Balancing-Energy Utility		
Average	$/therm	$0.055
Low	$/therm	$0.030
High	$/therm	$0.080
Natural Gas Injection and Transmission-Infrastructure Utility [a]		
Average	$/therm	$0.27164
Annual basic service charge	$/yr	$7,512

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Table 7-7. Key Cost Assumptions		
Parameter		Cost, $/therm
Broker/Offtaker RINs only		
Average	% of revenue	13
Low		7
High		20
Broker/Offtaker RINs and LCFS		
Average	% of revenue	30
Low		20
High		40

Note: Based on HHV delivered to pipeline.

a. Per CNGC's March 2020 Gas Tariff Schedule 663.

Table 7-8 presents the CNG cost assumptions used in the various sensitivity analyses.

Table 7-8. CNG Assumptions		
Parameter	Unit	Value
Commodity value		
Average		$0.20
Low	$/therm	$0.18
High		$0.32

Note: Based on HHV value delivered to pipeline.

7.2.5 Findings and Recommendations

Throughout the 20-year project life, the average net revenue is assumed to be in the $1.86 to 2.00 per therm range. Depending on the market outlook on the RFS and LCFS program and supply and demand of alternative fuels, the net benefit could range from $0.91 to $3.13 per therm ($0.68M to $2.69M, annually) if the City participates in the RFS only (this is 4 to almost 16 times the average estimated sale value for the NG commodity itself) of biomethane injected into the pipeline.

Key findings and recommendations resulting from the biomethane sale evaluation are as follows:

1. Calculations completed during Phase 2 of the project forecasted biomethane pipeline injection project net revenue at $2/therm. Using average forecasting and the best available information at the time of this analysis, the evaluation (2021) anticipates net revenues at $1.94/therm. Based on this updated evaluation, biomethane sale still provides an economic benefit and is the recommended digester gas use alternative.
2. There are potential financial benefits if the City participates in California's or Oregon's LCFS program and the EPA's RFS program through sale of credits for biomethane as RNG for use as transportation fuel. Based on the market outlook at the time of this evaluation, it is recommended the City plan to use only the RFS to capitalize on the biomethane pipeline injection project due to LCFS market saturation with ultra-low (negative) CI dairy manure fuel.
3. Because the market for RINs and LCFS credits will continue to evolve as the project transitions to startup, including the Washington State HB 1110, the City should continue to monitor RINs and LCFS prices and react based on the current market trends.

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4. If RINs and LCFS credit prices are unfavorable in the future, the City can change the biomethane sale strategy to a fixed price offtake and charge a premium for the renewable natural gas. Pricing for renewable natural gas not used as a transportation fuel can range from $7-19/MMBtu ($0.07 - $1.90 per therm), offering an alternate type of sale.
5. Because net revenues are based on fluctuating markets and incentives prevalent at the time of the analysis, it is recommended that an update of revenue trends be conducted at the early stages of design and prior to contracting with gas off-takers.
6. Unlike cost savings from efficiency upgrades or running a cogeneration engine, capitalizing on the RFS (and LCFS if favorable in the future) will require administrative City effort beyond equipment O&M and will be most effective if the City has a 'champion' to take on the role of managing third-party contracts and compliance. It is critical that the City is engaged with the RFS program for the biomethane pipeline injection program to be successful and generate revenues as forecasted.

7.2.6 Potential Risks and Opportunities

The market for renewable fuels is continuing to evolve and could impact project economics, so it is important for the City to monitor as the project progresses.

- While the LCFS demand market is projected to remain stable for CNG fuel pathways, there are some financial risks for pipeline injection projects. California and Oregon based projects that include onsite CNG vehicle fueling and have a dedicated City fleet or similar long-term contractual arrangement, the financial risks of LCFS participation are much lower. Out of state biomethane generators that intend to contract with a CNG off-taker in California (and Oregon) may face market saturation risks in the next 5 years.
- On February 27, 2021, a low carbon fuel bill, HB 1091, passed the Washington House of Representatives in a 52-46 vote and on April 8 the Washington Senate voted 27-20 in favor of H.B. 1091. The bill would direct the Department of Ecology to adopt rules to implement a Clean Fuel Standard by 2023. The program would be similar to California's LCFS with current goals to limit emissions per unit of fuel to be 10 percent below 2017 levels by 2028, and 20 percent below 2017 levels by 2035. The amended legislation was passed by the House and on May 17, 2021, the bill was signed but portions of the bill were vetoed by Governor Inslee. Lawsuits challenging the governor's selective vetoes are planned. BC will continue to track the status of this legislation related to Washington adopting a Clean Fuel Standard that could incentivize biomethane production and aligns with the state's sustainability goals.
- According to the Bellingham 2018 Climate Protection Action Plan, Sanitary Service Company (SSC) is upgrading their diesel trucks to CNG engines. Additionally, Amazon and other delivery services are increasing the size of their CNG vehicle fleet to reduce the carbon footprint of their businesses. The City should explore partnerships with companies like Amazon and SSC operating CNG fleets in the state as the biomethane project begins construction Fueling local trucks with the biomethane produced locally are typically viewed favorably by the public.
- If a nearby CNG fleet becomes available, onsite vehicle fueling is an option that could eliminate the administrative effort and fuel injection, transmission, and balancing costs. An onsite vehicle fueling station would include storage, high pressure compressors, and fuel dispensers.
- The voluntary market offers opportunities for renewable natural gas, with quoted prices as of March 2021 between $7 and $19 per MMBtu for a long-term contract. Biomethane demand in the voluntary space is increasing as large corporations have committed to environmental sustainability and decreasing their carbon footprint.

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- CNGC has expressed willingness to participate in the City's biomethane sale program by acting as the utility responsible for transporting the biomethane to the point of offtake. In that scenario, CNGC would operate the interconnect facility and charge for O&M of that facility as well as gas transport. An alternative to that approach would be for CNGC to purchase the compressed biomethane outright, as well as its environmental attributes.

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Section 8

Liquid Stream and Effluent Impact Update

This section of the Biosolids Facility Planning Report describes the City's biosolids and biogas upgrades implementation in the context of the anticipated Project impacts against the effluent discharge characteristics and antidegradation metrics to confirm existing and designated uses at Bellingham Bay are maintained and protected. This section summarizes TM 19—Effluent Impact Assessment (Appendix P).

8.1 Regulatory Requirements

Federal regulations (40 CFR 131.12) and Washington state surface water standards protect water quality and preserve designated beneficial uses of Washington's surface waters. Criteria are established for all marine waters under Washington Administrative Code (WAC) 173-201A-210 and regulated by the Washington Department of Ecology (Ecology). In addition, the antidegradation policy for surface waters is established under three Tiers as described in WAC 173-201A-300 through -330.

On November 19, 2021, EPA issued a letter specifically disapproving WAC 173-201A-210(1)(c)(i): allowable human contribution to natural conditions provisions for aquatic life temperature for marine water and WAC 173-201A-210(1)(d)(i): allowable human contribution to natural conditions provisions for aquatic life dissolved oxygen for marine water. The current WAC language remains while Ecology is developing alternative criteria and therefore remains the basis for this evaluation.

Tier I ensures existing and designated uses are maintained and protected. Tier II ensures that waters of a higher quality than the criteria assigned are not degraded unless such lowering of water quality is necessary and in the overriding public interest for polluting activities such as wastewater treatment plant discharges. Tier III prevents the degradation of waters formally listed as "outstanding resource waters".

Ecology requires preparation of a Tier II analysis for wastewater discharges regulated under the National Pollution Discharge Elimination System (NPDES) permit when all three of the following conditions are met:

- The facility is planning a new or expanded action. This includes a physical expansion of the facility with the potential to increase the amount of pollution to surface waters.
- Ecology regulates or authorizes the action.
- The action has the potential to cause measurable degradation to existing water quality at the edge of a chronic mixing zone.

Since this Project has the potential to meet all three of these conditions, this section summarizes the evaluation of the anticipated Project impacts against the effluent discharge characteristics over the past five years and antidegradation metrics to confirm existing and designated uses at Bellingham Bay are maintained and protected.

8.2 Potential Impacts

The wastewater treatment process flows and waste loading will remain as permitted under the plant's municipal NPDES Individual Permit No. WA-0023744. However, the current solids treatment process returns approximately one million gallons per day (mgd) of filtrate, centrate, and scrubber water to the head of the plant for treatment and discharge to Bellingham Bay. Two of the three return streams will change following commissioning of the Project:

- **Modification to centrate:** The current nitrogen loading returned with centrate is not measured. However, with the addition of anaerobic digestion prior to dewatering, it is anticipated that the dewatering recycle flow will be a higher source of nitrogen loading to secondary treatment than the current centrate. Within the 20-year planning period, the future dewatering process is projected to contribute up to 1,400 pounds per day of nitrogen to the effluent being discharged through Outfall 001. In addition, the centrate returning to the head of the plant following digestion and side stream treatment at an average of 90,000 gallons per day and 86 degrees Fahrenheit (ºF) will be warmer than the current centrate.
- **Elimination of incinerator scrubber water:** Currently, approximately 450 gallons per minute (gpm) of continuously sprayed plant utility water (effluent, also termed W3) serves as scrubber water to cool and remove particulate and pollutant matter from the incinerator exhaust. This return stream will no longer exist.
- **New periodic digester cooling:** Periodically, the City will utilize approximately 1,400 gpm of W3 in a "closed loop system" for cooling purposes when the digester heat pump is being serviced or there are extreme conditions in which there is insufficient cooling or heat demand to operate the heat pump. It is anticipated that the City will utilize W3 for several weeks out of the year, which will be returned to the W3 system and utilized for other process needs.

8.3 Mixing Zone

Post Point has a permitted mixing zone where the pollutant concentrations in the effluent mixing with the receiving water may exceed water quality standards as long as the discharge doesn't impact the receiving water body's designated uses. The 2014 Tier II analysis was prepared based on the Outfall Dilution and Water Quality Compliance Evaluation Report (January 1993) previously issued to Ecology for Outfall 001. In October 2016, the City submitted an updated Outfall Mixing Zone Study Report (2016 study) which also identified the acute and chronic mixing zones and the dilution factors within each through Year 2035 flows. Table 8-1 compares the predicted acute and chronic dilutions at worst-case conditions for aquatic life between the two reports.

Table 8-1. Comparison of Allowable Acute and Chronic Dilution Factors for Aquatic Life

Boundary	Dilution Factor (1993 Analysis)[1]	Year 2025 Dilution Factor (2016 Analysis)[2]	Year 2035 Dilution Factor (2016 Analysis)[2]
Acute Zone Boundary	33:1	49:1	47:1
Chronic Zone Boundary	70:1	73:1	65:1

1. Source: Table A-2; Predicted Dilutions for the Post Point Outfall for Various Effluent Flows and Ambient Conditions; Amendment to the Engineering Report (CH2M Hill, 1993). Based on 60 mgd maximum daily flow, 0.0 cm/sec current speed, and maximum summertime stratification conditions.

2. Source. Section 5 table based on predicted Year 2025 and 2035 effluent flows. Outfall Mixing Zone Study Post Point Wastewater Plant Outfall 001 (CH2M Hill, 2016). Based on highest daily maximum and highest monthly average flows, lowest (10th percentile) current speed, and maximum density stratification conditions.

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Ecology has adopted the 2016 study using the minimum dilution factor in the acute mixing zone as 47:1 and the dilution factor in the chronic mixing zone as 65:1. The Project does not impact the findings from the 2016 study and this review utilizes the adopted dilution factors from that study.

8.4 Antidegradation Analysis

The City previously issued the results of the Tier II analysis for Post Point to Ecology with the 2014 liquid stream upgrades (April 28, 2014). Those upgrades reduced flow bypassing secondary treatment, resulting in an improved effluent quality, particularly at higher flows. The analysis concluded there was no potential for Post Point's discharge to cause measurable degradation to existing water quality at the edge of the chronic mixing zone in Bellingham Bay.

Measurable degradation or change in water quality is defined in Washington state's Antidegradation Policy (WAC 173-201A-300-330) as:

- Temperature increase of 0.3 degrees Celsius (ºC) or greater.
- Dissolved oxygen decrease of 0.2 milligrams per liter (mg/L) or greater.
- Bacteria level increase of 2 colony forming units (cfu) /100 milliliter (mL) or greater.
- pH change of 0.1 units or greater.
- Turbidity increase of 0.5 nephelometric turbidity unit (NTU) or greater, or any detectable increase in the concentration of a toxic or radioactive substance.

8.4.1 Temperature

Measurable degradation of temperature is defined as effluent causing a temperature increase of 0.3 ºC or greater to ambient conditions during critical conditions at the edge of the chronic mixing zone in Bellingham Bay or the 99th percentile daily maximum effluent temperature exceeding 33 ºC. The 2016 study concluded that the Post Point discharge to Bellingham Bay would continue to demonstrate temperature compliance for worst-case conditions of maximum seasonal effluent temperature on the temperature change at the chronic mixing zone boundary. These minimum dilution factors continue to be reflective of conservative assumptions given higher effluent temperatures do not occur at maximum treatment plant discharge flows.

The anticipated net effect of the Project is a nominal reduction of effluent temperatures during the summer and nominal increase in effluent temperature during the winter given the elimination of the incinerator scrubber water return to the discharge. Based on a grab sample of the scrubber water temperature taken by plant staff, TM 19—Effluent Impact Assessment, Attachment B (Appendix P) shows the calculation of the current heat load continuously imparted by the scrubber water compared against the anticipated combined effect of the occasional heat load imparted for digester cooling and the warmer centrate.

The effluent temperature at the edge of the chronic mixing zone is calculated as:

$$T_m = (T_e + \text{dilution factor} \times T_a) / (\text{dilution factor} + 1)$$

Where:

- T_m is the temperature at the edge of the chronic mixing zone.
- T_e is the 95th percentile temperature of the final effluent.
- T_a is the worst-case temperature of the receiving water.

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Conservatively assuming there is negligible reduction in the maximum effluent temperature, the 95th percentile and the 99th percentile effluent temperature over the past five years is 23.6 ºC and 24.2 ºC, respectively. Based on an ambient annual 1-day maximum (1-DMax) temperature of 13.0 ºC at Ecology marine monitoring station BLL009 and Year 2035 dilution factor as documented in the 2016 study, the temperature at the edge of the chronic mixing zone is calculated to be an increase of less than 0.2 ºC, well within the state's maximum allowable threshold.

Table 8-2. Effluent Temperature Years 2017 to 2021

Year	Average	Maximum	Minimum	95th Percentile[1]
2017	17.6	24.5	10.0	23.5
2018	18.0	26.0	11.0	23.5
2019	18.2	24.9	7.6	23.9
2020	17.8	24.0	10.5	23.4
2021	18.0	24.5	10.5	23.7

1. 5-percent of values are higher.

8.4.2 Dissolved Oxygen

Measurable degradation of dissolved oxygen (DO) is defined as a decrease of 0.2 mg/L or greater at the edge of the chronic mixing zone. Oxygen demand is impacted by the biochemical oxygen demand in the effluent (faster reaction) and the oxidation of ammonia (slower reaction).

The 2014 Tier II analysis previously concluded that there was no reasonable potential for Post Point to result in measurable DO degradation based on effluent biochemical oxygen demand (BOD). The average, maximum, minimum and 5th percentile effluent DO concentrations for the past five years are summarized in Table 8-3.

Table 8-3. Effluent DO Years 2017 to 2021

Year	Average	Maximum	Minimum	1st Percentile[1]
2017	7.8	9.6	4.7[2]	6.3
2018	7.8	9.0	6.1	7.2
2019	7.8	8.6	6.1	7.2
2020	7.5	9.7	6.4	6.6
2021	7.8	9.5	6.4	6.7

1. 99-percent of values are higher.

2. Sample taken on May 10, 2017 from outfall 001 following the collapse of the RAS pipeline. This sample is not a reflection of the performance of the facility as typically operated but rather a manifestation of a major process element failure. Disregarding samples taken between May 7-13, 2017, the minimum daily DO concentration during the calendar year was 6.4 mg/L.

The effluent DO at the edge of the chronic mixing zone is calculated as:

$$DOm = (DOe + \text{dilution factor} \times DOa) / (\text{dilution factor} + 1)$$

Where:

- DOm is the DO concentration at the edge of the chronic mixing zone.
- DOe is the DO concentration of the final effluent.
- DOa is the worst-case DO concentration of the receiving water.

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Based on the worst-case scenario of 1st percentile effluent DO concentration of 6.3 mg/L, an ambient lowest annual 1-DMax of 4.7 mg/L at Ecology marine monitoring station BLL009 and Year 2035 dilution factor as documented in the 2016 study, the DO at the edge of the chronic mixing zone is calculated to increase the ambient DO by 0.2 mg/L.

Historically, there has not been regulatory limits on effluent ammonia to marine waters for water quality standards (other than toxicity) given the slower kinetic reaction would not have a dissolved oxygen impacts within the mixing zone. However, on December 1, 2021, Ecology also issued a new Puget Sound General Nutrient Permit (PSGNP) to control effluent discharges into Puget Sound to current nitrogen levels. The PSGNP introduced a yearly effluent total inorganic nitrogen (TIN) Action Level (threshold of TIN pounds per year) for Post Point.

The expected net effect of the Project is a nominal reduction of BOD loading to secondary treatment given the centrate will contain stabilized (digested) solids. However, the centrate stream from dewatering digested solids will represent a higher source of nitrogen loading to Bellingham Bay without additional treatment as shown in Figure 8-1.

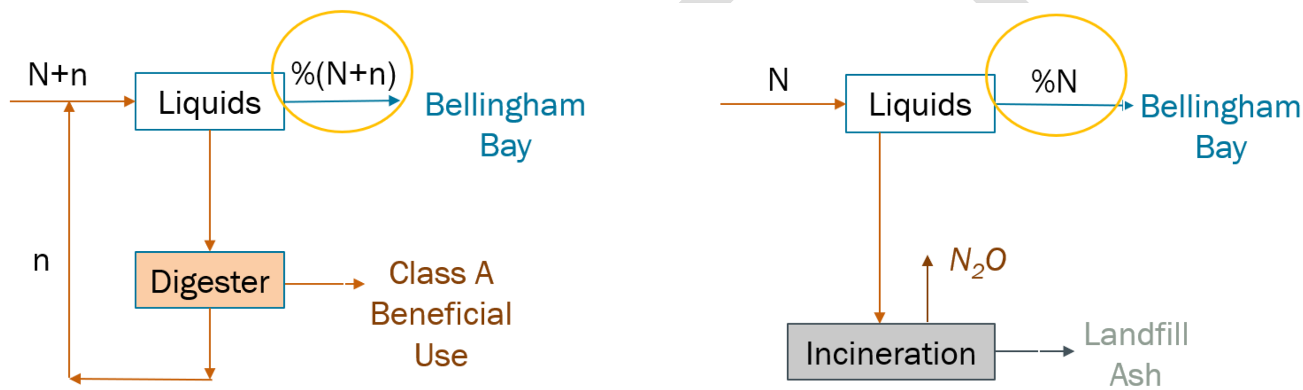

Figure 8-1. Comparison of Nitrogen Load to Bellingham Bay without Additional Treatment

The City will control nitrogen discharged to Bellingham Bay to current levels following commissioning of the project using two methods of additional treatment:

- Approximately 80 percent of the increase in nitrogen load from digestion will be removed by side stream treatment. Refer to Section 8.5 for the recommendation of an annamox based side stream treatment system.
- The remainder of the nitrogen load increase not removed by side stream treatment is expected to be removed through optimizing operational methods by operating Post Point in a nitrogen reduction treatment mode during the summer prior to Project commissioning.

8.4.3 Bacteria

The Project will have no impact on effluent fecal coliform concentrations. In the previous permit cycle, Ecology modeled the number of fecal coliform by a simple mixing analysis using the technology-based limit of 400 organisms per 100 mL and a dilution factor of 65. That analysis showed no violation of the fecal coliform water quality criterion under critical conditions.

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The average, minimum, and maximum daily effluent fecal bacteria concentrations are shown in Table 8-4.

Table 8-4. Effluent Fecal Coliform Concentrations Years 2017 to 2021				
Year	Average (cfu/100mL)	Maximum (cfu /100mL)	Minimum (cfu /100mL)	95th Percentile[1] (cfu/100mL)
2017	5	180	1	17
2018	76	25000	1	24
2019	9	73	1	30
2020	6	510	1	15
2021	24	4400	1	20

1. 5-percent of values are higher.

8.4.4 pH

The Project will have no impact on effluent pH. In the previous permit cycle, Ecology concluded compliance with the technology-based limits of 6.0 to 9.0 will assure compliance with the water quality standards of surface waters because of the high buffering capacity of marine water. The average, minimum, and maximum daily effluent pH values are shown in Table 8-5.

Table 8-5. Effluent pH Years 2017 to 2021				
Year	Average	Maximum	Minimum	5^{th} Percentile[1]
2017	7.2	7.5	6.9	7.0
2018	7.3	7.5	6.9	7.0
2019	7.3	7.7	7.0	7.1
2020	7.2	7.5	6.9	7.0
2021	7.3	7.5	6.7	6.9

1. 95-percent of values are higher.

8.4.5 Turbidity, Toxic or Radioactive Substances

Because of the elimination of scrubber water and the planned nitrogen reduction measures discussed under DO, it is anticipated that the effluent turbidity and toxics loadings of concern for marine waters (WAC 173-201A-240) will be similar to existing following the Project. For example, regulated biosolids pollutants (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc) currently retained in the dewatered cake are expected to remain in the solids phase following digestion, as described in TM 10—Biosolids Exceptional Quality and Total Kjeldahl Nitrogen Ratio (Appendix Q).

Ecology expects no violations of the turbidity criteria outside the designated mixing zone provided the facility meets its technology-based total suspended solids permit limits. The effluent turbidity concentrations discharged from Post Point for the past five years is summarized in Table 8-6. Therefore, the Tier II analysis submitted to Ecology on March 12, 2014, remains valid.

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Table 8-6. Effluent Turbidity Concentrations Years 2017 to 2021				
Year	Average (NTU)	Maximum (NTU)	Minimum (NTU)	95th Percentile[1] (NTU)
2017	5.4	71.5[2]	1.9	9.0
2018	4.0	10.2	1.6	5.8
2019	4.2	7.6	1.9	6.8
2020	3.4	7.4	1.8	5.8
2021	4.2	17.9	1.1	8.4

1. 5-percent of values are higher.

2. Sample taken on May 10, 2017 from outfall 001 following the collapse of the RAS pipeline. This sample is not a reflection of the performance of the facility as typically operated but rather a manifestation of a major process element failure. Disregarding samples taken between May 7-13, 2017, the maximum daily turbidity concentration during the calendar year was 18.9 NTU.

8.5 Side Stream Treatment

With the upgrade and expansion of the City's biosolids processing systems and construction of new anaerobic digesters and associated dewatering facilities, the dewatering recycle flow (centrate) has been identified as a key source of nitrogen loading to the secondary process. This section evaluates side stream treatment process alternatives and recommends the most suitable technology for this application as discussed in TM 20—Side Stream Nitrogen Removal Alternatives Assessment (Appendix R).

8.5.1.1 Background and Basis of Comparison

Table 8-7 summarizes the background information serving as the basis of the side stream treatment alternatives assessment. The design scenario envisions a side stream treatment facility operating year-round. A main stream nitrogen removal system would typically operate in the summer.

Table 8-7. Projected Centrate Characteristics					
Parameter	Design Scenario			With Tertiary BNR	Hydraulic Capacity
	Startup	Average	Max 2-week	Max 2-week	Peak flow
Flow, million gallons per day (mgd)	0.053	0.060	0.107	0.131	0.181
Total suspended solids, mg/L	500	500	500	–	–
Soluble chemical oxygen demand (sCOD), mg/L	150	150	150	–	–
Ammonia nitrogen (NH_3N), mg/L	1,829	2,036	1,569	1,765	–
Phosphate (PO_4P), mg/L	400	400	400	–	–
Alkalinity, mg/L calcium carbonate ($CaCO_3$)	5,000	5,000	5,000	–	–
Temperature, degrees Celsius (°C)	28	28	28	–	–
NH_3N, pounds per day (lb/d)	809	1,020	1,401	1,930	–

For alternatives development, the basis of design is the maximum 2-week scenario, with an ammonia loading of 1,401 lb/d. Modifications required to meet the tertiary BNR scenario (with an ammonia loading of 1,930 lb/d) are also addressed.

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8.5.1.2 Side Stream Nitrogen Treatment

Side stream treatment is a relatively new approach to wastewater treatment—focusing on the dewatering recycle flow instead of the full influent liquid stream. As nutrient regulations have been implemented around the world, efforts have been made to reduce capital and operating costs and improve the reliability of BNR processes. The dewatering recycle flow was identified as an area with potential for low cost and high reward investment.

The dewatering recycle flow typically contains between 15 to 30 percent of the total nitrogen load to the secondary process, as shown schematically on Figure 8-2.

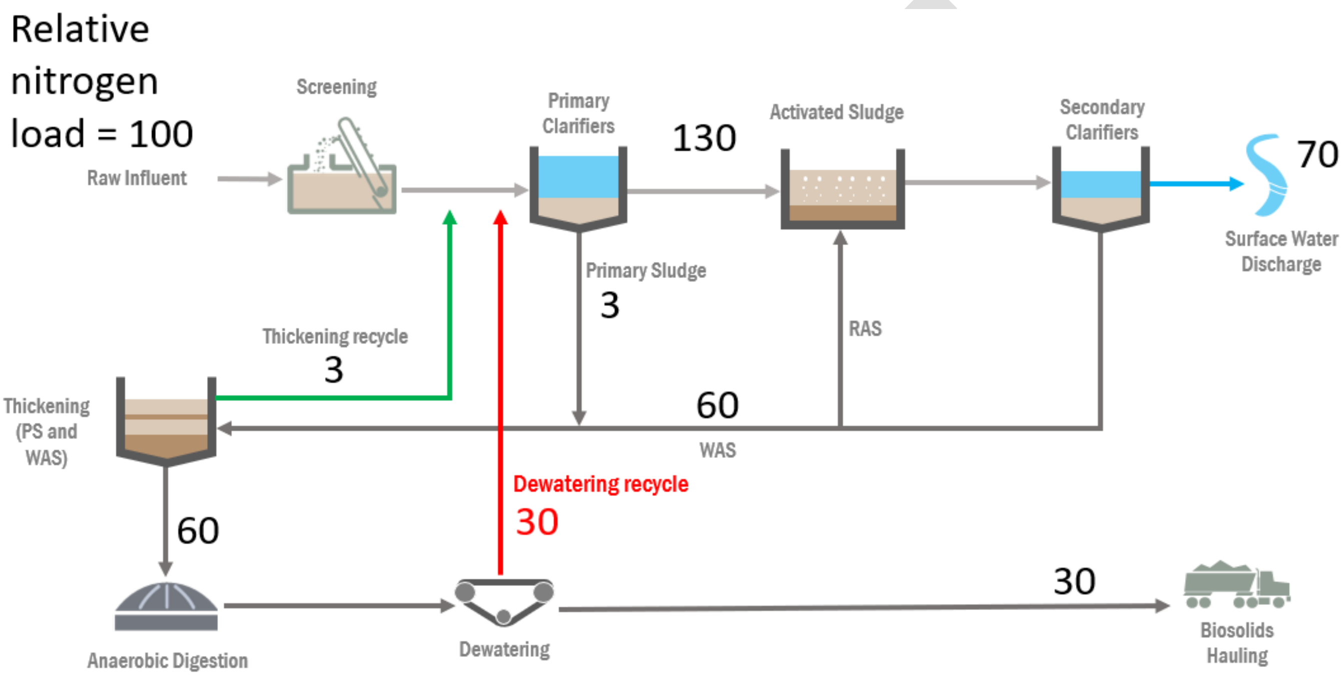

Figure 8-2. Relative Nitrogen Flux Across a Typical Tertiary Nitrogen Removal Plant

8.5.1.3 Side Stream Treatment Approaches

There are three approaches to side stream nitrogen removal: temporal, physical/chemical, and biological. Temporal approaches are focused on optimizing the timing of feeding the dewatering recycle flow to the main biological process. Physical/chemical approaches involve stripping ammonia from the recycle stream as a gas, and then scrubbing that gas to generate an ammonium sulfide product. Biological approaches to side stream nitrogen removal fall into two general categories—bioaugmentation and shortcut nitrogen removal.

Bioaugmentation involves growing a large and highly specialized community of nitrifying bacteria to treat the dewatering recycle flow, and then allowing those bacteria to seed the main biological process, enhancing the nitrification capacity of the overall system. Shortcut nitrogen removal seeks to bypass the traditional four-step nitrification and denitrification process, creating more efficient pathways which reduce operating costs. These approaches include simultaneous nitrification-denitrification, nitritation, and denitritation, and anammox. The anammox process, first implemented about 20 years ago, has made most of the other shortcut approaches obsolete for side stream treatment, due to its efficient biological pathway, and its demonstrated record of performance at municipal facilities. There are now approximately 200 installations of anammox-based side stream treatment worldwide (constructed or in design).

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Table 8-8 summarizes the three approaches for their applicability to Post Point.

Table 8-8. Alternatives Screening Summary

Approach Type	Alternatives Analysis

Temporal Systems	• Equalization and Load Pacing
	  • Use is generally associated with nitrifying activated sludge systems.
	  • Feast-or-famine loading patterns need a larger bacterial population than would otherwise be required.
	  • Facilities already practicing 24-7 dewatering (as planned for the City) would not benefit.
	• For tertiary fixed-film systems:
	  • Temporal systems are most effective with conventional activated sludge processes. Benefits when applied to tertiary fixed-film systems would be much smaller, and unlikely to produce operational cost saving.

Physical/ Chemical Systems	• Ammonia stripping and scrubbing
	  • Systems are expensive to install.
	  • Expected power and chemical costs of up to $500,000 per year (compared to $50K/year for anammox).
	  • Has higher operations and maintenance labor costs than anammox.
	  • Would generate ammonium sulfide which the utility would be responsible for marketing and selling.
	  • Not expected to be competitive with an anammox system in this application.

Biological Systems	• Bioaugmentation
	  • Not applicable for non-nitrifying systems or systems practicing tertiary nitrogen removal.
	• Anammox System
	  • Has a demonstrated record of performance at over 200 installations worldwide.
	  • The best-suited approach for this application due to carbon (methanol) savings. Based solely on methanol demand, the savings could be between $160,000 and $680,000/year.
	  • Additional savings would come from reducing the size and scope of tertiary facilities, aeration, and solids processing demands.
	  • Without an anammox system, methanol demands would increase by 20 to 30%.
	  • Plants with high methanol demands are likely to benefit the most from anammox-based side stream treatment.

Given the existing main stream treatment process, the proposed tertiary nitrogen removal system, and the 24-7 operation of the dewatering process, most of the more common side stream treatment processes are not applicable. Capital costs are similar for the biological, anammox-based treatment processes and the physical/chemical ammonia recovery system. However, the physical/chemical process is projected to have up to 10X higher annual operating cost, would be a much more complex mechanical system, and would produce an end-product which would require marketing and sales. The physical/chemical process is not expected to be competitive with an anammox-based biological process in a life cycle cost analysis. On this basis, the alternatives assessment was limited to the various anammox-based technologies which currently exist in the market.

8.5.1.4 Anammox System Alternatives

There are currently three major vendors in the North American market with anammox-based side stream treatment processes. Each vendor takes a slightly different approach to the process.

Section 4 of TM 20—Side Stream Nitrogen Removal Alternatives Assessment (Appendix R) describes in detail the different anammox system alternatives (DEMON®, ANITA™ Mox, and AnammoPAQ®). Refer to TM 20—Side Stream Nitrogen Removal Alternatives Assessment, Section 4 (Appendix R) for more information about specific alternatives and planning considerations for each.

Table 8-9 compares the three commercial anammox products.

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Table 8-9. Comparison of Commercial Anammox Systems			
Parameter	**DEMON®**	**ANITA™ Mox**	**AnammoPAQ®**
Flow	Most facilities use SBR technology, but new facilities are continuous flow	Continuous	Continuous
Method of retaining anammox bacteria	System of effluent weirs which retain granules	Coarse screens to retain chip-based media	Lamella clarifier inside reactor
Enrichment or wasting equipment	Hydrocyclones, microscreens	None	None
"Moving parts"	Some	Few	Fewest
Performance	Similar ammonia and N removal rates		
Worldwide installations (Oct. 2020)	65 (mostly municipal)	27	63 (mostly industrial)

The performance of the three systems is comparable, as are the operating costs. The systems are intended to remove 85 percent of the centrate ammonia, and 80 percent of the centrate total inorganic nitrogen. Operating costs, mostly related to power, should average approximately $50,000 per year.

8.5.1.5 Design Criteria

This discussion summarizes key design criteria associated with an anammox-based side stream treatment processes. Most of these design criteria are common to all three of the vendor-provided systems introduced in the previous section.

8.5.1.6 Pretreatment

A pretreatment system, focused on settled and floating solids removal, is recommended for any type of side stream treatment. The simplest application would be a gravity settling tank with a scum removal system. A typical design criteria for gravity settling is a surface overflow rate of 500 gpd/ft^2. That equates to a tank surface area of 154 ft^2 at the maximum two-week flow. If there is concern over the potential for struvite accumulation, the pretreatment step may include ferric chloride addition and chemical precipitation.

8.5.1.7 Flow Equalization

The dewatering process is being designed to operate continuously, 24 hours/day, 7 days/week. However, it is typical to expect variation in centrate flow rates. A flow equalization basin, located downstream of pretreatment, could serve a dual purpose of equalizing the flow and acting as a wet well for reactor feed pumps.

While a typical wet well may be quite small, a large equalization basin would allow any anammox-based treatment system to perform more reliably given a steady and stable feed, would offer protection against unforeseen issues impacting the quality of the recycle flow and could provide some flexibility towards operating the side stream treatment system. For planning purposes, a flow equalization basin has been included in this plan. This basin has been sized to hold 4-hours worth of dewatering recycle at the maximum month flow rate.

8.5.1.8 Anammox Reactors

To allow for regular and unexpected maintenance, the system should have at least two equally-sized anammox reactors. Additional reactors are not recommended, given the projected loadings of this system, as this would increase both the cost and complexity of the system. The system should have full redundancy, and the two reactors should be sized such that either reactor could treat the design load at the maximum acceptable loading rate.

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Anammox reactors are typically sized on the basis of ammonia loading. The three vendors have different benchmarks for loading, and as a result the reactor volume ratio varies for the three vendors. The vendors were asked to submit proposals based on the maximum 2-week loading of 1,401 lb/d, but also provide a plan to accommodate the tertiary N removal scenario with a loading rate of 1,930 lb/d.

Table 8-10 summarizes the vendor proposals comparing the loading rates to those typically associated with each system.

Table 8-10. Vendor Proposals and Loading Rates

Parameter		WWWI	Veolia	Ovivo
Proposed reactor volume, gallons		188,509	148,114	68,000
Typical maximum loading rate, kgN/m^3/d		1.0	1.2	2.0
Condition	Ammonia load, lb N/d	Specific loading rate, kgN/m^3/d[a]		
Startup	809	0.51	0.65	1.43
Average	1,020	0.65	0.83	1.80
Design (Maximum 2-week)	1,401	0.89	1.13	2.47
Tertiary N removal	1,930	1.23	1.56	3.40

a. With one reactor in service.

8.5.1.8.1 Equipment

The anammox system includes the following major equipment, which may be housed in a separate building or gallery. Refer to TM 20—Side Stream Nitrogen Removal Alternatives Assessment, Section 5.4 (Appendix R) for detailed descriptions of the equipment.

- Pretreatment equipment
- Influent and/or effluent pumps
- Aeration blowers
- Solids pumps
- Heat exchanger
- Mixers
- Diffusers
- Biomass retention and enrichment
- Foam suppression
- Instruments

8.5.1.9 Layout and Sizing

The facility layout includes the following elements:

- Centrate settling tank
- Centrate flow equalization basin
- Two anammox reactors
- Equipment gallery
- Electrical room

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The vendor proposals, included in Attachment C to TM 20—Side Stream Nitrogen Removal Alternatives Assessment (Appendix R), differ mainly in the size of the anammox reactors. While the Ovivo facility offers a smaller footprint, all three facilities would fit into the proposed site. Refer to TM 20—Side Stream Nitrogen Removal Alternatives Assessment, Figure 6 (Appendix R) for a relative arrangement of the three facilities.

8.5.1.10 Cost Comparison

Table 8-11 summarizes the scope of supply for each vendor system, along with the quote.

Table 8-11. Scope and Cost Comparison of Vendors

Component	WWWI	Veolia	Ovivo
Reactors	2	2	2
Reactor size, gallons	188,500	148,100	68,000
Site footprint per Figure 6, ft^2	5,724	5,074	4,050
Solids Loading Rate (SLR) at design, $kg/m^3/d$	0.89	1.13	2.47
Design SLR as % of typical maximum	89%	97%	123%
Enrichment equipment	2 settlers and microscreen	4 screens	2 settlers
Diffusers	46 panels	8 medium bubble grids	2 fine bubble aeration grids
Feed pumps	3 x 110 gallons per minute (gpm) with variable frequency drive (VFD)	Not included	Not included
Blowers	6 x 325 scfm with VFD	Not included	2 x 750 scfm
Mixers	4 with VFD	2 with VFD	N/A
Other equipment	3 submersible pumps with VFD	2 airlift pumps 2 air control valves 2 influent control valves 12,005 cf of media	
Instruments	pH, DO, conductivity, level	pH, DO, level	pH, DO, NO_3, NH_4
Air flow meters	2	2	Not included
Water flow meters	6	2	Not included
Inspection, startup, training	5 trips/20 days	Not specified	20 days
Remote monitoring	3-4 months	Through startup and performance testing	1 year
Vendor quote	$2,150,000	$1,296,000	$2,600,000

Conceptual cost estimates were developed for each system, using the layouts presented in TM 20—Side Stream Nitrogen Removal Alternatives Assessment (Appendix R). The estimates consider costs associated with concrete tankage, excavation and hauling, and major equipment. Standard multipliers are used to estimate costs for yard piping, HVAC, electrical, and instrumentation and control. These costs are summarized in Table 8-12. Details are provided in TM 20—Side Stream Nitrogen Removal Alternatives Assessment, Attachment B (Appendix R).

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Table 8-12. Conceptual Cost Comparison Between Vendors			
	WWWI	Veolia	Ovivo
Concrete	$852,000	$800,000	$664,000
Excavation and hauling	$1,381,000	$1,198,000	$853,000
Vendor package	$2,150,000	$1,296,000	$2,600,000
Package installation	$645,000	$389,000	$780,000
Equipment outside of package	$815,000	$1,300,000	$975,000
Yard piping[a]	$584,000	$498,000	$587,000
HVAC[2b]	$292,000	$249,000	$294,000
Electrical, instrumentation, and control[c]	$2,045,000	$1,744,000	$2,055,000
Subtotal	$8,764,000	$7,475,000	$8,808,000
Undesigned contingency[d]	$2,629,000	$2,242,000	$2,642,000
Base cost	$11,393,000	$9,717,000	$11,451,000
Bid cost[e]	$16,524,000	$14,093,000	$16,608,000
Total project cost[f]	$21,068,000	$17,969,000	$21,175,000

a. *Yard piping at 10%.*

b. *HVAC at 5%.*

c. *Electrical, instrumentation, and control at 35%.*

d. *Undesigned contingency at 30% of subtotal.*

e. *Bid cost includes contractor overhead and profit (15%), general conditions (12%), bonds and insurance (3.5%) and sales tax (8.8%).*

f. *Total project cost includes final engineering (15%), construction engineering (7.5%), and legal/administrative/permitting costs (5%).*

The Veolia ANITA™Mox system is projected to have the lowest cost, with the other two systems both projected to cost $3M more (an 18-19 percent difference). The difference is related primarily to the vendor quote, with the Veolia system quoted at 60 percent of the WWWI system, and half the price of the Ovivo system.

8.5.1.7 Recommendation

An anammox-based centrate treatment system is expected to remove 80 percent of the inorganic nitrogen content of the centrate. As a stand-alone process, this translates into a reduction of approximately 800 lb/d, or 150 tons/year, from the plant's total nitrogen discharge. The effluent discharge from these systems should have minimal impact on the performance of the non-nitrifying main stream treatment process or any of the biosolids processing systems.

Three vendors are currently marketing anammox-based side stream treatment processes, each of which is expected to deliver similar performance and operating cost. Given the differences between systems in terms of reactor size and equipment, the Project Team recommends that one vendor be selected prior to beginning the detailed design.

Based on the proposals received as part of this evaluation, Veolia's ANITA™Mox system appears to offer some cost savings when compared to its competitors. It is recommended that the Veolia system be used as the basis of the conceptual design, and that a formal preselection in the form of an evaluated bid take place before beginning detailed design.

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Section 9

Resource Recovery Center Programming and Configuration

This section summarizes the architectural programming and configuration analyses work completed as part of the Post Point Biosolids Project (Project). TM 8—Post Point Resource Recovery Center Building Programming and Configuration Development (Appendix S) was prepared as part of planning Phase 3; it documents the architectural programming effort which assesses the City of Bellingham's (City) operations, maintenance, and laboratory space needs and develops initial floor plan layouts to accommodate those needs. Refer to TM 8—Post Point Resource Recovery Center Building Programming and Configuration Development (Appendix S) for additional details about the architectural programming and configuration development.

9.1 Architectural Programming Overview

As part of the Project, a new Resource Recovery Center (RRC) was proposed, which includes operations and maintenance spaces and a laboratory. The RRC architectural programming was a multi-step process. The preliminary programming step evaluated the City's needs for the RRC, which included a questionnaire for the Operations, Maintenance, and Laboratory supervisors, and the Plant Superintendent, interviews with staff, and site visits. Space requirements, adjacencies, and conceptual floor and site plans were developed based on the information obtained.

After developing an initial conceptual floor plan, the programming information was refined through a series of workshops with City staff and the design team. The refined programming information was used to develop updated floor plan options. The City selected floor plan Option 1 as the preferred floor plan.

The City's comments were incorporated into the conceptual floor plans for Option 1 and the resulting architectural refinements improved circulation efficiency and incorporated several best practices from similar, contemporary facilities. These refinements are summarized below.

- Extend the lobby canopy over the entrance to protect the public from the weather and address local design precedents both at Post Point and in Bellingham in general.
- Reconfigure the stair and elevator core circulation from the lobby to the second-floor operations area to address security and provide roof access to mechanical space over the laboratory space.
- Enhance the mud room layout to incorporate a refined laundry space and provide uniform storage and exterior cubbies.
- Reconfigure the maintenance shop to allow interior access to lockers and the breakroom. Add a restroom for a single occupant in the shop and add an access stair from the maintenance bay to the second floor maintenance offices.
- Provide a covered outdoor space on the southwest corner of the maintenance bay for vehicle and equipment washdown.

Figures 9-1 and 9-2 illustrate the revised, preferred floor plans for the first and second floors.

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Figure 9-1. Revised Preferred Option First Floor Plan

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Figure 9-2. Revised Preferred Option Second Floor Plan

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9.2 Preliminary Conclusions and Next Steps

The proposed RRC design concept aligns with the City's goals for a new gateway to Post Point while coordinating with the existing architectural features of the plant and the city.

Elements of the RRC were informed by the City's new Operations Building (located in downtown Bellingham) to ensure consistency in City work environments. The RRC will provide a progressive, highly sustainable, and welcoming workplace for the City to recruit and retain staff. This facility will also serve as a public amenity by providing space for educational tours to highlight the City's commitment to resource recovery and the environmental health of the Puget Sound area.

The City's final concept for the RRC is still under development, however the following potential refinements are being considered:

- Shifting the RRC to the western side of the facility to provide space for a public amenity at the northwest corner of Post Point.
- Providing opportunities for greater community engagement with the site (e.g., adding a trail connection to the north side of McKenzie Avenue, adding pavilions for public gatherings and outdoor meeting areas, and adding interpretive signage along trails, at view corridors, and in pavilions).
- Adding electric vehicle charging stations.

These refinements will be explored as part of the ongoing predesign effort.

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Section 10

Environmental Permitting and Planning

This section summarizes the additional environmental and developmental permitting requirements and planning considerations (beyond the liquid stream and solid stream regulations discussed in Section 3) that are anticipated to pertain to the Project as recommended by this Plan.

10.1 State Environmental Policy Act and National Environmental Policy Act

State Environmental Policy Act (SEPA) review is required upon completion of this Plan update, and the draft SEPA Checklist is included in Appendix T. The City has adopted the SEPA policies (BMC 16.20.180) by reference. A SEPA review is an environmental checklist or report completed to ensure that there are no adverse environmental impacts from proposed projects. The City will issue a threshold determination as to whether significant environmental impact may be expected for implementation of the recommendations in this Plan. This determination will be sent to Ecology for concurrence.

As an anticipated recipient of federal loan funds from the Environmental Protection Agency (EPA), the Project is subject to the National Environmental Policy Act (NEPA) review. It is anticipated that the Project will fall under EPA's programmatic environmental assessment compliance path to evaluate the applicability of federal environmental cross-cutting authorities including the following, as applicable:

- Environmental Justice Executive Order No.12898
- Endangered Species Act (Section 7)
- Bald And Golden Eagle Protection Act
- Fish And Wildlife Coordination Act
- Marine Mammal Protection Act
- National Historic Preservation Act (NHPA) and Archeological and Historic Preservation Act (Section 106)
- Archaeological Resources Protection Act
- Native American Graves Protection And Repatriation Act
- Clean Water Act (Section 404) And Rivers And Harbors Act (Section 10)
- Protection Of Wetlands (Executive Order No. 11990 (1977), As Amended by Executive Order No. 12608 (1997))
- Flood Plain Management (Executive Order No. 11988 (1977), as Amended by Executive Order No. 12148 (1979))
- Safe Drinking Water Act
- Farmland Protection Policy Act

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- Coastal Zone Management Act
- Coastal Barriers Resources Act
- Wild And Scenic Rivers Act
- Essential Fish Habitat Consultation Process Under the Magnuson-Stevens Fishery Conservation and Management Act
- Migratory Bird Treaty Act
- Clean Air Act Conformity
- Wilderness Act

10.2 SERP

The City may wish to pursue Public Works Trust Funds and/or State Revolving Funds in the future so this Plan update will comply with the State Environmental Review Process (SERP; WAC 173-98-100). SERP was established "to help ensure that environmentally sound alternatives are selected and to satisfy the state's responsibility to help ensure that recipients comply with the NEPA and other applicable environmental laws, regulations, and executive orders" via public involvement and environmental documentation.

10.3 Clean Air Act

The Federal Clean Air Act of 1992 requires that all federally funded projects comply with state and regional air quality plans. The local air-quality authority is the Northwest Clean Air Agency (NWCAA). The NWCAA regulates construction and modification of potential air contaminant sources in Island, Skagit, and Whatcom Counties. The Agency must be notified of construction projects so that it may review whether a permit is required; the review requirements are outlined in Section 300 of these regulations.

The State Clean Air Act (RCW 70.94) differs from the Federal Clean Air Act in that it includes odors in its definition of "air contaminant." Odors are regulated by the regional air authorities under WAC 173-400. The regulation requires odor generators to take "reasonable" steps to reduce odor to a "reasonable minimum" (WAC 173-400_640(5)).

10.4 Historical and Archaeological Sites

Cultural resources are addressed in over 100 federal laws, regulations, and guidelines, including NEPA of 1969 and the National Historic Preservation Act of 1966 (NHPA), amended in 1992. Section 106 of the NHPA requires federally assisted undertakings to take into account the effects of those undertakings on historic properties that are included in or may be eligible to be included in the National Register of Historic Places. "Historic properties" refers to prehistoric archaeological sites as well as buildings, structures, and other historic sites.

Applicable state laws include: the Indian Graves and Records Act (Revised Code of Washington [RCW] 27.44), which prohibits knowingly disturbing a Native American or historic grave, Governor's Executive Order 05-05, which mirrors federal Section 106 review and consultation requirements and applies to capital projects that wouldn't have triggered the federal review process, and the Archaeological Sites and Resources Act (RCW 27.53), which requires that anyone proposing to excavate into, disturb, or remove artifacts from an archaeological site on public or private lands obtain a permit from the Office of Archaeology and Historic Preservation.

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The City has performed a cultural resources literature review as described in Cultural Resource Assessment (Environmental Science Associates, 2022) (Appendix U) to support the SEPA process. In addition, the City has conducted an archaeological site investigation to locate and assess any potential cultural resources within the Project area, which is documented in Cultural Resource Assessment for the Post Point Resource Recovery Plant Biosolids Project, Bellingham, Whatcom County, Washington (Drayton Archaeology, 2022) (Appendix V). Additional cultural resources review will be necessary because the City is pursuing federal funding for the Project. The City will consult with concerned tribes and the Department of Archaeology and Historic Preservation to solicit comments on proposed development and related mitigation for cultural resources and has begun contacting the following local tribal historic preservation officers:

Samish Indian Tribe Ms. Jackie Ferry 2918 Commercial Avenue Anacortes, WA 98221	Lummi Nation Ms. Lena Tso 2665 Kwina Road Bellingham, WA 98226	Nooksack Indian Tribe Mr. Trevor Delgado P.O. Box 157 Deming, WA 98244

10.5 Section 401 Water Quality Certification

Compliance with Section 401 of the Clean Water Act is triggered by a federal permit or funding mechanism. A Water Quality Certification ensures that a project will comply with state water quality standards and requirements and protect aquatic resources.

10.6 Coastal Zone Management Act

The Coastal Zone Management (CZM) program applies to all areas of 15 coastal counties in Washington State, and extends three nautical miles into the Pacific Ocean, excluding federal and tribal lands, and is aimed preserving and protecting coastal shorelines and waters. CZM compliance is triggered by a federal permit or funding mechanism.

10.7 Construction Stormwater General Permit

Stormwater runoff from construction sites can carry muddy water, debris, and chemicals into local waterways which can harm aquatic life and reduce water quality. Compliance with Ecology's Construction Stormwater General Permit is required when a project disturbs more than one acre, or from any site that has a possibility of stormwater leaving the site and entering a system that discharges to surface waters.

10.8 City Regulations

All construction must comply with the City's Development Standards including but not limited to the following:

- International Building Code
- International Fire Code
- Uniform Plumbing Code
- Washington State Energy Code
- Stormwater Management
- Zoning Variances
- Transportation concurrency

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- Clearing and Grading
- Shoreline Management Act

10.9 Wetlands and Flood Plains

The following sections describe the wetlands and flood plain evaluation for the Project.

10.9.1 Wetlands

In 2021, Environmental Science Associates (ESA) conducted a critical areas reconnaissance (limited to streams and wetlands) in areas relevant to this Plan update (City of Bellingham Post Point Resource Recovery Plant Biosolids Project Critical Areas Reconnaissance Memorandum, ESA 2021) (Appendix W). The effort included literature research and review and field investigation. Wetlands were investigated on the site using the federal method outlined in Regional Supplements to the U.S. Army Corps of Engineers 1987 *Wetland Delineation Manual* (Corps, 2010) as approved Ecology. The site investigation divided the site into three study areas: the Biosolids Project Boundary, Potential Additional Biosolids Project Boundary, and Future Nutrient Removal Area. No wetlands occur or are mapped as occurring within the Biosolids Project Boundary or the Potential Additional Biosolids Project Boundary. As described in the memorandum, the Biosolids Project Boundary of the site is largely developed with a maintenance yard and several buildings and collects water that enters as sheet flow from the south slope during rain events; however, does not meet wetland criteria. The Potential Additional Biosolids Project Boundary also does not contain any wetlands; this area has a small depression that likely collects some water during rain events from the grass and trail upslope, however, wetland criteria were not observed.

Additionally, the City maps one stream as occurring along the southern edge of the Future Nutrient Removal Area. The stream was observed during the May 9, 2021, site visit and appears to drain stormwater from the residential areas upslope to the east and into the coastal lagoon to the northwest of the site. The stream has a bank-full width of approximately 2 to 3 feet and did not have flow during the May 2021 site visit. The connection to the coastal lagoon to the northwest, which contains fish habitat, was not observed. However, within the project area the slope of the stream was gradual and less than 1 percent and would meet criteria for a fish bearing stream (Type F) per the WAC's definitions (WAC 222-16-303). All fish bearing streams within the City (outside of Padden, Connelly, and Baker Creeks) require a minimum 75-foot buffer per Bellingham Municipal Code (BMC) Table 16.55.500(A). It is recommended the ordinary high-water mark of this feature be determined and current buffers applied to assess any impacts to the buffers as a result of any future work in this area.

10.9.2 Floodplain

Based on the City's geographic information system (GIS) data, Post Point does not lie within the 100-year floodplain as delineated by 2019 Federal Emergency Management Agency (FEMA) floodway and floodplain mapping. However, Post Point remains within 'Frequently Flooded Areas' by way of the 2010 FEMA Floodplain which is subject to Chapter 17.76 BMC – Construction in Floodplains. A 500-year floodplain has not been identified on this site.

10.10 Future Planning Efforts

The Facility Plan effort included consideration of ongoing City climate change-related planning activities, specifically, floodplain, storm surge, tsunami, sea level rise, and seismic performance. These considerations will inform proposed resiliency design criteria for the Project with respect to seismic performance and flooding risk.

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After evaluating the aforementioned resiliency perspectives, the Project Team determined that tsunami risk is the governing hazard when compared to potential inundation/site flooding risk from the other hazards such as storm surge or floodplain considerations. The following sections provide more information about the different types of hazards considered.

10.10.1 Climate Resiliency

The following sections describe the different climate hazard conditions considered for the Project and the resulting planning recommendation.

10.10.1.1 Sea Level Rise, Storm Surge and Tsunami Conditions

The U.S. Geological Survey (USGS) has investigated the effect of various sea level rise scenarios to understand flooding impacts of coastal sites. The City has engaged with the USGS to implement a model across the Bellingham Bay and Whatcom County to aid in evaluating risks and opportunities for increasing infrastructure resiliency to storm surge and sea level rise. The USGS has developed a Coast Storm Modeling System (CoSMoS) that is currently available for most of the California coast. USGS is expanding the model by developing and implementing the Puget Sound Coastal Storm Modeling System (PS-CoSMoS) to provide information to federal, state, tribal and local agencies and communities. The model includes a spectrum of scenarios of sea level rise (0 to 2 meter, 5 meters) and coastal storms (e.g., daily conditions [1-year storm], 20-year storm, 100-year storm, etc.) that span planning horizons through 2100. Sea level rise projections vary between 1 meter and 2.5 meters occurring between 2060 – 2100, depending on the project used.

The Project Team reviewed USGS's preliminary sea level rise map for Post Point with flood extent and depth of water using an approximation of the 100-year storm event for current sea level conditions and scenarios of +0.5-meter and +1.5-meter of sea level rise, which represent the 1-percent chance (i.e., 1 occurrence every 100 years) of 2050 and 2100 sea level rise, respectively. Based on the preliminary sea level rise maps, there is not a significant flood risk at Post Point for 100-year storm surge events when the sea level rise is at 0.5m (1.6-feet). Significant flooding would occur under 1.5m and 2.0m sea level rise scenarios coupled with a 100-yr storm surge. However, these events do not present as much of a flooding risk as the maximum considered tsunami without sea level rise.

Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. Tsunami presents the most significant flooding risk to Post Point, and results in additional structural design requirements for facilities within the tsunami design zone. The design tsunami event was evaluated using the Washington Tsunami Design Zone Maps (WA-TDZ) to determine whether structures need to be designed with tsunami consideration and assess site flooding risks. Washington State Building Code adopted the 2018 International Building Code with additional state amendments. One 2021 amendment (codified in WAC 51-50-1615) directs designers, engineers, and architects to use the WA-TDZ maps where available in lieu of the ASCE 7-16 "Tsunami Loads and Effects" design maps. The WA-TDZ map for Post Point is also more conservative than the ASCE Tsunami Design Zone runup elevations.

10.10.1.2 Combined Effects

The Project Team considered different combinations of environmental hazards, based on available information, and the impacts to Post Point.

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The USGS has not yet studied the combined effect of storm surge and sea level rise. The Project Team conducted preliminary analysis of the combined sea level rise and storm surge to estimate potential impacts to design criteria. The WA-TDZ map indicates a runup elevation of 19 ft (NAVD88) within some specific areas on the site. The WA-TDZ map does not account for impacts of sea level rise. However, it is known that sea level rise would have an increasing effect on the runup elevation in a tsunami event. In the absence of specific code criteria to follow or site-specific tsunami modeling that includes sea level rise, it is prudent to establish a reasonably conservative design elevation for tsunami with sea level rise to use for the Project.

10.10.1.3 Planning Recommendation

The latest sea level rise projection scenarios (Sweet et al. 2017) show a 2-ft increase projected between 2046-2070 and a 3-ft increase projected between 2060-2100. However, the Project Team decided to include a 3-ft runup elevation allowance (to be added to the 2021 WA-TDZ map runup elevation) to account for impacts of sea level rise. The resulting runup elevation is 22-ft, which is recommended to be used as the basis of design for the Project. It should be noted that the 3-ft runup allowance does not account for 3-ft of sea level rise since the impact of sea level rise is not a simple additive effect, and 3-ft sea level increase would likely produce greater than 3-ft of increase in inundation depth in a tsunami event.

10.10.2 Future Plant Build-Out

As part of the planning process for the Project, future spatial needs for the developing regulations under the PSNGP as well as planned plant capacity expansion were taken into account. As indicated in Section 6, this Project's facilities and processes are condensed in the northern section of Post Point. This focused arrangement avoids use of the southeastern portion of the Post Point property, which would be available for any requirements from the PSNGP. This Project also avoids site space identified for future liquid stream expansion in the southwestern portion of the property. Finally, the Project has identified space within the Project site for future solids handling expansion of the TPAD processes.

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Section 11

Site Assessment and Remediation

The following sections summarize the geotechnical and environmental remediation considerations for the Project.

11.1 Geotechnical Conditions and Requirements

To inform the preliminary design for the Project, a geotechnical investigation was provided by GeoEngineers, Inc. The Technical Memorandum, titled Preliminary Design Considerations Post Point Biosolids Phase 3 Bellingham, Washington is attached in Appendix X. The main content of that geotechnical investigation is summarized herein.

The subsurface exploration completed by GeoEngineers for this Project site consisted of 10 borings with two water table level monitoring wells, and seven test pits that were excavated during the environmental assessment. The borings were completed using a hollow stem auger and were advanced to depths ranging from 16.5 to 51.5 feet below the existing ground surface. This work was completed on the area to the north of the existing Post Point site at 210 McKenzie Avenue.

11.1.1 Site Soil Conditions

The site soils were classified as fill (granular and mixed silt/clay), glaciomarine / undifferentiated glacial drift, and glacially consolidated soils / glacial till. A description of each of the classifications is provided in the following:

- **Fill*:*** The fill encountered was typically medium dense / stiff in the upper portion, grading to decreased density / consistency with depth. The fill thickness ranged from 1 to 15 feet below ground. The fill consisted of sand with gravel, sandy silt, silty / clayey sand, and sand with silt / clay. Some scattered organic material was also encountered in the fill soils. The fill has a moderate susceptibility to liquefaction.
- **Glaciomarine / Undifferentiated Glacial Drift*:*** Glaciomarine drift, also referred to as undifferentiated glacial drift, was encountered in all the bore locations except for three. The glaciomarine drift encountered generally consisted of soft to medium stiff silty and sandy clay with some clayey silt and sand with variable gravel content. The glaciomarine drift layer was found directly below the fill layer in all borings where glaciomarine drift was found. The medium stiff glacial drift has a moderate to high compressibility when new loads are applied.
- **Glacially Consolidated Soils / Glacial Till*:*** Glacially consolidated soil is distinguished from the undifferentiated glacial drift soil because of its higher density and lower moisture content. The glacially consolidated soils were found in all borings except for three at depths of 12.5 to 30 feet below ground surface. The glacially consolidated soils encountered were typically dense to very dense silty sand with gravel, with very stiff to hard sandy silt and clay at some locations.

The borehole locations and two cross sections of the soil stratification are shown in Figure 11-1, 11-2 and 11-3 respectively.

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Figure 11-1. Geotechnical Borehole Locations and Future Biosolids Layout

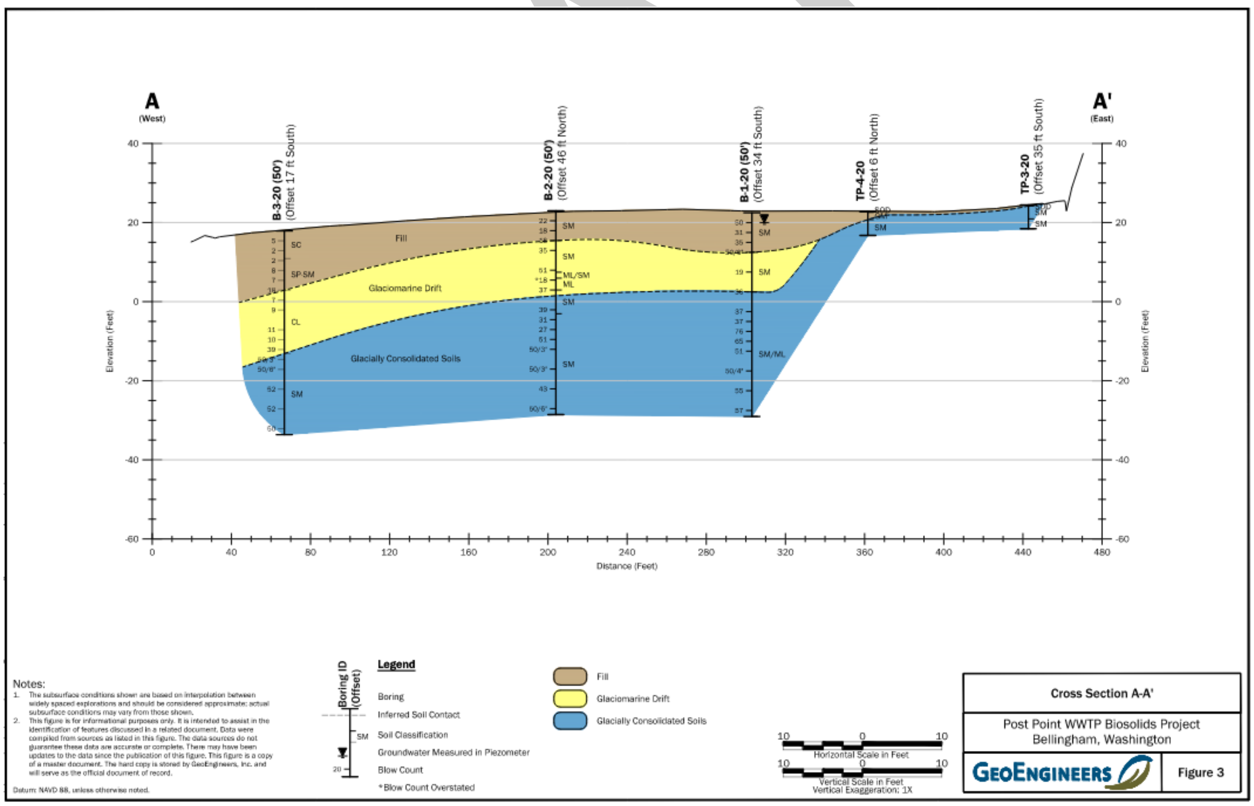

Figure 11-2. Section A-A Soil Stratification

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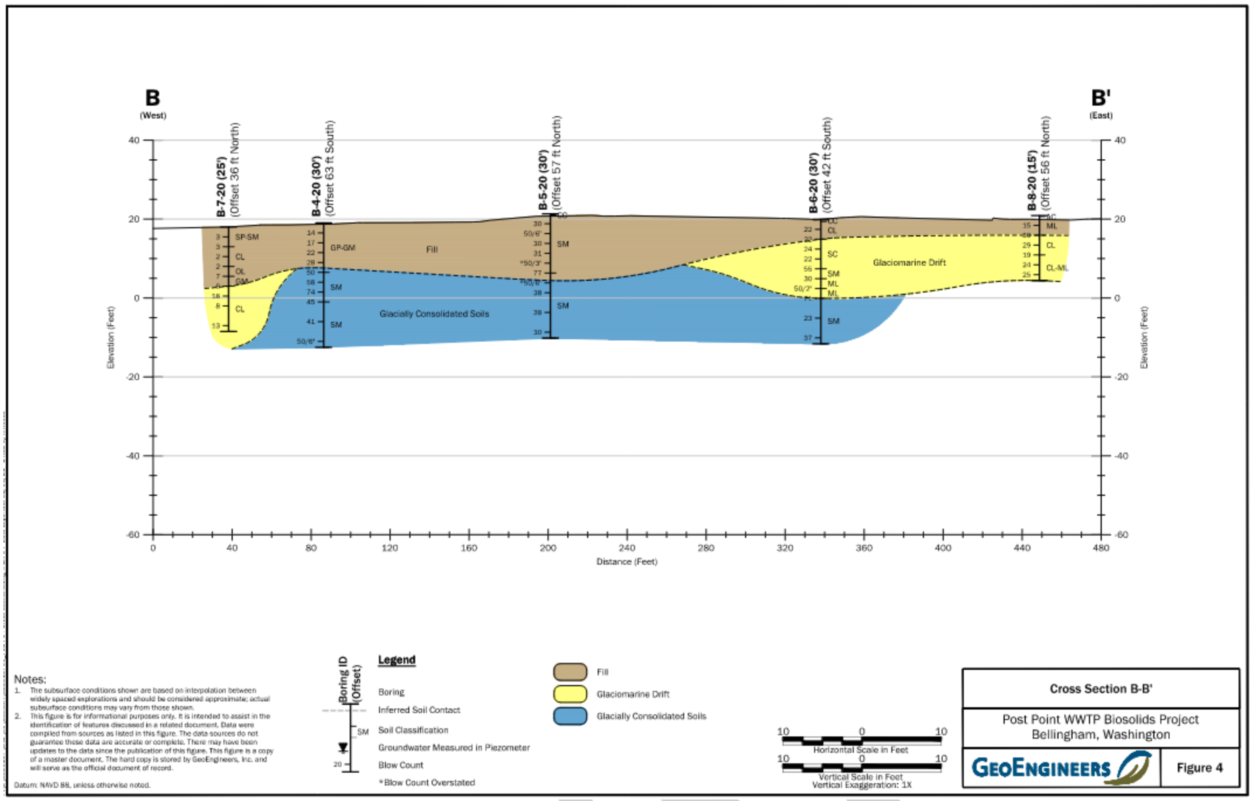

Figure 11-3. Section B-B Soil Stratification

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11.1.2 Site Ground Water Conditions

Relatively shallow groundwater conditions were observed at the project site, consistent with the location of Post Point relative to the nearby ocean. Groundwater was generally encountered between 19 and 20 feet below ground surface (bgs) at the high point and 14 and 15 feet bgs at the low point. Review of historical groundwater monitoring data indicated the groundwater could reach as high as 24.5 feet and decreasing to 8 to 10 feet on the western portion of the property. The elevation of the site at grade ranges from 15 to 25 feet.

11.1.3 Design and Construction Considerations

The following sections describe geotechnical design and construction considerations for the specific Project facilities.

11.1.3.1 Digesters

The proposed digesters are currently planned to be 60 feet tall and extend approximately 30 feet below grade to elevation -10 feet. At the planned depths, it is anticipated that the digester foundations will be placed on glacially consolidated soils. This soil layer will provide adequate bearing for shallow mat foundations that are typical for this structure type.

The foundations will largely be located at the same depth as the glacially consolidated soils; however, some portions at the western edge may be in the glaciomarine drift. Nominal settlement is anticipated after construction as the glacially consolidated soils are over consolidated. Differential settlements between foundations that are supported directly on glacially consolidated soils and portions that are supported on glaciomarine drift will require further evaluation if the structures are not fully supported on the denser consolidated soils.

Hydrostatic uplift of the tanks should be accounted for in the design, as the groundwater in this area may reach up to elevation +20 feet if permanent drainage provisions are not provided. Additional uplift control measures, such as widened structure foundations, concrete ballast, or tiedowns, may be required.

It is expected that excavation during construction will encounter groundwater and an active dewatering system with wellpoints will be necessary to limit groundwater flow into excavated areas. Groundwater contamination and treatment is discussed in Section 11.2. It is generally expected that there will be a minimal impact to existing structures provided adequate sloping, shoring, and dewatering are completed during construction. In locations without sufficient space for adequate excavation slopes, such as to the south side of the property, shoring is expected to be required.

11.1.3.2 Resource Recovery Center Building

The Resource Recovery Center is proposed to be built near existing site grades and be two stories tall. The fill found on the surface of the property will likely need to be over-excavated and replaced with a suitable engineered fill. Alternatively, ground improvements such as aggregate piers below the foundation can be used. The ground improvement from replacing the fill or from the aggregate piers could provide improved bearing capacity and reduce total and differential settlements for shallow footings or mat foundations.

Excavations for this structure will mainly be at grade and temporary slopes are likely feasible for these shallow excavations and shoring is not anticipated. Over-excavation of the fill material and replacement options will need to be coordinated, as some of the fill may be contaminated. The excavation work is expected to have a minimal impact on adjacent structures.

11.1.3.3 Boiler Building

Like the Resource Recovery Center building, the fill at the location for the boiler building will need to be over-excavated and removed or remediated with ground improvements. This building is also located in a known contaminated area where most of the fill may need to be removed and coordinated for disposal. The structure is currently planned for 2 stories and will include a basement. The basement would be advantageous as the fill would be removed and the building is planned to be supported on glaciomarine drift soil with shallow spread footings or a mat foundation.

Settlement will be mitigated through removing the fill material or by providing ground improvement, and it is not expected to be significant. If a basement proceeds for this structure, groundwater occurs at approximately elevation +14 feet and may create uplift forces on the basement, which will require mitigation. During excavation in this area, it may be desirable to limit dewatering due to handling and disposal of potentially contaminated groundwater. Sheet pile shoring systems that provide a barrier to groundwater flow may be preferred in this area to limit the scope of remediation.

11.1.3.4 Piping

The soils in the area for the new piping will generally provide adequate support; however, some over excavation and replacement may be necessary for uniform pipe support. The groundwater in this area may reach as high as +20 feet if permanent drainage is not installed, and uplift will need to be accounted for. An active dewatering system may be necessary to limit groundwater flow into the excavation depending on the depth.

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11.2 Site Contamination and Remediation

A site assessment was conducted by Whatcom Environmental Services during 2020 and 2021 for the Project. This section summarizes the Site Assessment Report Post Point Resource Recovery Plant Biosolids Project (Whatcom Environmental Services, 2021) provided in Appendix Y.

The site assessment was completed at 200 and 210 McKenzie Avenue, which is comprised of two parcels, 370211403538 and 370202452038. A Phase I Environmental Site Assessment (ESA) was conducted in 2006 for the property located at 210 McKenzie Avenue. Appendix Y provides the full Phase I ESA.

For purposes of this section, “Site” is defined per WAC 173-340-200 and includes “any area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise came to be located.” The “Site” is defined as the approximate areas of soil and groundwater contamination and buried waste material located on the eastern portion of Parcel #370211403538 and the western portion of Parcel #370202452038. The contaminated soil portion of the Site is approximately 0.62 acres.

The Site has been assigned the Facility Site ID #151016, Cleanup Site ID #3204, and former Voluntary Cleanup Program (VCP) Project #NW2179 (Site was removed from the VCP in December 2016).

11.2.1 Site History

The property was initially developed beginning in the late 1800s and industrial development began in the early 1900s. Additional phases of property development occurred over the next several decades. Historically, the property has been used as a brick manufacturing facility, a foundry, a chain manufacturing facility, boat manufacturing facilities, a warehouse and general storage facility, an auto repair shop, and as a machine shop.

The ESA performed in 2006 revealed evidence of multiple recognized environmental conditions (RECs) associated with the property, including:

1. The existence of subsurface petroleum contaminated soil associated with three former fuel storage tanks.
2. The presence of a gasoline underground storage tank,
3. Metal working operations associated with the former chain and forge business including galvanizing of chain and storage petroleum products.
4. Past and current boat fabrication operations, including sand blasting of boat hulls, painting activities, and the use of lead ballast.
5. Storage of numerous drums of unknown content.
6. Above ground heating oil and waste oil tanks at the auto repair business.
7. An underground hydraulic lift at the auto repair business.

The property RECs were initially investigated in April 2007 by excavating test pits at various locations across the entire property. Based on the work completed, the area at 210 McKenzie Avenue includes soil and groundwater contamination. The soil contamination consists of petroleum constituents, volatile and semi-volatile organic compounds, and metals at concentrations exceeding the Model Toxics Control Act (MTCA) Method A target cleanup levels.

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Appendix Y provides more details about previous soil and groundwater investigations and interim actions at the Site. Soil samples collected after soil cleanup activities indicated that the remediations in the impacted areas resulted in contaminant concentrations meeting appropriate MTCA Method A and Method B cleanup levels. For more detailed history and previous investigations, refer to Appendix Y.

11.2.2 2020 and 2021 Site Assessment

The following sections provide a summary of soil and groundwater contamination results, contaminated fill results, and conceptual site modeling.

The 2020 and 2021 site assessment included advancing nineteen soil borings to collect samples from a range of 10 feet to 50 feet below grade. Seven test pits were also excavated to depths of 5 to 6 feet below grade for arsenic testing. Lastly, two additional groundwater monitoring wells were installed on the site in two of the soil boring locations. The ESA and figures indicating the soil bores, test pits, and monitoring wells are provided in Appendix Y. The site assessment identified five areas of impacted soil and landfill waste (Figure 11-4). Impacted soil was found between the ground surface and 12.5 feet below ground surface. In total, it is estimated the Site has approximately 11,700 tons of impacted soil.

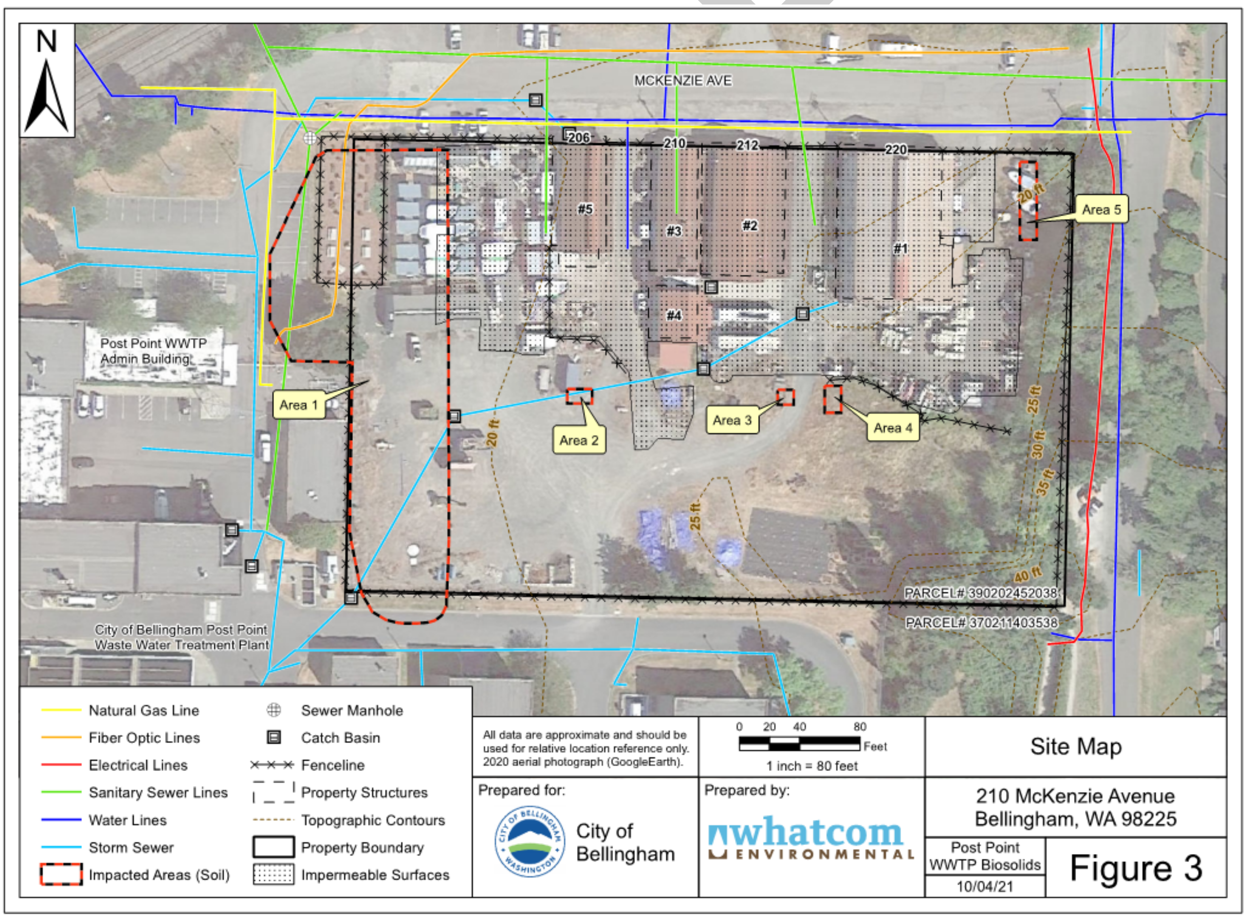

Figure 11-4. Site Contamination Map Illustrating the Five Impacted Areas (Figure 3 from Site Assessment Report Post Point Resource Recovery Plant Biosolids Project).

11.2.2.1 Soil Contamination Results

Target soil and groundwater cleanup levels for the Site are based on MTCA Method A. Of the thirty soil samples collected over 2020 and 2021, three had concentrations exceeding the MTCA Method A cleanup level. The Site soil contamination consisted of petroleum constituents, volatile and semi-volatile organic compounds, and metals at concentrations exceeding soil cleanup levels for unrestricted land use.

- Diesel and oil range TPH and lead were at concentrations exceeding MTCA Method A CULs (Boring B-3-20)
- Cadmium was found at a concentration that exceeded MTCA Method A CUL (B-9-20)
- Arsenic was found at a concentration that exceeded the MTCA Method A cleanup (Test Pit TP-7-20)

No other samples collected in 2020 or 2021 contained any constituents at concentrations exceeding the applicable cleanup levels.

11.2.2.2 Contaminated Fill Results

The contaminated fill that was identified along the western portion of the property was also evaluated per the Washington's Dangerous Waste Regulations (Chapter 173-303 WAC). The Dangerous Waste Regulations are based on the federal Resource Conservation and Recovery Act (RCRA), but are more protective, so part of the waste designation procedure includes determining if the waste qualifies as a Washington state-only dangerous waste.

The waste material was analyzed in two parts, first with a composite sample taken from a piezometer installed in one of the soil boring locations installed to a depth of 10 feet. Second, all historic soil samples collected from within the known contaminated area (Area 1 on Figure 11-4**Error! Reference source not found.**) were evaluated as a whole.

In both cases, the soil did not classify as a hazardous waste under RCRA regulations. Under Washington state-only designations, the toxicity criteria were evaluated by both the book designation procedure and by a bioassay test. The book designation procedure indicated that the soil may classify as a WT02 toxic dangerous waste. A fish toxicity test was completed for the bioassay on the composite sample obtained from the property and it was determined there was no mortality during the test. Based on the bioassay analysis, the composite sample taken does not designate as a state-only criteria. According to the regulations, if the bioassay and book designation procedure do not agree, the bioassay shall be used to designate the waste. Only the single bioassay was completed on the waste in Area 1.

After the preliminary evaluation with the soil composite sample and the historic soil samples, it is likely that the soil excavated from the Site in Area 1 would designate as either non-dangerous or as WT02. If soil from a particular area designates as WT02 from the book designation procedure, then a bioassay could be run to determine if the designation can be reduced to non-dangerous.

11.2.2.3 Groundwater Contamination Results

The Site groundwater contamination consists of dissolved arsenic, dissolved iron, and diesel and oil-range total petroleum hydrocarbons at concentrations exceeding groundwater cleanup levels. Groundwater samples were collected from all fourteen monitoring wells, except for two that are no longer accessible. The data obtained showed the following contamination:

- Diesel was found at concentrations exceeding the MTCA Method A cleanup level at one well (MW-3);

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- Oil was found at concentrations exceeding the MTCA Method A cleanup level in three wells (MW-2, MW-7, and MW-9); and
- Arsenic was found at concentrations exceeding the MTCA Method A cleanup level in three wells (MW-2, MW-10, and MW-11).

In summary, half of the sampled monitoring wells showed contaminants that exceeded their MTCA Method A cleanup levels. For detailed analytical results, refer to Appendix Y.

11.2.2.4 Conceptual Site Model

Figure 11-5 below shows the five areas of impacted soil found at the Site and the future planned Project infrastructure. In general, the contamination is primarily located on the western portion of the property (Area 1). Contamination was also discovered beyond the 200 McKenzie Avenue property's western boundary on the Post Point property, in the direction of the groundwater flow.

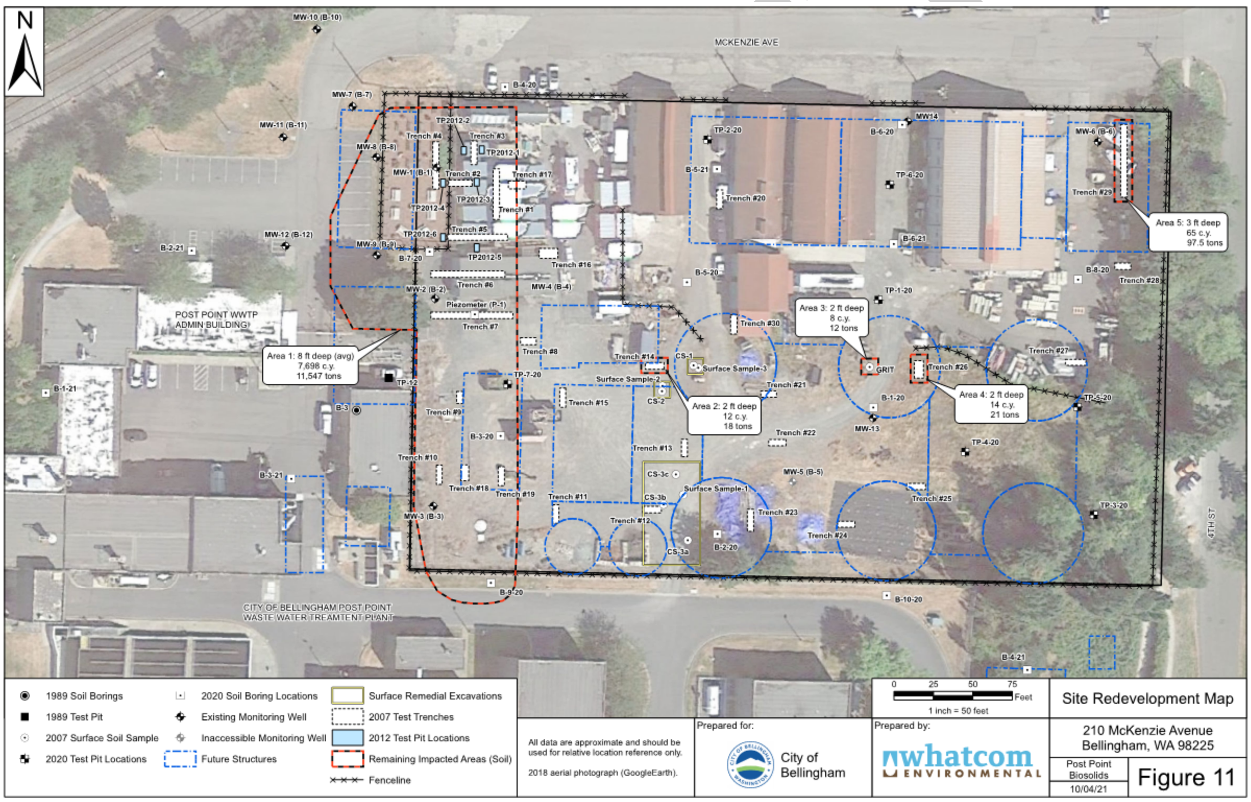

Figure 11-5. Property Soil and Groundwater Contamination Areas (red and black dashed lines) and Future Infrastructure (blue lines)

The five areas of impacted soil include contaminants of concern at concentrations which exceed the screening levels between the surface and 12.5 feet below ground. Area 1 comprises most of the impacted soil and extends to an average depth of 8 feet below ground, equating to approximately 11,547 tons of impacted soil. Areas 2, 3, and 4 extend to approximately 2 feet below ground, equating to approximately 18, 12, and 21 tons of impacted soil, respectively. Lastly, Area 5 extends to approximately 3 feet below ground, equating to 97 tons of soil. In total, it is estimated that approximately 11,700 tons of impacted soil are located at the Site.

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The primary potential exposure pathway / receptor for contaminants in the soil is human and /or terrestrial dermal contact or through ingestion of soil particulates. Since the property is primarily capped with gravel or paved surfaces, the most likely exposure scenario would be during site maintenance or construction activities that disturb the existing structures or the cap (e.g., soil excavation). There is no indication that soil contamination extends off-property, therefore no complete soil exposure pathway exists for off-site receptors.

The primary potential exposure pathway / receptor for contaminants in the groundwater is human, terrestrial, and / or ecological dermal contact, ingestion, or plant direct uptake of contaminated groundwater. The most likely exposure scenario would be during site maintenance or construction that contacts groundwater. There is currently no use of groundwater on the property for potable purpose, nor is there a reasonable likelihood of future use of groundwater for potable use. Monitoring wells located downgradient of the impacted soil areas have contained constituents of concern at concentrations above the target cleanup levels, indicating there is potential for a groundwater exposure pathway for off-site receptors and discharge to surface water.

11.2.3 Remediation Alternatives

As shown on Figure 11-5, only portions of the Project would be constructed within the impacted contamination areas. Two remedial options for the Project were evaluated. Contaminated groundwater entering areas of soil excavation would be removed from the Site during excavation dewatering activities. Contaminated groundwater remaining outside of the soil excavation areas would be left in place and monitored to track natural attenuation of groundwater contaminants which would occur after the contaminated soil source material is removed. The two remedial alternatives considered include:

- **Remedial Alternative 1** includes partial excavation of the contaminated soil / landfill waste only in areas where redevelopment will require excavation, installation of an asphalt and/or concrete cap over the remainder of the Site, preparation of an environmental covenant, and natural attenuation of groundwater contamination. This option leaves in place any identified contamination not located within a planned building footprint. Based on the current understanding of the Project, approximately 6,600 tons of impacted soil would be removed. In order to leave the contaminated soil in place, an impermeable cap would be required over the remainder of the contaminated area, and an environmental covenant would have to be placed on the property (and approved by Ecology). An Ecology-approved Site Management Plan would be required as part of the environmental covenant. Groundwater treatment would be addressed by monitored natural attenuation. Because Remedial Alternative 1 leaves some contaminated soil volume in place, it is presumed that meeting the target cleanup levels would take an extended period of time, and therefore groundwater monitoring would be required. This alternative assumes a minimum 10 years of groundwater monitoring. The estimated cost to complete Remedial Alternative 1 is between $2.7M - $2.9M (2021 dollars).
- **Remedial Alternative 2** includes complete removal of all contaminated soil / landfill waste at the Site and monitored natural attenuation of groundwater contamination. The estimated volume of contaminated soil at the Site is 11,700 tons. Since all contaminated soil would be removed from the property there would be no asphalt or concrete cap requirements and an environmental covenant would not be required. Groundwater treatment would be addressed by monitored natural attenuation. Because all contaminated soil would be removed, it is presumed that natural attenuation of any residual groundwater contamination would be achieved in a reasonable timeframe. This alternative assumes a minimum 2 years of groundwater monitoring. The estimated cost of Alternative 2 ranges from $3.9M - $4.3M (2021 dollars).

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11.2.4 Remedial Alternative Selection

The City selected Remedial Alternative 2 for the Site, which includes complete removal of all contaminated soil / landfill waste at the property and monitored natural attenuation of groundwater contamination. It was determined that within the context of the overall Project cost, the cost differential between Alternatives 1 and 2 was reasonable to limit long-term liability with contaminants at the property, future projects, and a potential environmental covenant.

11.2.5 Preliminary Soil Management Plan

A preliminary soil management plan has been prepared assuming the contaminated soil / landfill material can be disposed of offsite at a permitted treatment and disposal facility. In order to completely characterize the contaminated soil / landfill waste as per Ecology guidance, the waste designation procedure will need to be completed on approximately 22 soil samples collected from the landfill material in Area 1. The material can be characterized *in-situ* or after it is excavated and stockpiled onsite, prior to removal. However, there are certain protocols that are required to ensure the sampling obtains representative samples and to prevent diluting of the soil after excavation. Therefore, if soil is excavated prior to sampling, it is recommended that soil expected to be designated as dangerous waste be kept separate from other soil piles to avoid cross-contamination.

Following the sampling (either *in-situ* or after excavation), the excavated soil / landfill waste will need to be stockpiled onsite to allow dewatering of the material. The dewatered material will then be hauled offsite for disposal, presumably either to the RDS station in Ferndale for transportation via rail car, or to the Waste Management transfer station in Seattle.

The preliminary soil management plan assumes that stockpiled material will be dewatered onsite (i.e., pre-treated onsite via settling tanks and/or carbon flow through vessels) and then discharged to Post Point. Future remediation assessment is necessary for groundwater dewatering and is planned for future detailed design.

11.2.6 Final Soil Management Plan

Several additional tasks and documentation may be required to comply with the Ecology/MTCA requirements, prior to initiating either option for Site remediation. A Cleanup Action Plan (CAP) will be prepared prior to implementing a cleanup action at the Site, which describes the selected cleanup methods and specifies cleanup standards and other requirements. The CAP is based on information gathered during the Remedial Investigation/Feasibility Study (RI/FS). An RI/FS was prepared and submitted to Ecology in 2016; however, the FS portion of the document may require an update based on the final remedial option selected.

An Engineering Design Report (EDR) may also be required to describe specific details for implementation and operation of the selected cleanup action. A final Soil Management Plan will be included in the CAP/EDR documents.

Lastly, various permits will be required based on the selected cleanup option. Permits may include SEPA, Shoreline Management Act, Fill and Grade, and others as required by the City or Ecology. Facility Plan Section 10 discusses these permits further.

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11.2.7 Conclusions

11.2.7.1 Contaminated Soil Conclusions

The 2020/2021 site assessment identified five areas of impacted soil and groundwater. These areas are estimated to have a total of 11,700 tons of impacted soil.

Two alternatives were identified for cleaning up the site and included either removing all contaminated soil or removing only the soil in the areas that will be used for building and construction. The City selected Remedial Alternative 2, which will completely remove all contaminated soil/landfill waste at the property and include monitored natural attenuation of groundwater contamination. The planning level construction cost estimate ranges from $3.9M to $4.3M. Because all contaminated soil would be removed from the property, no asphalt or concrete cap requirements would be imposed on the Project footprint, and an environmental covenant would not be required.

A CAP will need to be prepared prior to implementation of a cleanup action at the Site that describes the selected cleanup methods and specifies cleanup standards and other requirements. An EDR may also be required to describe specific details for implementation and operation of the selected cleanup action.

11.2.7.2 Groundwater Considerations for Future Detailed Design

Management of contaminated groundwater will be required during excavations for removal of contaminated soil and for construction. Groundwater entering the excavations will likely be contaminated with dissolved phase organics, metals and possibly LNAPL. Slug tests conducted in monitoring wells screened below the fill layer indicate horizontal hydraulic conductivity (K) values ranging from 0.01 to 3.0 ft/day (3.5x10-6 to 1x10-3 cm/sec). Notably, the water levels in wells screened in the fill recovered too rapidly to estimate K. In the absence of more hydrogeologic information (e.g., cross sections, aquifer pumping tests results), these data indicate infiltration of groundwater from the excavations' side walls and bottoms will be significant. Vertical hydraulic conductivities have not been measured. It is not known if there is a deeper, laterally extensive, low-permeability layer or bedrock that may limit infiltration of groundwater. Control of groundwater infiltration by means of vertical flow barriers will likely be required. Depending on the depth of any low permeability layer, options include sheet piles or a grout curtain. In the absence of a low permeability layer, jet grouting might also be used to limit upward movement of groundwater, although that option is generally used only in extreme cases.

Dewatering wells, trenches or well points would be placed inside the sheet piles or grout curtain. Dewatering the excavation will produce vertical hydraulic head differentials approaching 20 feet. The uplifting force caused by this gradient can destroy the bottom of the excavation by boiling. The upward gradient can also cause piping of soil/groundwater adjacent to sheet piles. This will be evaluated during detailed design of the Project. The mitigation typically involves using vertical flow barriers (e.g., sheet piles, grout curtains) in conjunction with maintaining the groundwater level inside the excavation area below the excavation bottom.

An approximate (order of magnitude) groundwater infiltration rate might be estimated if there is sufficient geological information to support preparation of a hydrogeologic cross section through the construction area. Pump tests should be conducted to measure aquifer response and refine estimates of groundwater infiltration rates, as well as evaluate the concentrations of the constituents that will need to be treated.

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Section 12

Project Implementation

Section 12 summarizes the evaluation of procurement and delivery methods, phasing and schedule, and staffing and testing requirements. TM 17—Post Point Biosolids Project Delivery Method Evaluation (Appendix Z) provides details on the evaluation process and recommends a delivery method for the portion of the Biosolids Project (Project) that will be completed at Post Point. Off-site Project components were not included in the scope of the evaluation. TM 23—Staffing and Testing Requirements (Appendix AA) provides additional information.

12.1 Procurement Evaluation

The Project Team and select City of Bellingham (City) staff evaluated potential procurement and delivery methods for the Biosolids Project. The objective of the evaluation was to identify the most appropriate delivery method for the on-site project components (i.e., the facilities described in Section 6 of the Biosolids Facility Planning Report). The Project Team and the City met in a series of workshops for the purpose of understanding the following key Project elements:

- Overall Project objectives and success factors
- Previous experience with collaborative delivery methods
- Risk allocation
- Other variables, such as administrative familiarity and required City resources, that might inform a delivery method recommendation

Workshop topics included the following delivery methods:

- Traditional Design-Bid-Build (DBB)
- General Contractor/Construction Manager (GC/CM) (also referred to as Construction Management At-Risk [CMAR])
- Design-Build (DB) options
  - Progressive Design-Build (PDB)
  - Fixed-Price Design-Build (FPDB)

All of these methods are allowed in Washington State as they meet the criteria for public agencies delivering projects greater than $2 million and other criteria listed in Revised Code of Washington 39.10–Alternative Public Works Contracting Procedures.

The City opted to consider both GC/CM and PDB delivery methods as an alternative to DBB delivery.

12.1.1 Project Drivers

The following overall Project drivers were precipitated as an outcome of the workshops with the City:

- Focus on operational priorities and impacts:
  - Address operational objectives during design
  - Include life-cycle emphasis during pricing and decision-making
  - Maintain operations during construction

- Maintain a high level of City involvement during the design process (e.g., input, influence, and City control of design details):
  - Higher Touch: prescriptive requirements to reflect known preferences
  - Risk Avoidance: proven technology for primary process components
  - Lower Touch: “other scope” (e.g., scope unrelated to core treatment process that can be provided by others with minimal input or risk to the City)
- Risk: the City is willing to “buy risk down” (e.g., mitigate risk early in the project through detailed planning and robust design choices)
- Cost: early certainty is preferred; however, “best value” is a meaningful concept in lieu of only a low capital cost criterion
- Schedule: take the time to do things “right” (e.g., spend time planning and preparing to avoid schedule delays later)

These critical success factors were used to make a preliminary assessment of each delivery methods’ potential strengths, weaknesses, and overall potential applicability to the Project.

Table 12-1 summarizes the primary issues considered and a description of each. These issues’ prioritization and weight relative delivery methods was adjusted based on group input and consensus.

Table 12-1. Summary of Key Issues and Descriptions

Issue	Description
Touch What You Know	A high degree of City input is desired on core treatment process components; a less hands-on approach is needed for project components that are either unfamiliar or less critical from the City’s perspective
Early Price Certainty	Knowing the capital cost as early as is feasible in the design process is important to the City
Take Time to Do it Right	A delivery implementation that allows time and consideration for critical decisions is valuable to the City; “rushed” or uniformed decision-making is to be avoided
“Tried–True” Avoids Risk	The City is not interested in unproven or “leading edge” technology for core treatment processes; there is room for more innovation for ancillary project components that are not seen as being as critical

12.1.2 Analysis Summary and Conclusions

After confirming Project drivers and critical City success factors, the evaluation ranked the four delivery methods against these factors, screened out the delivery methods that did not align well with the City’s objectives, and ultimately identified two viable delivery methods. Both GC/CM and PDB were identified as viable potential delivery methods based on the following attributes:

- Selection on qualifications and best value
- High Owner engagement for planning and in critical design decisions
- Earlier price certainty relative to traditional delivery

While either GC/CM and PDB implementations would serve the City’s needs, the City’s previous positive experience with GC/CM and the certainty of applying proven treatment process design favored the selection of a GC/CM delivery methodology for the Project.

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The City Council authorized the GC/CM delivery method for the Project on December 6, 2021. Pursuant to Washington State regulations, the City presented use of the GC/CM contracting procedure to the Capital Projects Advisory Review Board (CPARB) Project Review Committee in January 2022. The CPARB approved the Project for GC/CM delivery, and the City has proceeded with this methodology for competitive procurement.

12.2 Project Phasing and Schedule

The need for project phasing (i.e., multiple contracts) has not been identified at this time. The minimum construction and startup period for the biosolids upgrade project is expected to be 3 years. The anticipated construction sequence is as follows:

1. Clear site and relocate building/utility/equipment.
2. Excavate digester area; remove contaminated soils early.
3. Construct digesters, batch tanks, digested solids storage tanks, digester control building, heat recovery building, and side stream treatment.
4. Construct digester gas cleaning, gas interconnect facility, and waste gas burners.
5. Complete regrading and site paving in new process areas.
6. Construct new solids screening system and building.
8. Construct cake loadout and odor control facility.
9. Commission digestion system and ancillary equipment.
10. Expand/replace thickening and polymer processes; update aging ancillary equipment in solids handling buildings.
11. Commission remainder of solids handling systems.
12. Construct Resource Recovery Center and shift operations, maintenance, and laboratory activities to new Resource Recovery Center.
13. Complete site paving, landscaping, public access areas.

These activities will be constructed in parallel, whenever possible. Anticipated key project milestones and activities are listed in Table 12-2.

Table 12-2. Key Project Milestones and Activities

Milestone	Date
Draft Facility Plan Update Delivered to Washington Department of Ecology (Ecology)	August 2022
Ecology–Approved Facilities Plan Update	November 2022
Preliminary Design Completion	November 2022
GC/CM Contractor Selection	Fall 2022
Detailed Design–Complete Construction Documents	Fall 2024
Construction	Late 2024–Late 2027
Startup and Commissioning	2027

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12.3 Staffing and Testing Requirements for the Facilities

The Project Team completed an analysis of the staffing and testing requirements that could be anticipated for Post Point once the biosolids and biogas upgrades are implemented. This analysis included a current staffing assessment, an evaluation of expected changes to staff responsibilities, and an estimation of labor requirements for operations, maintenance, and laboratory staff. In addition, estimated labor requirements for the current solids handling process at Post Point were compared to labor requirements for the biosolids upgrades and to the future nutrient removal upgrades.

The anticipated changes to staffing for operations, maintenance activities, and laboratory testing are presented in Table 12-3.

Table 12-3. Potential Staffing Changes Required Following Project Implementation

Project	Staffing Level Required [a]			
Labor Area	Operations	Maintenance	Laboratory	Total Additional Staff
Biosolids and biogas upgrades	-- [b]	1+	1+	2
Nutrient removal process (future project)	1+	1+	1+	

a. Assumes each position equals one additional full-time equivalent staff.

b. Operational labor needs for the biosolids upgrades are expected to remain relatively constant with the current operational level.

See TM 23—Staffing and Testing Requirements (Appendix AA) for additional information on staffing and testing requirements.

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Section 13

Financial Analysis

The following Section 13 describes the anticipated Project capital costs, capital funding sources, and the City's rate impact assessment.

13.1 Capital Cost Opinion

Following the selection of the solids handling upgrades and the Phase 3 development of the Project, a basis of cost opinion was developed for the recommendations. The expected accuracy level for this cost opinion follows the Association for the Advancement of Cost Engineering International (AACE International) Recommended Practice 18R 97 Cost Estimate Classification System – as Applied in Engineering, Procurement, and Construction for the Process Industries (2020). Cost opinions are designated as "Class 4" with an expected accuracy range of -15% to +30%.

Costs included in the opinion reflect the best understanding of planning level requirements, as they existed at the time the estimate was prepared (December 2021). Cost estimates are subject to change, and the cost of labor, materials, and equipment will vary as the project design matures or scope is modified.

The cost basis for the biosolids upgrade project includes the following new wastewater treatment processes: temperature-phased anaerobic digestion system with intermediate batch tanks, solids screening system, blended solids storage tanks, gravity belt solids thickening, cake storage and loadout, upgraded polymer system, digester gas conditioning, renewable natural gas production, waste gas burners, digester and space heating facilities, side stream treatment for nitrogen removal, and an odor control system. A new Resource Recovery Center will also be constructed, consisting of new administration, laboratory, and maintenance facilities. A high-level discussion of each line item in the cost estimate is included below. Line items are reported in the anticipated order of construction. Further information on specific unit processes can be found in other documents prepared as part of this Project.

- **Temporary electrical service/construction power:** An allowance for temporary electrical service connection to provide power for construction trailers and other construction equipment.
- **Remove scrubber system:** The chlorine gas scrubber system is in the process of being abandoned in place. Removing the scrubber building will allow for larger truck turning radiuses out of the new cake loadout facility.
- **Remove chlorine building:** The existing chlorine building is in the process of being abandoned in place and will be removed as part of this project. There is electrical equipment in the existing chlorine gas building that could be relocated to a new facility. An allowance was added to account for relocating that electrical equipment.
- **Relocate trailer:** Plant maintenance specialists maintain offices in a mobile trailer. The trailer and its contents will be relocated to allow for construction in that area.
- **Clear northeast area:** Site clearing to remove buildings and other materials from approximately 1.4 acres will allow construction of new digesters and support facilities.

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- **Site excavation, remediation, and dewatering:** Soil removal to allow construction of subgrade digesters and buildings. A considerable percentage of the excavated soil is expected to be contaminated with hazardous materials. For this estimate, complete soil excavation and off-site hazardous material disposal was assumed for approximately 11,700 tons of excavated material as indicated in Section 11.
- **Shoring and dewatering:** Approximately 350 lineal feet on the southern portion of the digester area and an equivalent length on the east side of the digester area are expected to require shoring. Shoring was assumed to be secant pile walls or equivalent. Dewatering while shoring is in place is expected to be required for 6 months.
- **Ground improvements:** Aggregate piles were assumed at 7-ft spacing and 15-ft deep under the Resource Recovery Center, batch digester tank area, and solids screening building.
- **Digesters:** Four, 800,000-gallon circular concrete tanks with fixed submerged covers. Includes digester gas safety equipment, digester mixing, and digester heating equipment.
- **Digester batch tanks:** Six, 170,000-gallon rectangular concrete tanks with concrete covers. Designed for thermophilic temperatures. Includes digester gas safety equipment.
- **Digester control building:** One 140 foot by 130 foot, single-story building for solids handling equipment.
- **Digested solids storage tanks:** Two, 320,000-gallon circular concrete tanks with concrete covers. Includes digester gas safety equipment.
- **Heat recovery building:** The heat recovery building will contain process and space heating boilers, heat pumps, the digester effluent cooling loop, and relocated water meters and backflow preventers. The building is expected to be 74 feet by 36 feet with two stories.
- **New roads:** Approximately 1,000 lineal feet of new roads at 27 feet wide.
- **Repaving existing roads and parking lots:** Approximately 37,000 square feet of existing roads and parking lots to be repaved.
- **Weather station relocation:** An allowance for relocating the existing weather station approximately 100 ft to the northeast.
- **Side stream treatment facilities:** Centrate treatment facilities using annamox bacteria for nitrogen removal.
- **Digester gas cleaning and thermal oxidizer:** Includes digester gas upgrading equipment to produce renewable natural gas and a thermal oxidizer to treat off-gas from the gas upgrading system. Dual process train to treat 175 to 540 scfm of digester gas using a pressure swing adsorption system.
- **Gas interconnect facility:** Equipment and connections required to convey renewable natural gas into the natural gas utility. Natural gas monitoring equipment included in the cost. Up to 2,800 feet of 4-inch steel pipeline to connect to main line at Harris Avenue and 9th Street. A new natural gas connection for the Post Point facility will be located in this area.
- **Remove existing 730 storage building:** Demolition of the existing 730 storage building.
- **Waste gas burners:** Construction of two new waste gas burners with a capacity of up to 700 scfm digester gas each.
- **Remove existing 720 shop building:** Removal of the existing 720 shop building.
- **Solids screening building:** A 40 foot by 60 foot, two-story building that contains new solids screens, screening bins, appurtenances, a bridge crane, and new electrical equipment.
- **Solids blend tanks:** Two rectangular concrete tanks with a working volume of approximately 54,000 gallons each.

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- **Temporary odor control:** An allowance for temporary odor control of the solids handling building during construction.
- **Remove existing odor control and electrical gear:** Removal of existing odor control facilities for the solids handling building and nearby electrical gear.
- **Cake loadout facility:** A 27-foot by 80-foot cake loadout building containing two cake storage hoppers and loadout equipment.
- **Odor control facilities for solids handling building and cake loadout:** System consists of two-stage treatment with a bioscrubber followed by carbon adsorption for up to 33,360 scfm.
- **Odor control upgrades for side stream treatment:** Upgrades to the preliminary treatment odor control facility may be needed to treat up to 1,000 scfm of odorous air from the side stream treatment system.
- **Remove solids handling building equipment:** Removal of nearly all process mechanical, building mechanical, electrical, and instrumentation within solids handling buildings and wet electrostatic precipitator building.
- **Seismic upgrades:** Changes and new equipment installed in the solids handling buildings will likely trigger additional seismic upgrades.
- **Space heating upgrades:** The existing space heating equipment in the solids handling, admin and laboratory facility, and solids screening building will likely require upgrades and replacements due to aging parts.
- **Thickening:** A room extension into the 510 building and building modifications to minimize NFPA classified spaces. Removal and replacement of existing thickening equipment with three new 2-m gravity belt thickeners, thickened solids storage tanks, and thickened solids pumps, and appurtenances.
- **Polymer:** Removal and replacement of the existing dry polymer system with an upgraded system and upgraded controls. The new system will contain an additional mix/age tank to provide 2 duty/1 standby operation.
- **Remove ash loadout building:** Removal of the existing ash loadout building.
- **Transfer SCADA operations to the Resource Recovery Center:** An allowance for transferring supervisory control and data acquisition (SCADA) operations from the existing administration facility to the Resource Recovery Center (RRC). Assumes upgrades to the existing software and hardware systems used by the facility.
- **Radio tower replacement:** Install a new radio tower to provide emergency communication services for the RRC and commercial leases.
- **Replace existing W2 system:** Remove and replace the existing W2 water tanks, W2 water pumps, and appurtenances.
- **Stormwater system:** Stormwater treatment vaults and site grading for stormwater management. Assumes 16 pre-cast concrete treatment filter structures.
- **Landscape architecture:** Allowance for new landscape architecture, including a public open-space amenity, site plantings, etc.
- **Flood protection measures:** An allowance for flood protection measures. Assumes 800 ft of temporary mobile flood protection structures.
- **Asbestos-containing material removal and lead abatement:** Given the age of the facility, demolition is expected to encounter asbestos and lead-containing materials. A cost allowance was added for special handling and disposal of those materials.

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- **Post Point RRC:** New administration, laboratory, maintenance, and other employee facilities. The construction of this facility is considerably different than the other buildings included in the biosolids project. Cost factors for each section of the building (administration, laboratory, etc.) are based on previous projects for similar buildings in the Pacific northwest region and include a 30% contingency. Additional costs were added for display exhibits, signage, furnishings, fixtures, and electrical devices.
- **Sitework for climate resiliency:** An allowance was added for additional site grading and fill to raise the elevation of the new heat recovery and digester control buildings above the anticipated inundation elevation during a design tsunami event.
- **Sitework and yard piping:** Sitework includes site preparation, establishing utility routes, and civil grading. Yard piping includes sub-grade piping between buildings to connect processes and facilities. A 12% cost factor was applied to a selection of the project direct costs that are reasonably expected to incur these costs.
- **Electrical, instrumentation, and control**: Site electrical connections, conduit, wire, computer systems, graphics screens, programming, etc. associated with new equipment.
- **Electrical utility service upgrade:** Additional electrical loads created by the biosolids upgrade may trigger the need for utility service upgrades. The extent and cost of these upgrades is unknown at this time, but an allowance was carried for this cost estimate. It is expected that the electrical utility service upgrade contract will be executed by the City and not the general contractor. Therefore, the cost for the upgrade is not expected to incur the indirect cost markups associated with other costs for this project.

Figure 13-1 shows how the aforementioned construction line items and associated costs can be generally allocated into ten broad categories as follows.

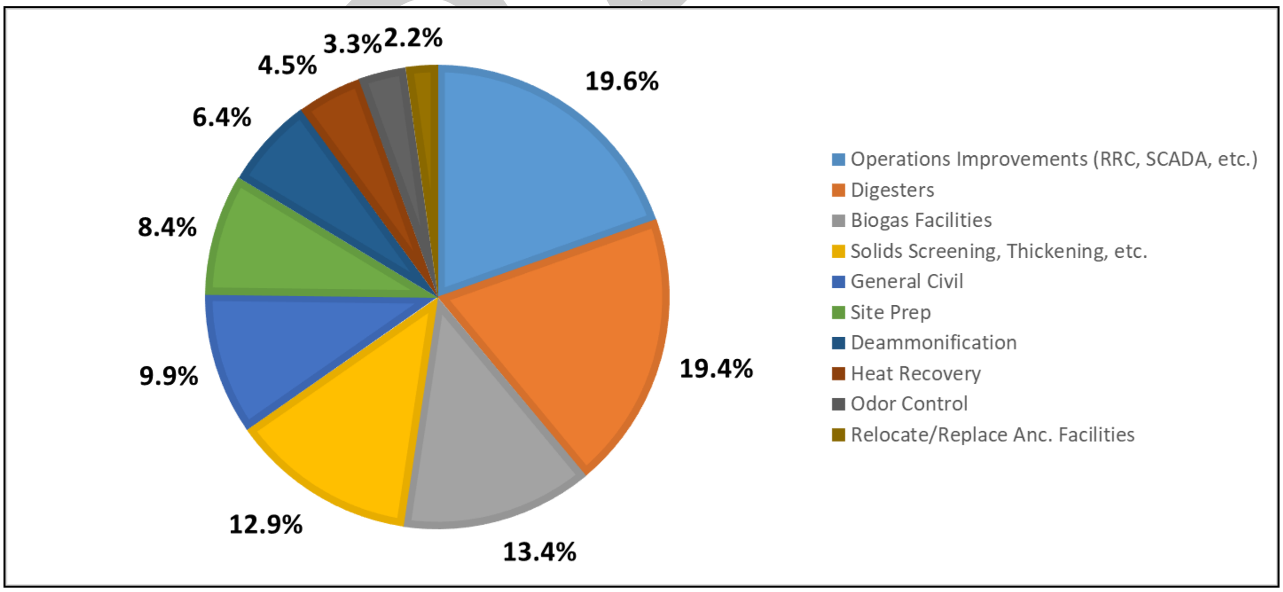

Figure 13-1. Post Point Construction Costs Breakdown

As presented in Figure 13-1, the new the operations improvements (RRC and SCADA, etc.), digesters, and biogas facilities constitute approximately half of the total Project costs. The other half of the total Project costs made up of other line items such as general civil, site prep, and upgrades to the existing solids handling facilities. Quantities and metric costs for each of the line items included above were utilized to develop the estimate of direct construction cost. Indirect cost factors for general conditions (including mobilization, supervision, insurance, bonds and permits), construction contingencies, contractor overhead and profit were added as a percentage to the direct cost to establish a total construction estimate. Engineering, legal and administrative fees, taxes and Owner's reserve for change orders were applied to the total construction cost to establish the total Project cost opinion. The resulting opinion in 2021 dollars is included below in Figure 13-2. Inflation was applied as part of the rate analysis described in Section 13.3.

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DESCRIPTION		TOTAL
PSE Temporary Electrical Service/Construction Power		$ 100,000
Remove Scrubber Building		$ 38,400
Relocate Electrical Equipment from Chlorine Bldg		$ 100,000
Remove Chlorine Building		$ 100,000
Relocate Trailer		$ 5,000
Remove Digester Area Buildings		$ 300,000
Clear and Prep Lot		$ 118,800
Site Excavation, Remediation, and Dewatering		$ 2,578,450
Shoring and Dewatering		$ 4,065,000
Ground Improvements		$ 1,751,627
Digesters, Batch Tanks, and Control Bldg		$ 16,440,000
Digested Solids Storage Tanks		$ 1,210,000
Heat Recovery Bldg		$ 4,120,000
New Roads		$ 681,750
Repaving Existing Roads and Parking Lots		$ 918,500
Weather Station Relocation		$ 200,000
Sidestream Treatment		$ 5,800,000
DG Cleaning and Thermal Oxidizer		$ 6,500,000
Gas Interconnect Facility		$ 3,650,000
Remove 730 Storage Building		$ 112,000
Waste Gas Burners		$ 2,020,000
Remove Existing Shop		$ 128,000
Solids Screening Building		$ 3,500,000
Solids Blend Tanks		$ 600,000
Temporary Odor Control		$ 150,000
Remove Existing Odor Control and Electrical Gear		$ 96,000
Cake Loadout Facility		$ 4,000,000
Odor Control for Solids Handling		$ 2,440,000
Odor Control Upgrades for Sidestream Treatment		$ 295,937
Remove Acid Room, Solids Blend Tank, and Incin 1		$ 45,540
SHB Roofs		$ 1,000,000
Seismic Upgrades		$ 506,030
Space Heating Equipment		$ 800,000
Thickening		$ 1,900,000
Remove Incin 2		$ 13,500
Polymer		$ 430,000
Remove WESP Equipment		$ 28,800
Remove Ash Loading Building		$ 25,600
Transfer SCADA Operations to RRC		$ 1,000,000
Build New Radio Tower		$ 290,000
Replace W2 and Air Systems		$ 720,000
Stormwater System		$ 579,600
Landscape Architecture		$ 1,000,000
Flood Protection Measures		$ 280,000
ACM and Lead Abatement and Removal		$ 200,000
Post Point Resource Recovery Center (PPRRC)		$ 15,800,000
Site Grading for Climate Resiliency	2.0%	$ 1,733,000
Sitework and Yard Piping	12.0%	$ 5,883,000
E&IC	20.0%	$ 14,168,000
TOTAL DIRECT COST		**$108,420,000**
General Conditions	15.0%	$16,263,000
Subtotal		**$124,683,000**
General Contractor Overhead and Profit	12.0%	$14,961,960
Subtotal		**$139,644,960**
Estimator's Contingency	27.5%	$38,402,364
Construction Contingency	2.5%	$3,491,124
Subtotal		**$181,538,448**
Project Tax Rate	8.7%	$15,793,845
TOTAL ESTIMATED CONSTRUCTION COST		**$197,300,000**
Engineering, Legal & Administration Fees	25.0%	$49,330,000
Owner's Reserve for Change Orders	5.0%	$9,865,000
Puget Sound Energy/Electric Utility Service Upgrades		$2,000,000
TOTAL ESTIMATED PROJECT COST		**$258,500,000**

Figure 13-2. Estimated Project Cost

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13.2 Capital Funding Sources

The City will fund the Project using a combination of sewer rates (cash), revenue bonds, a cost share paid by Lake Whatcom Water and Sewer District, and federal loan funding. The federal funds will come from the Water Infrastructure Finance and Innovation Act (WIFIA) loan program administered by the U.S. Environmental Protection Agency (EPA). The WIFIA loan program offers supplemental, low-cost credit assistance for critical water and wastewater infrastructure projects. WIFIA can finance up to 49% of eligible project costs and includes up to 35 years maximum final maturity date from substantial completion. WIFIA loans offer favorable loan terms and structuring flexibilities to fit with other forms of funding and financing. Loan repayments can also be deferred up to 5 years after project substantial completion. WIFIA funding provides the City the benefit of a lower-cost financing option as compared to revenue bonds. The WIFIA loan introduces a federal nexus and will require the Project to comply with NEPA and other environmental cross-cutting authorities.

The City submitted a WIFIA letter of interest (LOI) in July 2021 and was invited to apply by the EPA. The City's LOI included the biosolids and biogas improvements described in this Biosolids Facility Plan and an emergency generator and controls replacement project. On May 9, 2022, the Bellingham City Council authorized staff to formally apply for the WIFIA loan program. The WIFIA program is flexible to changes in project cost estimates between LOI submittal and the later application submittal. During the application development process, the City updated cost estimates and the requested WIFIA loan amount for the biosolids project increased to $211 million (49% of the estimated total eligible project costs of approximately $430.3 million). The interest rate currently assumed is 3% based on economic conditions in June 2022, however the final interest rate will be determined at loan closing. The City is seeking to collaborate with the EPA during the project review, negotiation, and closing process to close the loan with 7 to 8 months of application submittal and prior to the start of construction.

The remaining 51% of the biosolids project costs are planned to be funded by cash reserves, the Lake Whatcom Water and Sewer District cost share, and revenue bonds. The City may consider additional funding options such as grants and/or the State Revolving Fund loan program.

13.3 Rate Impact Assessment

To assess the impacts of the Project, FCS Group (FCSG) prepared a wastewater rate forecast for the City. The forecast extends through 2039 and includes the subject Project as well as other capital improvement projects and the potential costs to comply with the Puget Sound Nutrient General Permit (PSNGP). The forecast was initially performed in February 2021, updated in May 2022, and refined again in June 2022. The Updated Wastewater Rate Forecast (FCSG, June 2022) is included in Appendix BB.

A summary of key assumptions are as follows:

- Resource Recovery Project (biosolids and biogas improvements) cost included at $258.5 million (2021 dollars).
- Construction inflation was conservatively estimated as 12% in 2022, 9% in 2023, 6% in 2024 and 3% per year thereafter. Consumer Price Index (CPI) estimated at 6% in 2022, 5% in 2023 and 3% per year thereafter.
- WIFIA loan would be applicable for 49% of the Project cost, with remaining costs covered by bond proceeds, cash reserves and contributions by Lake Whatcom Water & Sewer District under the current interlocal agreement. The interest rate for the WIFIA loan was estimated at 3%.

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- A second WIFIA loan, or similar program loan, was assumed for the capital improvement costs resulting from the PSNGP in 2029.

The forecast resulted in the recommendation for overall rate increases of 16% per year for seven years, from 2023 through 2029. After that, rate increases of 5.5% per year would be needed for another five years, from 2030 through 2034, and then a 3% increase in 2035. A summary of the Updated Wastewater Rate Forecast is included in Figure 13-3.

Summary of June 2022 Rate Forecast						
Year	Rate Increase	Single-Family Monthly Bill	Assumed SF Monthly Bill in 2022 Dollars*	Annual Capital (Rounded, Inflated $000)	Debt Proceeds	Debt Comments
2022		$49.10	$49.10	$19,300	-	
2023	16.0%	$56.96	$55.30	$29,300	-	
2024	16.0%	$66.07	$62.28	$59,900	200,900,000	WIFIA #1 proceeds
2025	16.0%	$76.64	$70.14	$161,700	55,000,000	Bond proceeds
2026	16.0%	$88.90	$78.99	$118,200	-	
2027	16.0%	$103.13	$88.96	$95,800	93,000,000	Bond proceeds
2028	16.0%	$119.63	$100.19	$52,400	-	
2029	16.0%	$138.77	$112.83	$77,700	232,800,000	WIFIA #1 pmts begin, WIFIA #2 proceeds
2030	5.5%	$146.40	$115.57	$80,100	-	
2031	5.5%	$154.45	$118.37	$57,200	-	
2032	5.5%	$162.95	$121.25	$45,900	-	
2033	5.5%	$171.91	$124.19	$78,500	-	
2034	5.5%	$181.36	$127.20	$62,500	-	WIFIA #2 pmts begin
2035	3.0%	$186.80	$127.20	$64,300	-	
2036	0.0%	$186.80	$123.50	$7,700	-	
2037	0.0%	$186.80	$119.90	$8,000	-	
2038	0.0%	$186.80	$116.41	$8,200	-	
2039	0.0%	$186.80	$113.02	$8,400	-	
Total				**$1,035,100**	**$581,700,000**	
Cumulative						
2029	**183%**					
2039	**280%**		**Assumes 3% annual income growth to match assumed long-term CPI.*			

Figure 13-3. Summary of Updated Wastewater Rate Forecast

The Updated Wastewater Rate Forecast includes a sensitivity analysis around several factors including inflation changes, inclusion of further capital improvements, changes in loan rates amongst others. The Rate Forecast and updates were presented to the City Council in December 2021, May 2022 and July 2022 in advance of the anticipated rate increases in Fall 2022.

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Section 14

Limitations

This document was prepared solely for City of Bellingham in accordance with professional standards at the time the services were performed and in accordance with the contract between City of Bellingham and Brown and Caldwell dated November 8, 2019. This document is governed by the specific scope of work authorized by City of Bellingham; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by City of Bellingham and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Section 15

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