Technical Memorandum

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Subject: Nutrient Impacts

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Limitations:

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List of Abbreviations

°C	degrees Celsius
cf	cubic feet
$	US dollar
4SMB	four stage modified Bardepho
A/O	anaerobic/oxic
AACE	Association for the Advancement of Cost Engineering
AKART	All-known, available and reasonable treatment
AL	action level
AL0	first action level
AL1	second action level
AOB	Ammonia Oxidizing Bacteria
ASB	activated sludge basins
aSRT	aerobic solids retention time
BAF	biologically active filter
BAF-N	Biologically Active Filter–Nitrification
BAF-N/DN	Biologically Active Filter–Nitrification/ Denitrification
BAF/DN	Biologically Active Filter/Denitrification
BC	Brown and Caldwell
BNR	Biological Nutrient Removal
BOD	biochemical oxygen demand
Carollo	Carollo Engineers, Inc.
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CEPT	chemically enhanced primary treatment
City	City of Bellingham
COD	chemical oxygen demand
DIN	dissolved inorganic nitrogen
DN	Denitrification
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EFF	Effluent
ft	feet
Fup	unbiodegradable fraction of the influent COD
gfd	gallons per square foot per day
gpd	gallons per day
HRT	hydraulic retention time
IFAS	integrated fixed film activated sludge
IMLR	internal mixed liquor return
INF	influent
kg	kilogram
lb	pound(s)
M	million
MBBR	moving bed bioreactor
MBR	membrane bioreactor
mgd	million gallon(s) per day
mg/L	milligrams per liter
ML	mixed liquor
MLE	Modified Ludzak-Ettinger
MLSS	mixed liquor suspended solids
MMDWF	maximum month dry weather flow
MMWWF	maximum month wet weather flow
N/A	not applicable
N	Nitrogen
N_2	Nitrogen gas
NOB	Nitrite Oxidizing Bacteria
NPDES	National Pollution Discharge Elimination System
NPW	net present worth
NTF	nitrifying trickling filter
NWEA	Northwest Environmental Advocates
O&M	operations and maintenance
ppd	pound(s) per day
PAX	polyaluminum chloride
PC	Primary Clarifier
Post Point	Post Point Resource Recovery Plant
PSNSRP	Puget Sound Nutrient Source Reduction Project
RAS	return activated sludge
scfm	standard cubic feet per minute
sf	square feet
SRT	solids retention time
SSM	Salish Sea Model
TIN	total inorganic nitrogen
TM	technical memorandum
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
VSS	volatile suspended solids
WAC	Washington Administrative Code
WAS	waste activated sludge
WQBEL	water quality based effluent limits
WWTP	wastewater treatment plant

Executive Summary

The City of Bellingham (City) is currently updating the Post Point Resource Recovery Plant (Post Point) Biosolids Facility Planning Report, which focuses primarily on biosolids management. The City recognizes that the future National Pollution Discharge Elimination System (NPDES) permits are likely to require nutrient reduction measures with potentially significant costs and substantial treatment plant space requirements that need to be accounted for in conjunction with developing the biosolids improvements. This memorandum provides a summary of the Washington State Department of Ecology's (Ecology's) efforts to investigate the effects of nitrogen pollution in Puget Sound. This memo also presents a conceptual evaluation of technologies, layouts, and costs for meeting a range of future nitrogen limits.

Background

Ecology is in the process of developing and refining models to understand the impacts that wastewater treatment plants (WWTPs) have on nitrogen input into Puget Sound and the Salish Sea. Their initial results have shown that the increased nitrogen has resulted in lower dissolved oxygen concentrations and lower water quality, which is detrimental to aquatic life in the region. Ecology is using the Salish Sea Model (SSM) to explore responses of the Puget Sound to changes in nutrient inputs. The SSM results indicate that between 19% and 23% of the Puget Sound area fell below the water quality standards in 2014 and 2006, respectively. Compared to current loading conditions, the SSM predicts that reducing WWTP effluent total inorganic nitrogen (TIN) to less than 8 milligrams per liter (mg/L) during the summer months of April through October will result in substantial reductions in the noncompliant areas and the number of noncompliant days in both the Puget Sound and Bellingham Bay.

In November 2018, Northwest Environmental Advocates (NWEA) submitted a petition to Ecology to revise state regulations to establish year-round technology-based effluent limits of 3 mg/L for total nitrogen and no more than 0.1 mg/L for total phosphorus. Ecology denied NWEA's petition for technology-based nutrient effluent limits in January 2019 and is planning to issue a general permit to address the nutrient issues. A preliminary draft of the Puget Sound Nutrient General Permit was issued in January 2021. Proposed "action levels" are identified in the draft general permit for Post Point. The team is reviewing the draft permit and action level and will provide comments prior to the March 15, 2021 comment due date.

Potential Effluent Nitrogen Scenarios

What level the future nutrient requirements will be set at are uncertain. Therefore, to inform the City's facility planning process, the Brown and Caldwell (BC)/Carollo Engineers, Inc. (Carollo) project team considered six potential nutrient reduction scenarios. The team recommended proceeding with two effluent nitrogen scenarios that would bookend the likely future range of nitrogen regulations:

- Worst Case: 3 mg/L TIN annual effluent limit as proposed in the NWEA petition.
- Moderate Case: 8 mg/L TIN summer only effluent limit as used by Ecology in the SSM.

These scenarios fit within the recent preliminary draft of the general permit, which indicates that Ecology expects the range of final effluent limits to vary between 3 and 10 mg/L TIN, with 3 mg/L being around the lower limit of current technology. For both effluent nitrogen scenarios at least two technologies were evaluated. These technologies included mainstream treatment and adding a tertiary nitrogen removal process. Due to the site constraints for the Worst Case scenario, mainstream treatment was evaluated with intensification, or treatment enhancements that allow for increased treatment capacity within the same footprint. For the Moderate Case scenario, mainstream treatment was evaluated both with and without intensification.

Scenario Layouts

Conceptual layouts were developed for the scenarios considering space limitations, environmentally sensitive areas, constructability, and sequencing. However, limited information was available for subsurface utilities, geotechnical and structural conditions. Depending on the nutrient limits and the technologies selected, the impacts to Post Point varied. All the conceptual layouts for the scenarios fit within the constraints of the Post Point boundary and would require the utilization of the available spaces in the northern and southeastern parts of the plant. Among all the scenarios, only mainstream intensification for the Worst Case scenario would require construction within the heron rookery protection buffer which would not be supported by the City or the local community. Moderate Case scenarios, like adding tertiary process and mainstream intensification, would have some minor construction within the heron vegetation retention and no disturbance buffer but would remain outside of the protection buffer. Adding a tertiary process in the Worst Case scenario and mainstream treatment in the Moderate Case scenario are outside of both buffers would be viewed more favorably. A summary of the impacts and the advantages and disadvantages of the layouts are summarized in Table ES-1.

Table ES-1. Scenario Impact Summary and Comparison

Scenarios	Limit Type	Construction and New Facilities up until 2045			
		No Major Impacts to Existing Infra./Rehab	Outside Heron Protection Boundary	Outside Southeast Open Space	Construction Considerations
Mainstream Intensification	Worst Case	X	X	X	• Significant rehab and demolition of existing facilities • Complex and challenging staging requirements • Major construction in environmentally sensitive areas
Tertiary Process	Worst Case	✓	✓	X	• Moderate to major excavation and geotechnical work required for new facilities and piping/conduits • Capacity limited; no capability for treatment expansion beyond 2045 flows and loads
Mainstream	Moderate Case	✓	✓	X	• Moderate to major excavation and geotechnical work required for new facilities • Piping through part of the Heron Vegetation Retention; no disturbance buffer
Tertiary Process	Moderate Case	✓	✓[1]	X	• Moderate to major excavation and geotechnical work required for new facilities and piping/conduits
Mainstream Intensification	Moderate Case	✓	✓[1]	X	• Moderate excavation and geotechnical work required for new facilities • Piping through part of the Heron Vegetation Retention; no disturbance buffer

1. Some impacts within 300 feet (ft): Vegetation Retention and No Disturbance Buffer.

A red X symbol indicates that a new infrastructure or modifying an existing system is required for a particular scenario to achieve the nitrogen removal goal. A green ✓ symbol indicates that a particular scenario does not need a new infrastructure or any modification to the existing systems to achieve the nitrogen removal goal.

Scenarios Evaluation

The implications of the technologies evaluated for the Worst Case and Moderate Case scenarios were estimated using a calibrated whole plant model and the results are summarized in Table ES-2. For both the Worst Case and Moderate Case effluent limits scenarios, one representative technology was selected to develop planning level capital and operations and maintenance (O&M) costs above current levels and 20-year net present worth (NPW) costs. These costs are summarized in Table ES-3.

Table ES-2. Bellingham Nitrogen Removal Scenario Implications					
Parameter	Worst Case: TIN < 3 mg/L Year-Round		Moderate Case: TIN < 8 mg/L During the Summer		
	Mainstream Intensification	Tertiary Process	Mainstream	Tertiary Process	Mainstream Intensification
New Infrastructure					
Alkalinity feed to primaries	X	X	X	X	X
Chemically enhanced primary treatment	✓	X	X	X	X
Fine Screening	X	X	✓	X	✓
New Aeration Basins	X X	✓	X X X	✓	X
External carbon feed	X X	X X X	X	X X X	X X
New Pump Station	X X X	X	X X	X	✓
Tertiary Process	X	X	✓	X	✓
Dewatering Return Treatment [1]	X	X	X	X	X
Modify Existing Infrastructure					
Demolish existing infrastructure	X	✓	✓	✓	✓
Primary Treatment	X	✓	✓	✓	✓
Aeration Basins	X	✓	X	✓	X
Blower Building	X	✓	X	✓	X
Return Activated Sludge Pump Station	✓	X	X	X	X

1. The addition of a new digestion system under biosolids improvement project would generate a recycle stream from dewatering process which would be introduced to the head of the Plant. The new recycle is high in ammonia and would increase the existing nitrogen load to the plant, therefore exceeding the nutrient cap based on existing conditions. To comply with the new permit requirement, the dewatering return treatment will be included as part of the biosolids improvements project.

A red X symbol indicates that a new infrastructure or modifying an existing system is required for a particular scenario to achieve the nitrogen removal goal. A green ✓ symbol means a particular scenario does not need a new infrastructure or any modification to the existing systems to achieve the nitrogen removal goal.

The number of X symbols in each cell provide a qualitative metric to compare footprint/capacity required among scenarios:

X = low   X X = moderate   X X X = significant

Table ES-3. Bellingham Nitrogen Removal Scenarios – Cost Estimate[1]		
Parameter	**Worst Case Scenario**	**Moderate Case Scenario**
TIN Discharge Limit	3 mg/L	8 mg/L
Compliance Period	Year Round	Summer only (April – October)
Technology Category	Tertiary Process	Tertiary process
Estimated Project Costs [1,2]	$322M	$294M
Annual O&M Cost, above current levels [3,4]	$2.6 - $4.0M	$1.6M - $2.4M
Total NPW [5]	$361M - $382M	$318M - $330M

1. Values shown in 2020 dollars and presented in million dollars.

2. Includes estimator's contingency (40%), contractor general conditions (15%), contractor overhead and profit (20%), tax (8.7%), engineering legal and administration (25%), owners reserve for change orders (5%).

3. Includes estimator's contingency (40%).

4. O&M costs shown in 2020 dollars and adjusted to year 2035 projected flows and loads.

5. 20-year present worth calculated based on a net 3% discount rate.

This analysis found that the estimated capital costs for the Worst Case scenario is approximately 15% higher than the Moderate Case. The annual O&M cost was heavily influenced by the carbon source cost fluctuations. Therefore, the cost in Table ES-2 was presented in a range to take into account the current (low) and historical (high) carbon source prices. Twenty-year NPW costs for Moderate Case ranged from $318M to $330M, while the NPW for the Worst Case ranged from $361M to $382M.

While the implementation of a tertiary treatment process to remove nitrogen does not involve modifications to the existing liquid stream process, this comes at a high O&M cost due to its reliance on external carbon for denitrification. To fully understand the impact of carbon addition needs, another Moderate Case Scenario was evaluated that uses intensification instead of a tertiary treatment. In contrast, to meet a summer only TIN limit of less 8 mg/L, selecting intensification over a tertiary treatment process could reduce costs of nitrogen removal by approximately $0.5M to $1M per year and between $7.2M to $15M over a 20-year period.

Section 1: Purpose

The City is updating portions of the Post Point Facility Plan to address improvements to the biosolids system. The City understands that Ecology is likely to impose nutrient limitations on Post Point and other point sources to protect water quality in Puget Sound and the Salish Sea. The BC/Carollo team prepared this memorandum to provide longer-term planning assessments of a range of potential future nutrient reduction targets for consideration in the Facility Plan update and identify the potential nitrogen reduction impacts associated with biosolids improvements.

Section 2: Background

Post Point is owned and operated by the City. The plant provides secondary treatment for wastewater from the City and surrounding communities. Discharges from Post Point are regulated by NPDES permit number WA 0023744. The NPDES permit specifies a maximum monthly design flow of 34.3 million gallons per day (mgd).

Ecology issued the current permit for the period July 1, 2014, to July 1, 2019. The City applied for permit renewal in September 2018, but the new permit has not yet been issued. The current permit terms and conditions will remain in effect until Ecology issues the new permit and it becomes effective for Post Point (Ecology, 2019a).

The current individual NPDES permit for Post Point does not contain specific nutrient limits nor nutrient load reduction requirements, however Ecology's recently released preliminary draft general permit indicates that Post Point will be subject to "Action Levels" (i.e., effluent loading levels that trigger additional study and process improvements). The next individual NPDES permit will likely include Action Levels for effluent nitrogen similar to those found in the general permit.

Section 3: Puget Sound Nutrient Source Reduction Project

Low concentrations of dissolved oxygen (DO) have been measured throughout the Puget Sound and the Salish Sea. In many instances, the observed DO concentrations violate state water quality standards for protection of aquatic life. Ecology has determined that nutrients from human sources are an important contributor to these low DO concentrations (Ecology, 2019b).

In addition to low DO, excessive nutrient loading can cause other adverse impacts, including:

- Acidification, which can prevent shellfish and other marine organisms from forming shells.
- Shifts in the number and types of organisms that live on the seafloor, resulting in changes in the food chain.
- Reduced water clarity, with potential impacts to submerged aquatic vegetation.
- Increases in nuisance macro-algae, which can impair the health of eelgrass and shellfish beds.
- Increases in harmful algal blooms and other nuisance species, such as jellyfish.
- Changes in food web dynamics.

Ecology initiated the Puget Sound Nutrient Source Reduction Project (PSNSRP) to address DO and other water quality problems associated with nutrient loads from human sources. The goal is to improve Puget Sound water quality to support salmon and orca recovery and increase resiliency to climate change impacts (Ecology, 2019b).

3.1 Salish Sea Model

Ecology is using the SSM to explore responses of the Puget Sound to changes in nutrient inputs. This model was originally developed by the Pacific Northwest National Laboratory and has been through multiple iterations/adjustments over the last decade. These include the addition of sediment diagenesis and ocean acidification modules, with subsequent recalibration. The model is likely to undergo additional adjustments in the future.

As described in the *Puget Sound Nutrient Source Reduction Project, Volume 1: Model Updates and Bounding Scenarios* report (Ecology, 2019c), Ecology used the SSM to evaluate the impacts of nutrients from marine WWTPs and anthropogenic watershed sources on DO concentrations in Puget Sound. Ecology used the SSM to simulate DO for 3 years (2006, 2008, and 2014) with varying hydraulic residence times.

The residence time of a basin in Puget Sound is the ratio of the basin volume to the volume transport of exchange flow coming into the basin. Longer residence times allow more time for biogeochemical processes to use up the DO in the water column. Consequently, basins with relatively long residence times, such as Hood Canal, are more prone to hypoxia (low DO concentrations) (Puget Sound Institute, 2017). Residence time in a basin can vary seasonally and from year to year due to varying river flow, salinity, and other factors (Babson et al., 2006).

A “reference condition” scenario was developed to reflect pre-industrial (i.e., natural) nutrient loading rates to the Sound. Ecology developed the reference condition scenario by setting watershed inputs and marine source inputs to an estimated natural load of nitrogen and carbon while keeping the model year climate, hydrology, and ocean boundary conditions the same as the existing conditions scenario (Ecology, 2019c). The model was then used to simulate a range of bounding scenarios with varying levels of anthropogenic loading. The five bounding scenarios were defined as follows:

1. *Total Existing Load*. All human sources (marine WWTPs plus anthropogenic watershed sources) set to existing conditions.
2. *Marine Point Sources Only*. All marine WWTPs set to existing conditions, with watershed sources set to reference or natural conditions.
3. *BNR All*. Biological Nitrogen Removal (BNR) at all marine WWTPs with existing watershed loads.
4. *BNR 1000*. BNR at marine WWTPs that discharge greater than 1,000 kilograms (kg) Dissolved Inorganic Nitrogen (DIN) per day with existing watershed loads.
5. *BNR 8000*. BNR at marine WWTPs that discharge >8,000 kg DIN per day with existing watershed loads.

The impact of each scenario was evaluated by computing the difference between the scenario and the reference or natural condition. All five scenarios include nutrient discharges from marine point sources, which are defined as WWTPs that discharge directly to the United States portion of the Salish Sea. Scenarios 1 and 3 through 5 include anthropogenic watershed sources such as livestock, septic systems, storm water runoff, and WWTPs that discharge into rivers tributary to Puget Sound. Scenarios 3 through 5 assume that BNR would be operated from April through October and produce effluent containing 8 mg/L DIN and 8 mg/L of 5-day carbonaceous biochemical oxygen demand ($CBOD_5$).

Washington state water quality standards (summarized in the Washington Administrative Code [WAC] 173-201A-210) include numeric criteria for DO. Some marine waters, such as poorly flushed inlets, can fall below the numeric DO criteria due to natural conditions. The state water quality standards require that when a waterbody’s DO concentration is less than the numerical criterion due to natural conditions, human actions considered cumulatively may not cause DO concentrations to decrease by more than 0.2 mg/L from the natural condition. To identify areas that exceeded this “human allowance” for DO depletion, Ecology calculated the differences between simulated DO for each scenario and the simulated reference or natural watershed conditions for the three modeled years (Ecology, 2019c).

The SSM results for Scenario 1 (total existing load) indicate that the cumulative impact of all human sources caused DO concentrations to fall below water quality standards at multiple locations throughout Puget Sound for all three modeled years. Under existing loading conditions, about 23% of the Puget Sound area did not meet the DO standard during 2006, which Ecology deemed a high residence time year. The Scenario 1 simulation for 2014, a year with a more typical residence time, indicated about 19% of the Puget Sound was noncompliant. As noted above, the residence time of a basin is the ratio of the basin volume to the volume transport of exchange flow coming into the basin. Longer residence times allow more time for biogeochemical processes to use up the DO in the water column (Puget Sound Institute, 2017).

Waters that do not contain enough DO to sustain marine life are referred to as "hypoxic." Hypoxic conditions can occur when temperature and/or salinity differences limit vertical mixing in the water column. When this "stratification" occurs, DO concentrations in the deeper layer decline due to decomposition and lack of re-aeration. Ecology estimated that the cumulative annual hypoxic volume (i.e., the volume of water containing less than 2 mg/L of DO) was 28% to 35% higher under current conditions as compared to reference conditions (Ecology, 2019c).

Anthropogenic watershed loads appear to contribute significantly to non-compliance with DO standards. In Bellingham Bay, nutrients from anthropogenic watershed sources alone (i.e., no inputs from marine WWTPs) would cause noncompliance with DO standards, but nutrients from marine WWTPs alone would not (see Figures 29 and 30 in Ecology 2019c).

Table 3-1 shows how the three BNR scenarios would affect the non-compliant area and the number of non-compliant days per year throughout Puget Sound. The table shows how much each BNR scenario would reduce the simulated area and duration of DO non-compliance, as compared to current loading conditions (Scenario 1). As expected, Scenario 3 (implement BNR at all marine WWTPs) was the most effective, reducing the DO noncompliant days and area of greater Puget Sound by about 50%.

Table 3-1. Simulated Improvement in Puget Sound DO Compliance from BNR at Marine WWTPs

Scenario[1]	Percent Reduction in Noncompliant Area			Percent Reduction in Noncompliant Days		
	2006	2008	2014	2006	2008	2014
3 (BNR All)	47	51	42	51	61	51
4 (BNR 1000)	37	41	33	43	49	42
5 (BNR 8000)	23	24	13	31	33	22

1. Assumes BNR effluent contains 8 mg/L DIN and 8 mg/L $CBOD_5$ from April through October.

Source: Ecology 2019c.

Table 3-2 shows the simulated benefits of the BNR scenarios in terms of DO compliance in Bellingham Bay. Compared to current loading conditions (Scenario 1), the BNR All and BNR 1000 scenarios resulted in substantial reductions in noncompliant area and the number of noncompliant days but the BNR 8000 scenario showed little improvement in DO compliance. This is because BNR would be applied to the Post Point WWTP was under both the BNR and BNR 1000 scenarios but not under the BNR 8000 scenario (Ecology, 2019c).

Table 3-2. Simulated Improvement in Bellingham Bay DO Compliance from BNR at Marine WWTPs						
Scenario[1]	Percent Reduction in Noncompliant Area			Percent Reduction in Noncompliant Days		
	2006	2008	2014	2006	2008	2014
3 (BNR All)	66	51	26	87	77	59
4 (BNR 1000)	66	51	26	87	77	59
5 (BNR 8000)	7	0	0	6	5	2

1. Assumes BNR effluent contains 8 mg/L DIN and 8 mg/L $CBOD_5$ from April through October.

Source: Ecology 2019c.

The Scenario 1 (existing conditions) results indicate that more than 80% of the non-compliant area is below the DO standard by 0.2 mg/L or less. Less than one half of one percent of the Sound was predicted to experience an anthropogenic DO depletion of more than 1 mg/L, and these primarily occurred in poorly-flushed areas where DO is naturally lower than 4 mg/L. These Scenario 1 results indicate that although management strategies such as BNR might cause significant decreases in areas or days of non-compliance with the human allowance, the actual improvement in DO would be less than 0.2 mg/L in the great majority of the Sound. The ecological benefits of these small increases in DO are not clear. Derivation of ecologically-based DO criteria for areas that experience naturally-low DO would be an alternative to a human allowance-based standard, and one that could significantly change compliance requirements/costs. This approach has been successfully applied to DO in Chesapeake Bay. However, there is no indication that Ecology is pursuing ecologically-based DO targets at this time.

Ecology is now optimizing the SSM. This two-year process, which began in the summer of 2019, includes running new nutrient-related model scenarios for the Puget Sound, intended to explore geographic effects, annual vs. seasonal effects, climate change, implications of future population growth, and the potential benefits of advanced nutrient controls on both point and nonpoint sources. Ecology plans to share the results of the first year of optimization modeling in June 2020, and complete the second year of optimization modeling in 2021 (Ecology, 2019e). However, in the August 2020 Nutrient Forum meeting, Ecology updated the timeline to state that the first year of optimization modeling will be presented sometime in late 2020 or 2021. Some stakeholders have requested more open access to the SSM and independent review of its capabilities/limitations. Either independent reviews or Ecology's own evaluations could result in changes to the SSM, which could alter model scenario predictions.

3.2 Puget Sound Nutrient General Permit

In January 2021, Ecology issued a preliminary draft general permit to address nutrients from WWTPs. The draft general permit outlines facilities that would be covered by the permit and the "action levels" (in units of pounds [lb] per year of effluent TIN) that would trigger the need for additional study and/or upgrades for each facility. Post Point is included in the draft general permit. Figure 3-1 compares the ranged of projected effluent TIN loads to the proposed action levels (AL) in the general permit. If the effluent TIN load for Post Point is under the first action level (AL0), the plant will need to complete monitoring and reporting of influent and effluent nitrogen concentrations along with the development of operational strategies to optimize the plant to reduce effluent TIN. Little to no equipment investment is anticipated if the effluent TIN load is able to stay below AL0. If Post Point's effluent TIN load exceeds the AL0 but is below the second action level (AL1), increased implementation costs are anticipated to keep the effluent TIN below the AL1 criteria. Potential upgrades could involve the addition of internal mixed liquor return (IMLR) pumping to allow for summer denitrification. If Post Point's effluent TIN exceeds the second action level AL1, the plant will need to develop a long-term plan to control effluent nitrogen. More significant process upgrades are triggered by the exceedance of AL1. The draft permit, including the action levels for Post Point, was reviewed and comments were submitted to Ecology on March 15, 2021 (Appendix A). It is anticipated that elements of this nitrogen review Technical Memorandum (TM) will apply to the required Nitrogen Optimization Plan, but that additional review will be required to satisfy the general permit.

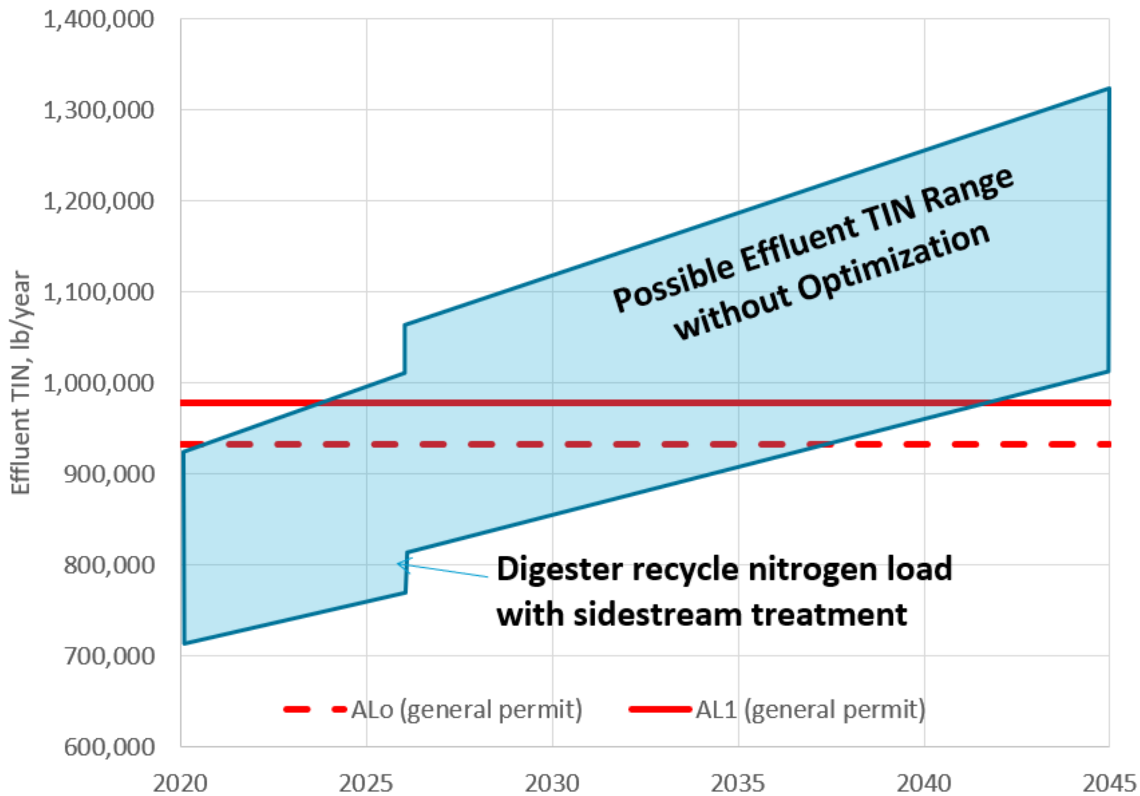


Figure 3-1. Comparison of Projected Effluent Nitrogen Loads and General Permit Action Levels

3.3 AKART Petition

In November 2018, NWEA submitted a Petition for Rulemaking regarding the definition of "all known, available, and reasonable treatment" (AKART) in Washington State regulations. The Petition requested a presumptive definition of AKART as tertiary treatment for municipal WWTPs discharging to Puget Sound and its tributaries. The Petition asked Ecology to revise state regulations (Chapter 173-221, WAC) to establish year-round technology-based effluent limits of 3 mg/L for total nitrogen and no more than 0.1 mg/L for total phosphorus (NWEA, 2018).

Ecology denied NWEA's Petition for technology-based nutrient effluent limits in January 2019. Ecology noted that AKART requires treatment technology that is economically as well as technically feasible. Ecology indicated that water-quality based effluent limits (WQBELs) would be more appropriate for Puget Sound because they are not limited by economic feasibility; rather, WQBELs are set at the levels necessary to ensure a discharger does not cause or contribute to water quality standards violations (Ecology, 2019f).

NPDES permits can include compliance schedules if Ecology determines that the permittee will need additional time to make needed modifications to treatment processes in order to meet permit limits or requirements. Compliance schedules are commonly used for construction and treatment plant upgrades (Ecology, 2016) that cannot be completed within a 5-year permit term.

State and federal regulations allow for water quality variances in certain situations where it is unknown whether state water quality criteria or effluent limits can be met. For example, the regulations may allow a water quality variance if meeting effluent limits or criteria would cause substantial and widespread social and economic hardship. Water quality variances are time-limited and difficult to obtain however. They require formal rule-making by the state and approval by the United States Environmental Protection Agency (USEPA). Ecology has yet to issue a water quality variance under the current rules.

In February 2019, NWEA filed an appeal with Governor Inslee, asking that he direct Ecology to undertake rule-making to establish a presumptive AKART standard of year-round tertiary treatment and presumptive effluent limits of 3 mg/L for total nitrogen and no more than 0.1 mg/L for total phosphorus (NWEA, 2019a). NWEA also filed a lawsuit in Thurston County Superior Court to appeal Ecology's denial of the AKART petition (NWEA, 2019b). The outcome of those appeals have been denied, but Ecology has decided to move forward with the previously discussed Nutrient General Permit.

Section 4: Potential Nutrient Scenarios for Post Point Facility Planning

Although the primary purpose of the Post Point Facility Plan update is to provide biosolids management, the City recognizes that Ecology's current direction will likely result in future NPDES permits including nutrient reduction requirements. To implement the scenario conditions defined in Ecology's SSM, the City would likely incur significant costs and require treatment footprint to manage the nitrogen load. Although these requirements could vary considerably depending on the specific nutrient reduction measures contained in future general and/or individual NPDES permits for Post Point, this needs to be identified and accounted for in conjunction with developing the biosolids improvements.

Ecology's response to the NWEA AKART petition suggests that a water-quality based approach is more appropriate than a technology-based AKART approach because the latter requires that the treatment technology be both economically and technically feasible. In contrast, water-quality based effluent limits are set at the levels necessary to ensure a discharger does not cause or contribute to a violation of water quality standards and are not limited to technology that is known, available, and reasonable. Ecology stated that it plans to use the PSNSRP outputs and outcomes to develop water-quality based effluent limits (Ecology, 2019f). In practice, technology-based and water quality-based effluent limits can be similar. This is the case when water quality models are used to identify compliant scenarios, but the point source limits used in those scenarios are set using technology-based considerations.

Based on initial discussions with Ecology, at this time, Ecology intends to impose action levels similar to those in the general permit as part of the City's individual NPDES permit until a future general permit is implemented. Ecology's premise for action level is to not allow any additional nitrogen to be discharged into Bellingham Bay than what is currently being discharged.

As part of the new digestion system, a recycle stream from the dewatering process will be introduced back to the head of Post Point. This recycle stream has a high concentration of nitrogen, which will increase the nitrogen load to the secondary treatment process and allow for greater nitrogen in the effluent. Because the action levels would be based on existing conditions, it is not inclusive of the nitrogen load from the new digestion recycle stream. As a result, once the digestion process comes on-line, nitrogen removal upgrades will be required to remove the nitrogen in the recycle stream to comply with the action levels.

These future nutrient removal requirements, particularly related to the general permit conditions, are currently uncertain. Therefore, to inform the City's facility planning process, the project team recommends evaluating several nutrient reduction scenarios that bracket the anticipated range of future requirements for

Post Point. The evaluation includes modeling of potential treatment processes and development of planning-level cost estimates discussed in later portions of the memorandum. Table 4-1 lists nutrient reductions scenarios identified based on the existing information summarized in Section 3. This information was presented to the City in May 2020 meeting and is included in Appendix B. It should be noted that, while the NWEA petition requested an effluent limit for total nitrogen and Ecology's Bounding Scenario modeling is based on DIN concentrations in WWTP effluent; at public workshops to date and the preliminary draft general NPDES permit, Ecology has been discussing potential effluent limits for TIN. Therefore, the scenarios summarized in Table 4-1 assume a TIN limit, per initial discussions with Ecology at public workshops.

Table 4-1. Potential Nutrient Reduction Scenarios for Post Point WWTP Facility Planning

Scenario	Effluent [TIN] [1, 2]	Duration	Rationale
1	3 mg/L	Year-round	NWEA's AKART petition requested rule-making to presumptively define AKART as tertiary treatment, with year-round effluent limits of 3 mg/L for total nitrogen (N). Ecology denied the AKART petition but NWEA has appealed in Superior Court.
2	3 mg/L	April through October	This scenario could occur if : (1) NWEA's appeal is successful but SSM optimization results demonstrate that 3 mg/L year-round N limits would provide marginal DO benefit over seasonal limits, or (2) SSM optimization shows that a seasonal limit of 3 mg/L is necessary.
3	8 mg/L	April through October	The Bounding Scenario report (Ecology, 2019c) indicated that the BNR and BNR 1000 scenarios, which assumed 8 mg/L [DO] April through October would provide substantial DO improvements in Bellingham Bay.
4	8 mg/L	Year-round	This scenario could occur if SSM optimization results indicate that year-round N limits would provide significant DO improvement over seasonal limits.
5	Optimize nutrient removal within existing footprint	April through October	The initial SSM results indicate that anthropogenic watershed sources are a significant contributor to DO problems in Puget Sound. For example, the Bounding Scenarios report noted that anthropogenic watershed sources alone would produce DO depletion in Bellingham Bay (Ecology, 2019c). Therefore, Ecology has suggested that water quality trading may be appropriate. This scenario could help support the evaluation of potential water quality trading. If Ecology determines that additional N reductions are needed, the City could conduct or support measures to reduce anthropogenic watershed loads (e.g., improved manure management, conservation easements for dairies). This type of approach could increase the environmental benefits from the City's investment in water quality.
6	Optimize nutrient removal within existing footprint	Year-round	See rationale for Scenario 5.

1. Assume 2045 flows and loads at Post Point.

2. Recent discussions and workshops with Ecology indicate that future N effluent limits are likely to be expressed as TIN.

To provide a "bookend" understanding of the potential impacts with the initial planning efforts, the BC/Carollo Team recommended the City initially limit the evaluation to Scenarios 1 and 3. Scenario 1 would represent the most stringent nutrient controls of the potential range in outcomes. Scenario 3 was already evaluated at the Puget Sound scale as part of Ecology's Bounding Scenario study. Should Scenario 1 or 3 be deemed to not be feasible within the existing Post Point footprint, the BC/Carollo Team would undertake a second round of planning efforts to define Scenario 5.

Section 5: Technology Review and Selection for Nutrient Scenarios

There are multiple nitrogen removal technologies and processes that could potentially be used at the Post Point to meet future nitrogen limits. However, as the recommended scenarios in Section 4 have different limits and potentially different seasons to meet these limits, the technologies will vary by scenario. This section describes the technology categories and presents a list and description of the retained technologies that will be evaluated at each nutrient scenario described above.

5.1 Technology Categories

To simplify technology screening, each technology was categorized by its implementation type or how it would affect Post Point, which resulted in four different categories: mainstream, sidestream, tertiary treatment, and intensification. A description of each of these categories is presented below:

- **Mainstream treatment technologies:** These technologies are employed as the mainstream biological secondary treatment process and must be capable of nitrogen removal.
- **Intensification technologies:** These technologies allow for operating the mainstream treatment process at higher rates in a smaller footprint by allowing for a higher amount of biomass concentration in the same footprint. They do not necessarily remove nitrogen on their own but are used in conjunction with a nitrogen removal mainstream or tertiary treatment process.
- **Tertiary treatment technologies:** These technologies are employed after biological secondary treatment and solids separation. They are used for nitrification and nitrogen removal of the plant effluent after full secondary treatment.
- **Sidestream treatment technologies:** These technologies are implemented only on the plant biosolids and dewatering streams. They are capable of removing nitrogen in the biosolids/dewatering streams or used to nitrify these streams and seed nitrifiers back to the main process to allow for lower solids retention time (SRT) operation of the mainstream technologies.

5.2 Representative Technology Selection and Process Descriptions

For planning purposes, representative technologies from two categories were selected for evaluation to meet the permit limits laid out in Scenarios 1 and 3. This section describes the representative technologies selected for each scenario, the reasoning behind the selection, and presents a process description of each selected technology. For each Scenario, two to three different technology categories are considered. These options include (from lowest effluent nitrogen to highest effluent nitrogen):

- Scenario 1a – Mainstream Intensification: 4 Stage Modified Bardenpho (4SMB) configuration with membrane bioreactor (MBR) intensification.
- Scenario 1b – Tertiary: Existing plant configuration, tertiary nitrification and denitrification.
- Scenario 3a – Mainstream: Aeration basins operated in the Modified Ludzak-Ettinger (MLE) mode with summer nitrification.
- Scenario 3b – Tertiary: Existing plant configuration, tertiary nitrification and denitrification.
- Scenario 3c – Mainstream Intensification: Integrated fixed film activated sludge (IFAS) intensification of Scenario 3a.

For both Scenarios 1 and 3, it is assumed sidestream treatment would also be employed to manage the nitrogen returned from the future digestion system recycle streams. The representative sidestream process recommended for evaluation is an anammox treatment system. This type of system was selected because it is a proven technology, it is cost effective, and it has a minimal footprint capable of removing up to 90% of the sidestream nitrogen. A process description and flow diagram are presented here.

Anammox-Based Sidestream Treatment

Anammox-based sidestream treatment processes can be used to remove nitrogen from dewatering recycle streams via a shortcut process that reduces overall aeration and alkalinity requirements, while also eliminating carbon demands for denitrification. The shortcut involves allowing only partial nitrification under aerobic conditions, where approximately half of the ammonium is converted to nitrite, followed by anaerobic conversion of ammonium to nitrogen gas using Anammox bacteria. In contrast to a typical denitrification process, where an external carbon source is required to convert nitrate/nitrite to nitrogen gas, the Anammox bacteria can remove ammonia under anaerobic conditions using nitrite as the electron acceptor and carbon dioxide as the carbon source. There are several commercially available processes that utilize Anammox bacteria for sidestream treatment (e.g., DEMON®, ANITA™ Mox, AnammoPAQ™, etc.). A process flow diagram of the DEMON® process is shown in Figure 5-1.

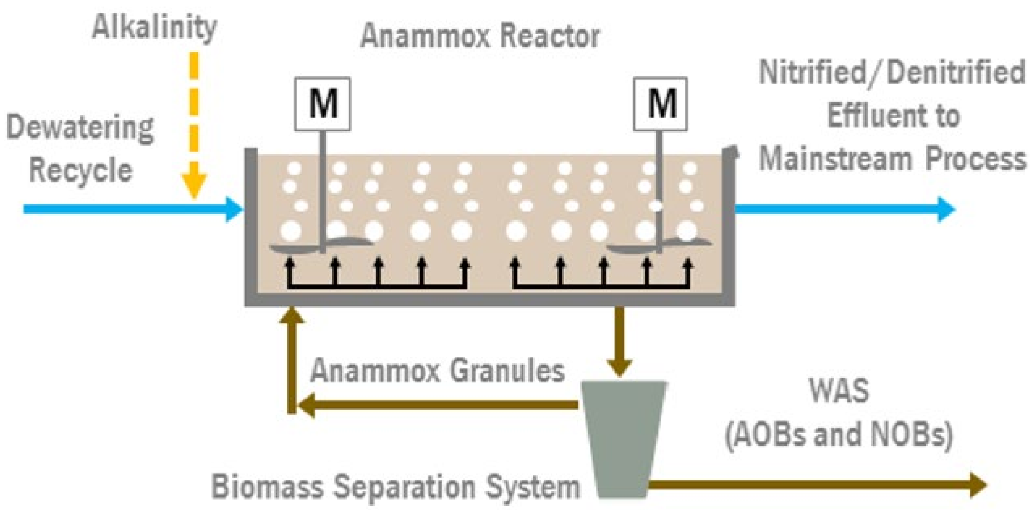


Figure 5-1. Anammox Process Flow Diagram

(example for continuous version of DEMON)

5.2.1 Scenario 1a: 4SMB with MBR Intensification

Scenario 1a assumes an effluent permit limit of 3 mg/L TIN year-round. This evaluation investigates the 4SMB process to meet this limit. This process was chosen because it is the only established secondary treatment process configuration capable of consistently achieving less than 3 mg/L TIN operating for biological nitrogen removal only (i.e., no biological phosphorus removal). It is likely that operating this process to achieve a low level of effluent nitrogen will require intensification. An MBR was selected as the intensification process because it is an established technology at the same scale as Post Point, it provides the smallest footprint (greatest intensification), and conservatively typically carries the highest cost of the intensification technologies. A description of the 4SMB process and MBR treatment is provided below.

4SMB Process

The 4SMB process is an expansion of the MLE process that adds a second set of anoxic and aerobic zones. The mixed liquor leaving the first aerobic zone enters a second anoxic zone where the residual nitrate is further reduced via denitrification. Most frequently, because the soluble carbon has been consumed in the previous two zones, an external carbon source (e.g., methanol) is added to the second anoxic selector to achieve a higher level of nitrogen removal. The second aerated zone serves as a polishing step to nitrify the ammonia formed in the second anoxic zone and to oxidize any residual carbon from the second anoxic zone. Figure 5-2 shows a process flow diagram of the 4SMB process.

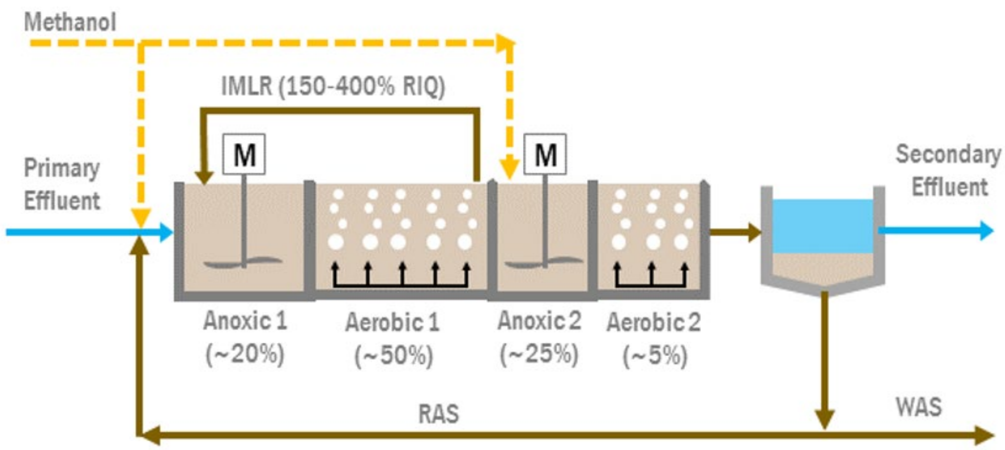


Figure 5-2. 4SMB Process Flow Diagram

MBR Intensification

MBRs operate with highly concentrated mixed liquor suspended solids (MLSS) of approximately 10,000 mg/L, allowing biological performance goals to be met within a smaller basin volume. The MBR configuration does not require secondary clarifiers for solids separation. Rather, a microfiltration or ultrafiltration membrane is used to separate solids from the secondary effluent, resulting in a further reduction in site footprint requirements. However, MBRs typically have high capital costs and higher operational costs than activated sludge with traditional secondary clarifiers. The operational costs are primarily associated with aeration demand required for membrane scouring. Figure 5-3 shows a process diagram of the MBR process.

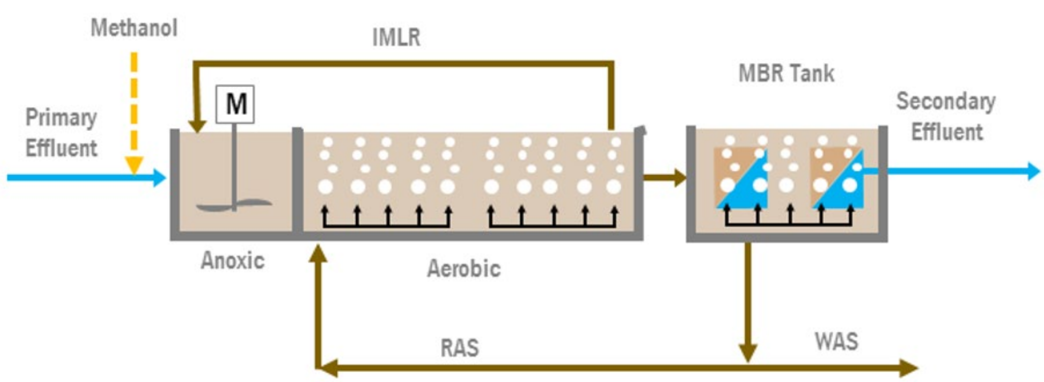


Figure 5-3. MBR Process Flow Diagram

(example of MLE process with MBR for solids separation)

5.2.2 Scenario 1b: Tertiary Nitrification/Denitrification

For this alternative, tertiary nitrification and denitrification processes would be added to complete nitrogen removal without using the existing secondary process. Tertiary processes selected are a biologically active filter (BAF) for tertiary nitrification and denitrification. These were selected because they are established technologies that have been implemented at plants of similar size to Post Point. Tertiary treatment technologies would also offer the least construction disruption to current facility operation. A description of the tertiary technologies selected is below. This scenario also includes sidestream anammox treatment.

Tertiary Nitrifying Fixed Film System

Fixed film processes can be used in tertiary application to support the growth of nitrifying organisms and to prevent washout and decouple hydraulic retention time (HRT) from SRT. With these systems, a fixed film media is required to grow a nitrifying biomass to convert ammonia to nitrate in the secondary effluent. Air is added to support nitrifier growth. Little additional biomass is grown due to low growth rates of nitrifiers and lack of carbon for heterotrophic growth. There are multiple types of these systems, each operating slightly differently. The most commonly used of these are the nitrifying BAF and nitrifying moving bed bioreactor (MBBR), and nitrifying trickling filter (NTF). A process flow diagram of the tertiary BAF process is shown in Figure 5-4.

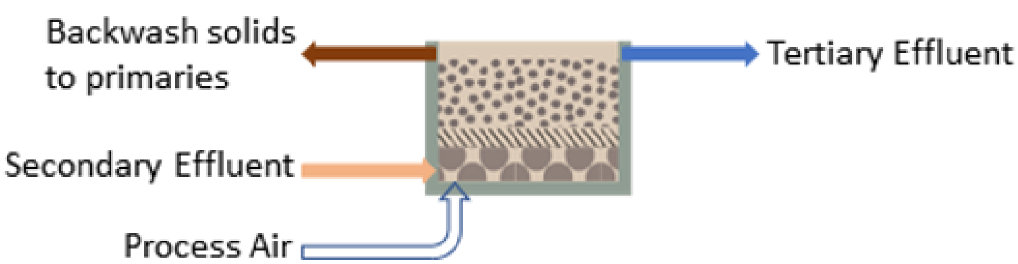


Figure 5-4. Tertiary Nitrifying BAF Process Flow Diagram

Tertiary Denitrifying Fixed Film System

Fixed film processes can also be used in tertiary application to support growth of denitrifying organisms to prevent washout and decouple HRT from SRT. With these systems, a fixed film media is required to grow a heterotrophic denitrifying biomass to convert nitrate in the secondary effluent to nitrogen gas after secondary solids separation. Because this fixed film process requires external carbon input for driving the denitrification process, significant additional biomass growth occurs, and backwash and solids handling is required. There are multiple types of these systems, each operating slightly differently. The most commonly used of these are denitrifying sand filters but a denitrifying second stage to the BAF system could be coupled to minimize the overall tertiary footprint. Both tertiary denitrifying filter technologies would have similar process flow diagram as shown in Figure 5-5. For planning purposes, the BC/Carollo team has selected a 2-stage tertiary BAF system,

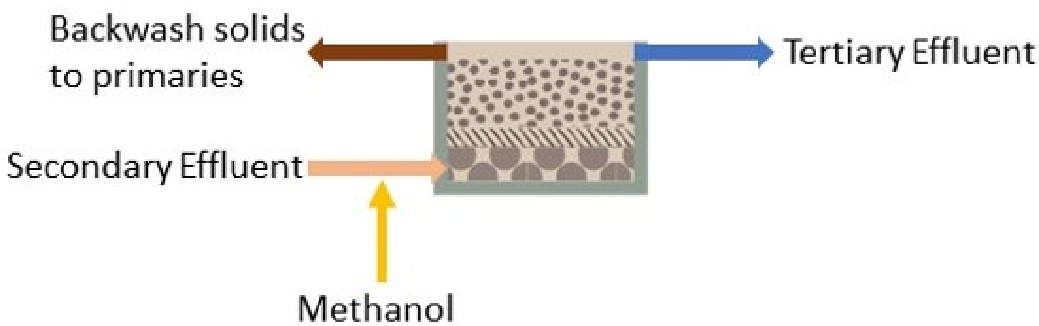


Figure 5-5. Tertiary Denitrifying Upflow Filter Process Flow Diagram

5.2.3 Scenario 3a: MLE Conversion

Scenario 3a looks at an effluent TIN limit of 8 mg/L for the summer (April– October) period. For this scenario, modification to the MLE process was selected for evaluation. This process was selected because it is an established technology capable of achieving effluent TIN limits less than 8 mg/L. It is also the process configuration that requires the least modification to the existing aeration basins. During the winter period, the IMLR pumps would be turned off and the aeration basins would operate in their current anaerobic/oxic (A/O) mode, the current process configuration. For this scenario evaluation, sizing of an MLE system to achieve the effluent TIN requirement will be conducted. If it is determined during the evaluation that the MLE process would not fit on the existing plant footprint without intensification, an intensification technology will be considered at that time. This option also includes sidestream anammox treatment. A description of the MLE process is provided here.

MLE Process

The MLE process is an activated sludge system with an unaerated (anoxic) zone followed by an aerated zone, with an IMLR from the aerated zone to the anoxic zone. Ammonia in the primary effluent passes through the anoxic zone and is oxidized to nitrate in the aerated zone via the nitrification process. The resulting nitrate is denitrified (converted to nitrogen gas) in the anoxic zone by returning a portion of the nitrate-rich mixed liquor from the aerated zone to the anoxic zone through the IMLR. Denitrification uses the carbon available in the wastewater, or an external carbon source (e.g., methanol) can also be added to increase nitrogen removal if the wastewater is carbon limited. Secondary clarifiers separate the biological solids from the clarified effluent. The settled biological solids are returned to the anoxic zone via the RAS flow. A process flow diagram of the MLE process is shown in Figure 5-6.

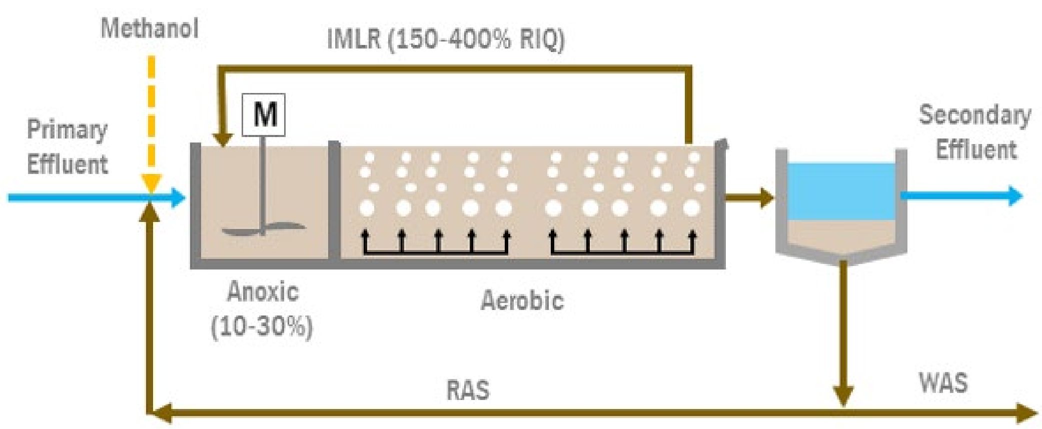


Figure 5-6. MLE Process Flow Diagram

5.2.4 Scenario 3b: Tertiary Nitrification/Denitrification

Scenario 3b looks at the same effluent limit as 3a but maintains the existing treatment process. This alternative would be similar to Scenario 1b and consists of adding (fewer) tertiary nitrification and denitrification processes to complete nitrogen removal without using the existing secondary process. Tertiary processes selected are a BAF for tertiary nitrification and denitrification.

5.2.5 Scenario 3c: IFAS Intensification

Scenario 3c looks at the same effluent limit as 3a but intensifies the existing process. This intensification allows for the existing aeration basins to operate at a longer SRT, thus allowing for nitrification and denitrification to occur. Several intensification process are available including: IFAS, BioMag and InDense. The intensification process selected is an IFAS system. This process was selected because it is an established technology that have been implemented at plants of similar size to Post Point. A description of the IFAS process is provided below. This scenario also includes sidestream anammox treatment.

IFAS System

The IFAS system is similar to the conventional activated sludge nitrification and denitrification process described for Scenario 3a in that they both typically use aeration and clarification tanks for treatment. One advantage of intensification with IFAS is that they reduce the size of aeration tanks needed for biological nitrification. This is accomplished by adding media (plastic pieces, ropes, or sponges) to the aeration tanks. Bacteria grow on the surface of the media in a “fixed film,” and effectively increase the amount of bacteria that can be held within a given tank size. Figure 5-7 provides a process flow diagram for an IFAS process.

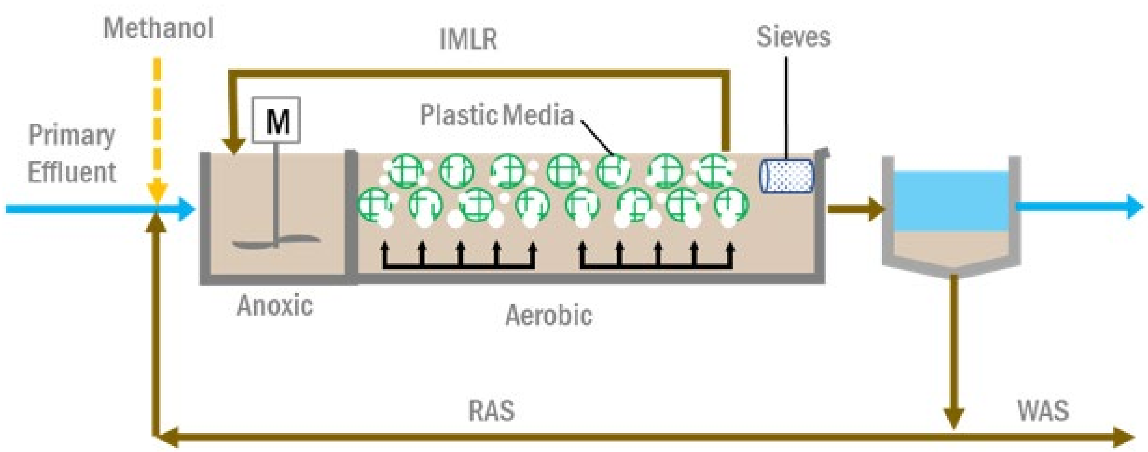


Figure 5-7. IFAS Process Flow Diagram

Section 6: Process Modeling Assumptions and Results

The planning-level implications of each of the representative technologies associated with the two nutrient Scenarios were evaluated using a calibrated whole plant model developed in BioWin version 6.1 as discussed in TM No. 3 – Flows and Loads. Due to uncertainty in the influent solids measurements, the model was calibrated using three different assumptions for the influent loads. These results were presented to the City in May of 2020 and the Project Team decided to use the middle calibration (Calibration 3) provided in Table 6-1.

Table 6-1. Calibration Summary

Parameter	Measured Data (Year 2019)	Calibration 3: 8% Less than Measured Influent Data
Influent biochemical oxygen demand (BOD), ppd	21,345	20,429 (4% low)
Influent total suspended solids (TSS), ppd	24,256	21,999 (8% low)
Primary Effluent BOD, ppd	13,762	13,509
Primary Effluent TSS, ppd	8,569	8,878
Primary Sludge, ppd	9,099	15,782 (73% high)
Mixed Liquor Suspended Solids, mg/L	1,513	1,571
Aerobic Solids Retention Time (aSRT), days	1.73	1.73
WAS, ppd	12,130	11,933
Thickened solids, ppd	23,366	26,052 (11% high)
Dewatered solids, ppd	21,919	25,140 (13% high)
Influent chemical oxygen demand (COD) characterization	**BioWin Default**	**Calibration 3: 8% Less than Measured Influent Data**
Fraction of unbiodegradable COD (Fup)	0.13	0.23
COD/volatile suspended solids (VSS) of unbiodegradable VSS	1.6	1.7

Abbreviations: Fup - unbiodegradable fraction of the influent COD; ppd - pound(s) per day

This section summarizes the process modifications and results made to the calibrated BioWin model to reflect the different nutrient scenarios projected to the year 2045 maximum month flows and loads (refer to TM No. 3). Ancillary equipment impacts are shown in the subsequent layout and costing sections. Since Scenarios 1a and 1b dealt with nitrogen removal during the entire year, the projected maximum month wet weather flows (MMWWFs) were coupled with the maximum month loads for more conservative model simulations. Since Scenarios 3a, 3b and 3c dealt with nitrogen removal during the summer months, the projected maximum month dry weather flows (MMDWF) were coupled with the projected maximum month loads.

All scenarios assume that the future permits would continue to allow for flow blending (Special Condition S12) during wet weather conditions where Post Point experiences periods of flow that exceeds its secondary treatment capacity (37 mgd). For the purposes of this planning impact study, the BC/Carollo Team assumed that the peak instantaneous flow through secondary/tertiary treatment would equal to 140% of the year 2045 projected MMWWF or 45.7 mgd to account for diurnal variability. Flows in excess of 45.7 mgd would be treated through primary treatment, diverted around secondary/tertiary treatment, and disinfected prior to discharge.

6.1 Scenario 1a: 4SMB with MBR Intensification + Deammonification

Table 6-2 presents the model assumptions for Scenario 1a; Table 6-3 summarizes the layout implications of Scenario 1a. Scenario 1a modifies the existing process to meet the most stringent anticipated future TIN limit of 3 mg/L year-round as follows:

- Adds fine screening downstream of primary clarification.
- Demolishes two of the secondary clarifiers and replacing that footprint with MBR tanks.
- Provides additional primary clarifier capacity by converting one of the existing secondary clarifiers to a primary clarifier.
- Converts all existing activated sludge basins (ASBs) to a 4SMB process and adding one additional ASB. The RAS from the MBR is deoxygenated in the first two zones of the selector tank with the influent being added to the third zone of the selector. ASB1 acts the anoxic zone with MLSS from the anoxic zone routed to the three existing and one new ASBs (2-5). The first two thirds of ASBs 2-5 act as the aerobic zone with the final third of ASBs 2-5 acting as the post-anoxic zone. Methanol is assumed to be added to the post anoxic zone to further reduce the effluent nitrate. The membrane tank acts as the reaeration zone.
- Handle the majority of the ammonia load returned from the anaerobic digestion process using a sidestream deammonification process prior to secondary treatment.

Table 6-2. Scenario 1a Model Assumptions

Parameter	Value
Design condition	MMWWF
Modeled Temperature	11 degrees Celsius
Primary Clarification	Convert 1 secondary clarifier to a primary clarifier
Primary Clarifier TSS removal	60%
Peak flow through secondary treatment	45.7 mgd (1.4 x projected 2045 MMWWF)
Fine Screening	Required
ASB configuration	4SMB
ASB Fractions	
Deoxygenation	8% (2/3 of Selector Basin)
Anoxic	21% (1/3 of Selector Basin + ASB1)
Aerobic	41% (part of ASBs 2-5)
Post-anoxic	21% (part of ASBs 2-5)
Reaeration	8% (membrane tank)
Return activated sludge flow	4 x influent flow
aSRT	10 days
MLSS	8,000 mg/L aeration basin; 10,000 mg/L membrane tank
Methanol dose	900 gallons per day
Max month and peak membrane flux	12 gfd (MMWWF); 17 gallons per square foot per day (peak)
Deammonification process	Dewatering return ammonia converted to: 80% N_2, 10% ammonia, 10% nitrate
Redundancy	1 aeration basin out of service during the summer, 1 MBR tank out of service at all times

Abbreviation: N_2 - Nitrogen gas.

Table 6-3. Scenario 1a Layout Implications

Parameter	Value
Primary clarification	Convert 1 secondary clarifier to a primary clarifier
Fine Screening	Required for peak flow through secondary treatment.
ASBs	1 new ASB
Modifications to the existing ASBs	• Re-route influent to be feed into third zone of selector tank • Baffle wall dividing the second and final third of ASBs 2-4 • Mixers added to the final third of ASBs 2-4 • External carbon feed • Alkalinity feed
Blower Building Modifications	Swap out two small blowers for two larger (6,500 standard cubic feet per minute [scfm]) blowers; add one additional large blower (6,500 scfm).
RAS Modifications	Replace RAS pump station with a pump station in the MBR building capable of pumping up to 130 mgd.
MBR tanks	8 tanks total with 20 cassettes/tank and space for 22 cassettes/tank (3,078,000 square feet [sf] firm)
Dewatering return treatment	Deammonification process

6.2 Scenario 1b: Tertiary Nitrification/Denitrification + Deammonification

In lieu of modifying or demolishing existing infrastructure, Scenario 1b adds onto the existing process to meet the most stringent anticipated future TIN limit of 3 mg/L year round as follows:

- Adds fine screening downstream of primary clarification.
- Adds a two stage BAF process. The tertiary Biologically Active Filter (BAF) process converts most of the ammonia present in the secondary effluent to nitrogen gas.
- Uses chemically enhanced primary treatment (CEPT) to maintain a minimum primary treatment performance level during high flow.
- Handles the majority of the ammonia load returned from the anaerobic digestion process using a sidestream deammonification process prior to secondary treatment.

No changes are required to the existing secondary treatment process. Table 6-4 summarizes the model assumptions for Scenario 1b; Table 6-5 summarizes the layout implications of Scenario 1b.

Table 6-4. Scenario 1b Model Assumptions

Parameter	Value
Design condition	MMWWF
Modeled Temperature	11°C
CEPT	Yes, 25 mg/L dose as polyaluminum chloride (PAX) when flow exceeds 23 mgd
Primary Clarifier TSS removal	60%
Peak flow through secondary treatment	45.7 mgd (1.4 x projected 2045 MMWWF)
ASB configuration	A/O
ASB Fractions	
Anaerobic	17%
Aerobic	83%
Return activated sludge flow	40% of influent flow
aSRT	2.0 days
MLSS	3,000 mg/L
Methanol dose	3,800 gpd [1]
Backwash solids	9,933 ppd [1]
Deammonification process	Dewatering return ammonia converted to: 80% N_2, 10% ammonia, 10% nitrate
Redundancy	• 1 aeration basin or secondary clarifier out of service during the summer • 1 BAF-nitrification and denitrification tank in backwash all times

1. Vendor provided values, scaled to projected MMWWF ammonia loads.

Table 6-5. Scenario 1b Layout Implications

Parameter	Value
Primary clarification	No new primary clarifiers; CEPT used when flows exceed 23 mgd
ASBs	No new ASBs
Modifications to the existing aeration basins	None
RAS pump station	1 additional pump
Biological aerated filter	• BAF pump station • Nitrification stage = 8 total filters (1,600 sf each) • Denitrification stage = 5 filters (1,150 sf each) • External carbon feed • Alkalinity feed
Dewatering return treatment	Deammonification process

6.3 Scenario 3a: MLE Conversion + Deammonification

Table 6-6 summarizes the model assumptions for Scenario 3a while Table 6-7 summarizes the layout implications of Scenario 3a. Scenario 3a modifies the existing process to meet the moderate future TIN limit of 8 mg/L during the summer by converting the existing aeration basins from an A/O process to a MLE process as follows:

- Uses CEPT to maintain a minimum primary treatment performance level during high flow.
- Converts all ASBs to a MLE process. RAS from the secondary clarifiers and primary effluent is routed to the first zone of the selector basin. The selector basin and ASB number 1 act as the anoxic zones with MLSS from the anoxic zones routed to the three existing and three new ASBs (2-7). Methanol is assumed to be added to the anoxic zone to further reduce the effluent nitrate.
- Handles the majority of the ammonia load returned from the anaerobic digestion process using a sidestream deammonification process prior to secondary treatment.

Table 6-6. Scenario 3a Model Assumptions

Parameter	Value
Design condition	MMDWF
Modeled Temperature	13.5°C
CEPT	Yes, 25 mg/L dose of PAX when flow exceeds 23 mgd
Primary Clarifier TSS removal	60%
Peak flow through secondary treatment	45.7 mgd (1.4 x projected 2045 MMWWF); 39.9 mgd dry season peak
ASB configuration	MLE
ASB Fractions	
Anoxic	24%
Aerobic	76%
IMLR flow	250% of influent flow
RAS flow	40% of influent flow
aSRT	7 days
MLSS	3,000 mg/L
Methanol dose	275 gpd during the summer, none required in the winter
Deammonification process	Dewatering return ammonia converted to: 80% N_2, 10% ammonia, 10% nitrate
Redundancy	1 aeration basin or secondary clarifier out of service during June–September or during the winter.

Table 6-7. Scenario 3a Layout Implications

Parameter	Value
Primary clarification	CEPT for flows greater than 23 mgd
ASBs	3 new ASBs
Modifications to the existing aeration basins	• Add mixers to ASB1 • IMLR pumping • External carbon feed • Alkalinity feed
Blower Building Modifications	Swap out one small blowers for one larger blower (6,500 scfm blower)
RAS Pump Station	1 additional pump
Dewatering return treatment	Deammonification process

6.4 Scenario 3b: Tertiary Nitrification/Denitrification + Deammonification

Similar to Scenario 1b, Scenario 3b adds onto the existing process to meet the moderate anticipated future TIN limit of 8 mg/L during the summer as follows:

- Adds fine screening downstream of primary clarification.
- Adds a two-stage BAF process (smaller than Scenario 1b). The tertiary BAF process converts most of the ammonia present in the secondary effluent to nitrogen gas.
- Uses CEPT to maintain a minimum primary treatment performance level during high flow.
- Handles the majority of the ammonia load returned from the anaerobic digestion process using a sidestream deammonification process prior to secondary treatment.

No changes are required to the existing secondary treatment process. Table 6-8 summarizes the model assumptions for Scenario 3b while Table 6-9 summarizes the layout implications of Scenario 3b.

Table 6-8. Scenario 3b Model Assumptions

Parameter	Value
Design condition	MMDWF
Modeled Temperature	13.5 °C
CEPT	Yes, PAX dose of 25 mg/L when flow exceeds 23 mgd
Primary Clarifier TSS removal	60%
Peak flow through secondary treatment	45.7 mgd (1.4 x projected 2045 MMWWF); 39.9 mgd during the dry season
ASB configuration	A/O
ASB Fractions	
Anaerobic	17%
Aerobic	83%
Return activated sludge flow	40% of influent flow
aSRT	2.0 days
MLSS	3,000 mg/L
Methanol dose	3,300 gpd during the summer, no methanol required during the winter [1]
Backwash solids	9,300 ppd [1]
Deammonification process	Dewatering return ammonia converted to: 80% N_2, 10% ammonia, 10% nitrate
Redundancy	• 1 aeration basin or secondary clarifier out of service during the summer • 1 BAF nitrification and denitrification tank in backwash at all times

1. Vendor provided values, scaled to projected MM ammonia loads.

Table 6-9. Scenario 3b Layout Implications

Parameter	Value
Primary clarification	No new primary clarifiers; CEPT used when flows exceed 23 mgd
ASBs	No new ASBs
Modifications to the existing aeration basins	None
RAS pump station	1 additional pump
Biological aerated filter	• BAF pump station • Nitrification stage = 7 total filters (1,600 sf each) • Denitrifications stage = 5 filters (800 sf each) • External carbon feed • Alkalinity feed
Dewatering return treatment	Deammonification process

6.5 Scenario 3c: IFAS Intensification + Deammonification

Scenario 3c modifies the existing process to meet the moderate future TIN limit of 8 mg/L during the summer as follows:

- Using CEPT to maintain a minimum primary treatment performance level during high flow.
- Intensifying the existing ASBs using an IFAS system. Due to the hydraulic constraints of the IFAS process, no IMLR was assumed and instead the nitrified ammonia is denitrified with an external carbon source. RAS from the secondary clarifiers and primary effluent is routed to the first zone of the selector basin. Two additional ASBs are required and the process flow train is converted to a five stage process: (1) aerobic without media - Selector Basin; (2) aerobic with media - ASB1 and first portion of ASBs 2-6; (3) deoxygenation zone, aerobic without media - second part of ASBs 2-6; (4) anoxic with external carbon, no media - third part of ASBs 2-6; (5) re-aeration zone, aerobic without media - fourth part of ASBs 2-6.
- Handling the majority of the ammonia load returned from the anaerobic digestion process using a sidestream deammonification process prior to secondary treatment.

Table 6-10 summarizes the model assumptions for Scenario 3c while Table 6-11 summarizes the layout implications of Scenario 3c.

Table 6-10. Scenario 3c Model Assumptions

Parameter	Value
Design condition	MMDWF
Modeled Temperature	13.5°C
CEPT	Yes, 25 mg/L dose of PAX when flow exceeds 23 mgd
Primary Clarifier TSS removal	60%
Peak flow through secondary treatment	45.7 mgd (1.4 x projected 2045 MMWWF); 39.9 mgd dry season peak
ASB configuration	Three-stage nitrification/denitrification
ASB Fractions	
Aerobic – no media	12% (Selector Basin)
Aerobic – media	43% (ASB1 + part of ASBs 2-6)
Deoxygenation (Aerobic) – no media	7% (part of ASBs 2-6)
Anoxic	33% (part of ASBs 2-6)
Re-aeration (Aerobic) – no media	5% (part of ASBs 2-6)
Media specific surface area	244 square feet/cubic feet
Total media	34,600,000 square feet
Mixed liquor return flow	none
Return activated sludge flow	40% of influent flow
aSRT	7 days
MLSS	3,200 mg/L
Methanol dose	1,040 gpd
Redundancy	1 aeration basin or secondary clarifier out of service during June – September or during the winter

Table 6-11. Scenario 3c Layout Implications	
Parameter	**Value**
Primary clarification	CEPT for flows greater than 23 mgd
ASBs	2 new ASBs
Modifications to the existing aeration basins	• Diffusers to Selector Basin • Media and media retention screens to ASBs 1 - 6 • 4 baffle walls in ASBs 2-6 • Mixers in anoxic zones of ASBs 2-6 • External carbon feed • Alkalinity feed
Blower Building Modification	Swap out two small blowers for two larger (6,500 scfm) blowers; add one additional large blower (6,500 scfm)
RAS Pump Station	1 additional pump
Dewatering return treatment	Deammonification process

6.6 Scenarios Evaluation and Layout Implications

The planning-level implications of each of the representative technologies associated with the two nutrient Scenarios were presented individually for each scenario in previous sections. This section and Table 6-12 summarize the findings reviewed before and provides a holistic comparison among the potential scenarios as follows:

- Scenario 1a (Mainstream Intensification for the Worst Case scenario) is the only scenario that requires conversion of one of the existing secondary clarifiers to primary clarification. However, only this scenario does not require the use of CEPT. Additionally, this is the only scenario that requires a new RAS pump station and MBR tanks.
- All scenarios require alkalinity adjustment at primary clarification and dewatering return treatment.
- Fine screening is required for both scenarios when a tertiary process is added to reduce nitrogen (Scenario 1b and 3b) and for the Worst Case scenario with mainstream intensification (Scenario 1a).
- No additional new ASBs, modifications to the existing ASBs or modifications to the existing blower building are required for both scenarios when a tertiary process is added to reduce nitrogen (Scenarios 1b and 3b). However, these scenarios require a significant addition of external carbon for denitrification.

Table 6-12. Bellingham Nitrogen Removal Scenarios – Layout Implications

Parameter	Worst Case: TIN < 3 mg/L Year-Round		Moderate Case: TIN < 8 mg/L During the Summer		
	Mainstream Intensification	Tertiary Process	Mainstream	Tertiary Process	Mainstream Intensification
Primary Clarification	Convert 1 secondary clarifier to a primary clarifier	No new primary clarifiers	No new primary clarifiers	No new primary clarifiers	No new primary clarifiers
Alkalinity feed to primaries	yes	yes	yes	yes	yes
Chemically enhanced primary treatment	no	yes	yes	yes	yes
Fine Screening	yes	yes	no	yes	no
ASBs	1 new ASB	No new ASBs	3 new ASBs	No new ASBs	2 new ASBs
Modification to existing aeration basins	• Re-route influent to be feed into third zone of selector tank • Baffle wall dividing the second and final third of basins 2-4 • Mixers added to the final third of basins 2-4	None	• Add mixers basin 1 • Mixed liquor return pumping	None	• Diffusers to Selector Basin • Media and media retention screens to basin 1 • Four baffle walls in basins 2-6 • Mixers in anoxic zones of basins 2-6
External carbon feed	Minimal	Greatest	Minimal	Greatest	Moderate
Blower Building Modifications	Swap out two small blowers for two larger blowers; add 1 large blower	No	Swap out one small blower for a larger blower	No	Swap out two small blowers for two larger blowers; add 1 large blower
RAS Pump Station	New RAS pump station in MBR building to pump 130 mgd	1 additional pump	1 additional pump	1 additional pump	1 additional pump
MBR Tanks	Eight tanks with space for 22 cassettes per tank	NA	NA	NA	NA
Tertiary Process	NA	• Tertiary feed pump station • Nitrification stage = 8 filters • Denitrification stage = 5 filters	NA	• Tertiary feed pump station • Nitrification stage = 8 filters • Denitrification stage = 5 filters	NA
Dewatering Return Treatment	Deammonification process	Deammonification process	Deammonification process	Deammonification process	Deammonification process

Section 7: Layouts

7.1 Major Assumptions

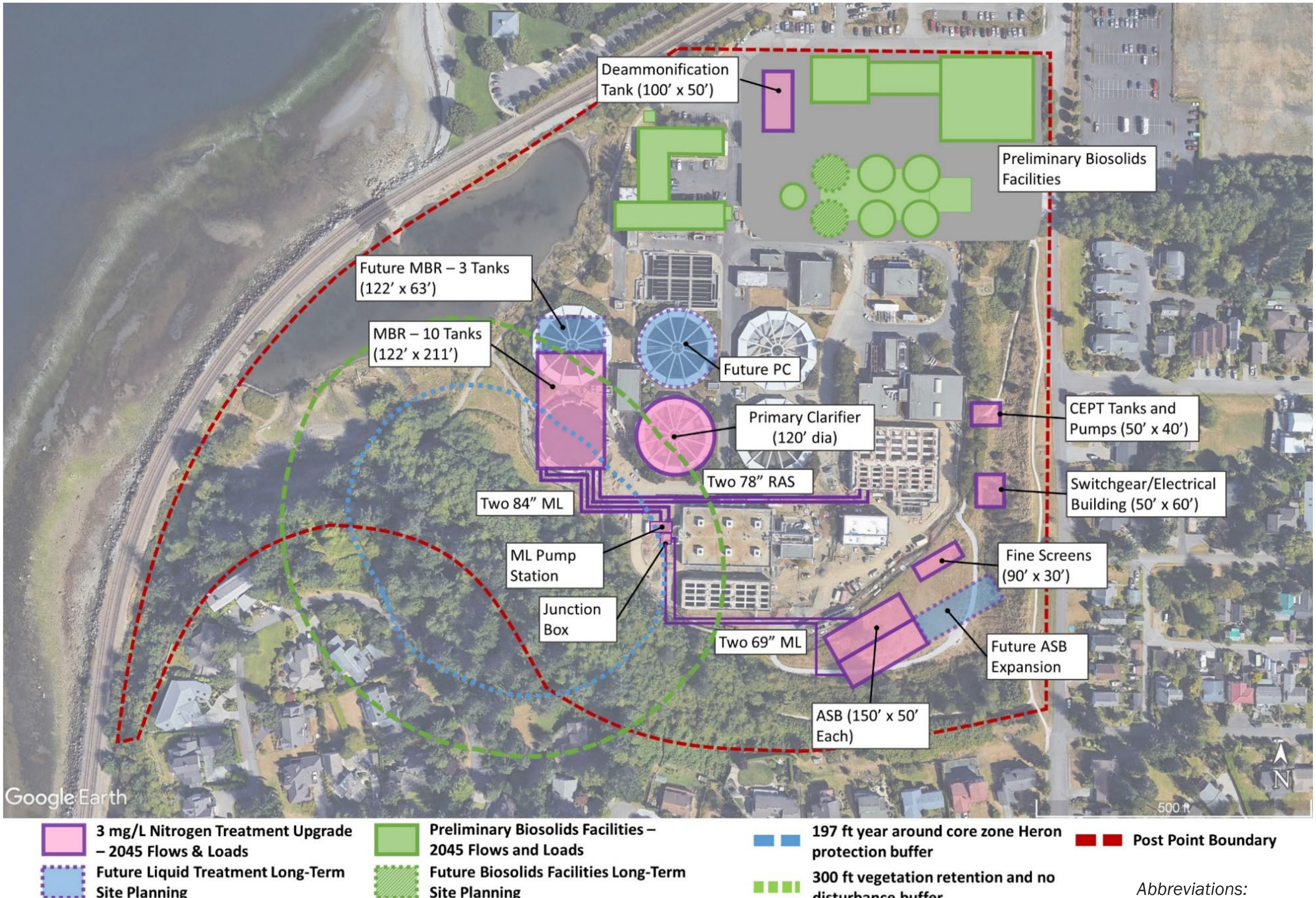
The site layouts for the scenarios shown in Section 7.2 were developed without comprehensive evaluations of Post Point's site/civil, environmental, structural, and geotechnical conditions. These layouts are conceptual and assume the following:

- Reasonably achievable constructability and sequencing of construction.
- Process sizing using year 2045 flows and load established in TM No. 3 – Flows and Loads Projections.
- Ability to potentially construct in the heron protection and no disturbance boundaries.
- Ability to construct in the open space in the southeast corner of the plant.

7.2 Layouts

Conceptual layouts were developed for the five scenarios taking into consideration the following limitations:

- Limited space at Post Point would require utilization of the northeastern, eastern, and southeastern areas of the property.
- The southeastern and eastern areas have steep slopes and would require moderate to major excavation and geotechnical work.
- Limited availability of surveys for subsurface utilities.
- Layouts considered the feasibility of bypassing processes, operating temporary treatment systems, or maintaining existing treatment processes in operation during construction.
- Post Point is located adjacent to Bellingham Bay and is home to several environmentally sensitive areas. One of the few Great Blue Heron rookeries in the state is located in between privately owned property and the plant's Southwestern corner. It is the last colony in Bellingham and is considered of great importance to the City and to the Community. The Post Point Lagoon located just west of the rookery is one of only seven remaining pocket estuaries in the bay. This lagoon habitat plays a vital role in the local ecosystem and is a foraging habitat for the Great Blue Herons. The layouts were developed to avoid as much negative impacts to these areas as possible. The City does not support impacting these areas and scenarios that required construction in these areas were viewed less favorably.
- Site layouts included facility treatment requirements for year 2045 flows and loads shown in pink shaded shapes. Blue shaded shapes represent future liquid treatment for long-term site planning. Green shapes represented components of the preliminary biosolids facilities.
- Preliminary layouts for the biosolids facilities and integrated administration building have been sited in the northeastern area of Post Point.
- The layouts presented here have been modified and further refined since they were presented to the City in May of 2020 (Appendix B).



Abbreviations:
ML – Mixed Liquor;
PC – Primary Clarifier

Figure 7-1. Scenario 1a: 4SMB with MBR Intensification + Deammonification

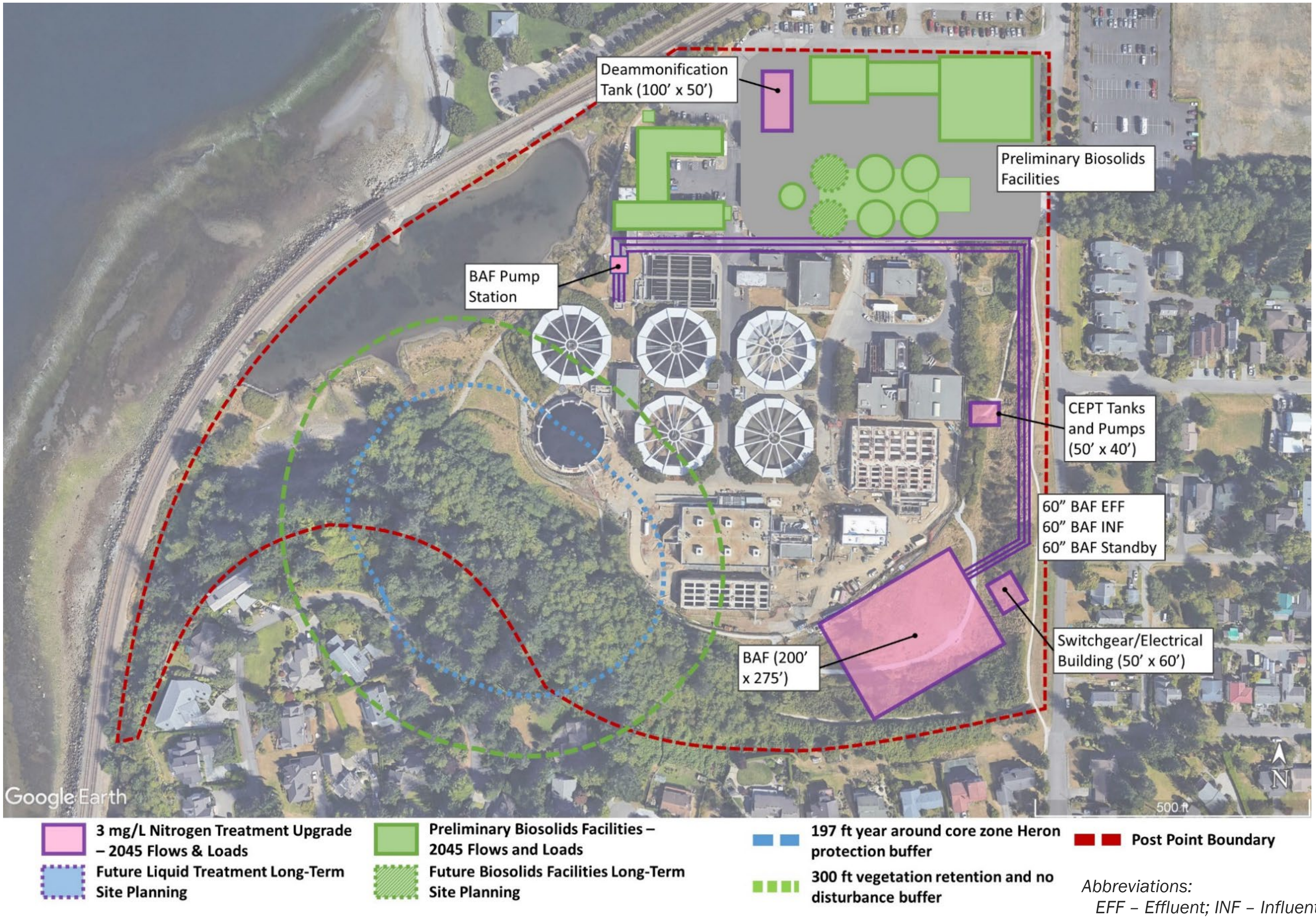


Figure 7-2. Scenario 1b: Tertiary Nitrification/Denitrification + Deammonification

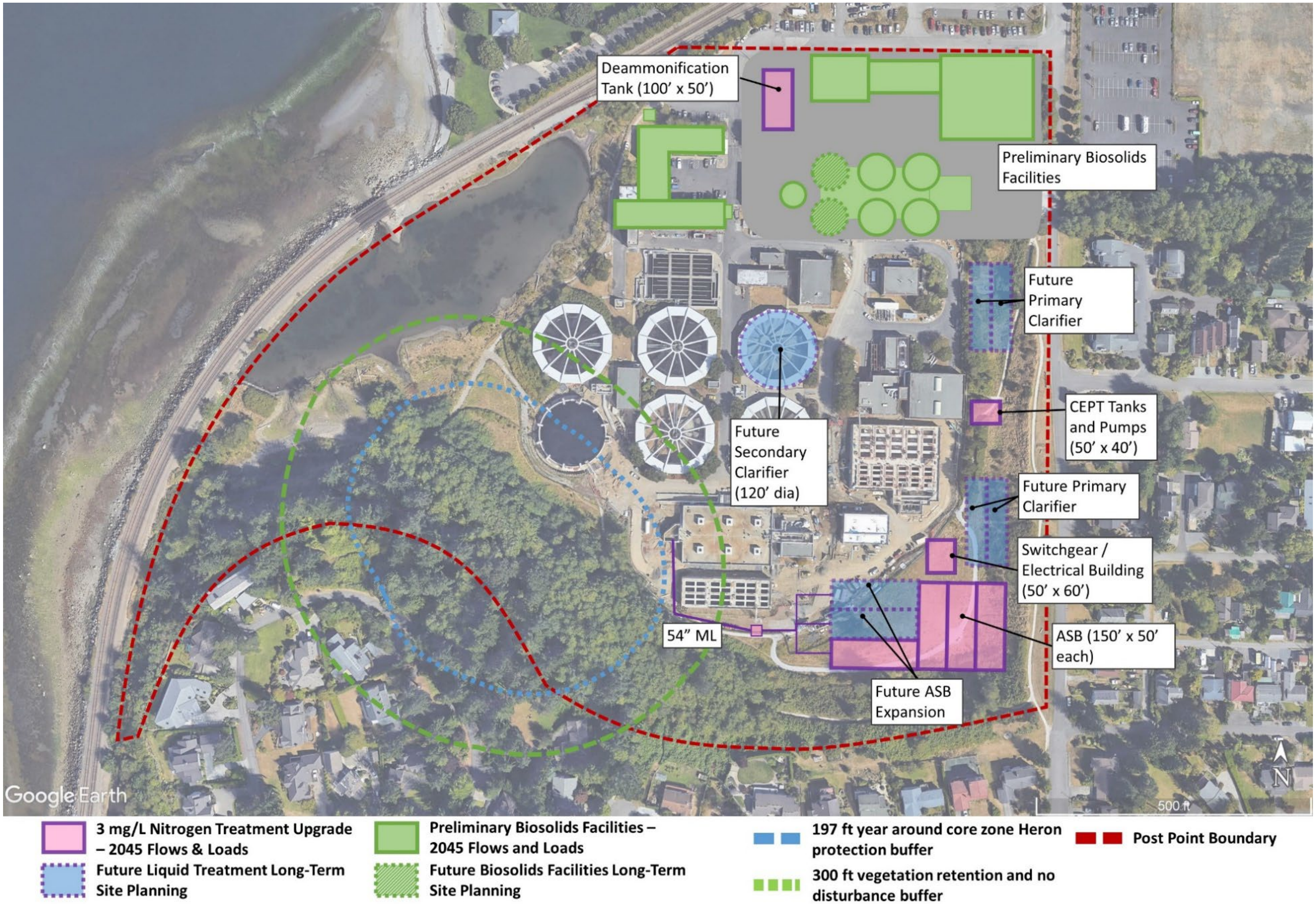


Figure 7-3. Scenario 3a: MLE Conversion + Deammonification

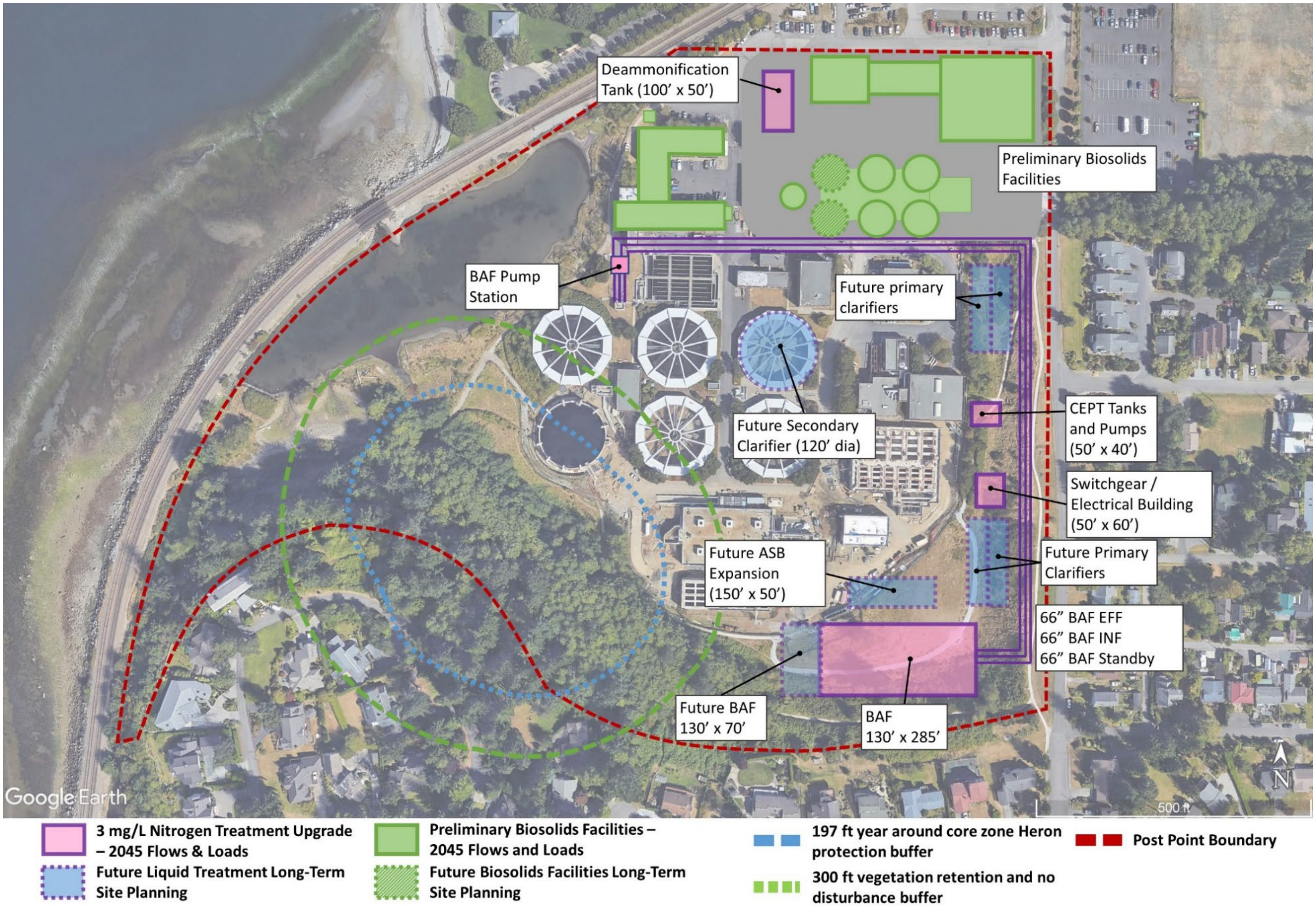


Figure 7-4. Scenario 3b: Tertiary Nitrification/Denitrification + Deammonification

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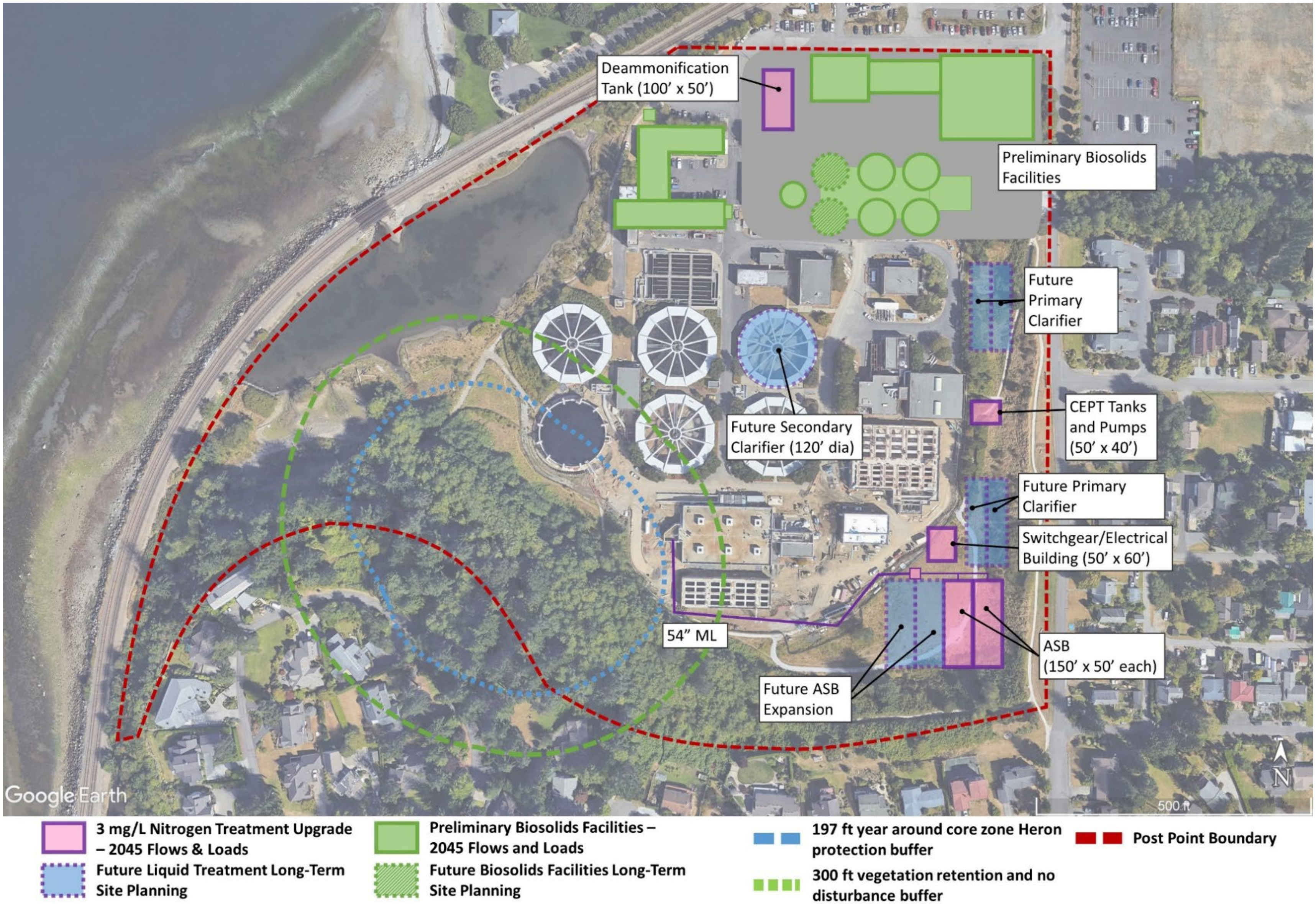


Figure 7-5. Scenario 3c: IFAS Intensification + Deammonification

7.3 Advantages/Disadvantages Comparison

The scenarios would have a varying degree of impacts to the existing treatment plant site and processes based on the technology and nutrient limit. This section provides a general description and comparison of the different scenarios. Table 7-1 provides a summary of the scenario layouts and their impacts.

Table 7-1. Scenario Impact Summary and Comparison

Scenarios	Limit Type	Construction and New Facilities up till 2045			
		No Major Impacts to Existing Infra./Rehab	Outside Heron Protection Boundary	Outside Southeast Open Space	Construction Considerations
1a	3 mg/L Year-round	X	X	X	• Significant rehab and demolition of existing facilities • Complex and challenging staging requirements • Major construction in environmentally sensitive areas
1b	3 mg/L Year-round	✓	✓	X	• Moderate to major excavation and geotechnical work required for new facilities and piping/conduits • Capacity limited with no capability for treatment expansion beyond 2045 flows and loads
3a	8 mg/L Summer only	✓	✓	X	• Moderate to major excavation and geotechnical work required for new facilities • Piping through part of the Heron Vegetation Retention and No Disturbance Buffer
3b	8 mg/L Summer only	✓	✓[1]	X	• Moderate to major excavation and geotechnical work required for new facilities and piping/conduits
3c	8 mg/L Summer only	✓	✓[1]	X	• Moderate excavation and geotechnical work required for new facilities • Piping through part of the Heron Vegetation Retention and No Disturbance Buffer

1. Some impacts within 300 ft Vegetation Retention and No Disturbance Buffer.

A red X symbol means a new infrastructure or modifying an existing system is required for a particular scenario to achieve the nitrogen removal goal. A green ✓ symbol means a particular scenario does not need a new infrastructure or any modification to the existing systems to achieve the nitrogen removal goal.

Scenario 1A would result in major demolition of existing infrastructure including Secondary Clarifier No. 3 and No.4 to fit the new MBR tanks. Secondary Clarifier No.2 would also be retrofitted into a primary clarifier while Secondary Clarifier No. 1 would be retrofitted beyond 2045. Additional Activated Sludge Basins would be constructed in the open space to the southeast of the plant. Major piping for the mixed liquor, RAS, and other recycle lines would run northwest around the Activated Sludge Basin No. 2 and No. 3 from the activated sludge basins to the MBR which would cross into the heron protection and no disturbance buffers. The requirements for construction in these areas will likely create challenges with environmental and community groups that oppose any actions that could directly or indirectly impact the heron rookery. The City has also expressed strong opposition to plans that would negatively impact the heron rookery and as a result, this scenario is unfavorable. The sequencing of construction is more complex for this scenario due to the demolition of the existing operational unit processes.

Scenario 1B would construct a tertiary BAF facility in the open space to the southeast. This area is abutted by high slopes to the south and east and would require moderate to major excavation and geotechnical work. No major demolition is required of existing mainstream treatment facilities and most major piping is routed around the perimeter of the existing plant. Two large conduits would be used to carry influent and effluent flow to and from the BAF facility that would be routed along the eastern edge of the plant and then routed west to the Chlorine Contact Tanks. One additional conduit would act as a standby pipe. The eastern perimeter of Post Point has high slopes that may present some challenges for construction. No construction or other activities are required within the heron disturbance and protection buffers. This scenario does not include construction after year 2045 due to site capacity constraints.

Scenario 3A constructs four additional activated sludge basins in the southeastern corner of the plant. These aeration sludge basins are located in areas of high slope and would require moderate to major excavation and geotechnical work. Space for two additional activated sludge basins are allocated for future construction. Secondary effluent pipes would be routed west from the new activated sludge basins to run along existing Aeration Basin 4. A set of four future primary clarifiers would be allocated in the eastern side of the plant where there are high slopes. No requirements for major plant process demolition and retrofits are needed to meet year 2045 flows and loads. However, future capacity expansions would require the conversion of existing Primary Clarifier No. 1 to a secondary clarifier and replacing the lost primary clarifier capacity with new primary clarifiers.

Scenario 3B is similar to Scenario 1b which would construct a tertiary BAF facility in the open space in the southeast area of the plant. This BAF is smaller in size and is sited further south on the steep slope which would require moderate to major excavation and geotechnical work. No major demolition is required of existing mainstream treatment facilities and most major piping is routed around the perimeter of the existing plant. Two major conduits would carry influent and effluent flow to and from the BAF facility that would be routed along the eastern edge of the plant and then routed west to the Chlorine Contact Tanks. One additional conduit was included as a standby pipe. The eastern perimeter of Post Point has high slopes that may present some challenges for construction. A set of four future primary clarifiers would also be sited in this area. No construction or other activities are required within the heron disturbance and protection buffers. No requirements for major plant process demolition and retrofits are needed to meet year 2045 flows and loads. Future capacity expansions would require the conversion of existing Primary Clarifier No. 1 to a secondary clarifier.

Scenario 3C would construct two additional activated sludge basins in the open space in the southeast area of the plant. The activated sludge basins are sited on the face of a hill which would require moderate to major excavation and geotechnical work. Piping from these activated sludge basins would be piped to the junction chamber located west of Activated Sludge Basin No.2 and would require construction in the heron no disturbance buffer. A set of four future primary clarifiers would on the eastern perimeter where there are high slopes. No requirements for major plant process demolition and retrofits are needed to meet 2045 flows and loads. Future capacity expansions would require the conversion of existing Primary Clarifier No. 1 to a secondary clarifier.

Section 8: Planning Level Cost Opinions

All the representative technologies modeled for the two Scenarios to meet the 20-year planning horizon were determined to reasonably fit within the existing Post Point property limits with varying levels of modifications to the existing infrastructure. For long-term planning purposes, the BC/Carollo team provided an order of magnitude cost opinion for the addition of a tertiary process for each Scenario. Of the technology categories reviewed, the construction of a new downstream process would likely be the least disruptive and lowest risk to current daily plant operations.

8.1 Capital Costs

The expected level of accuracy for this cost estimate follows the Recommended Practice 18R-97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented.

The capital improvements cost and the basis of cost opinion were developed for two of the five modeled scenarios:

- Scenario 1b – year-round nitrogen removal with a tertiary process to 3 mg/L N.
- Scenario 3b – summer only nitrogen removal with a tertiary process to 8 mg/L N.

These two scenarios were selected to as they represented alternatives that could fit within the constraints of the site with the least modifications to the existing plant conveyance system.

Construction costs include contractor-related costs, such as materials, labor, equipment involved in the installation, subcontractor costs, and indirect costs (i.e., contractor mobilization, demobilization, startup, commissioning, warranties, and sales tax). Planning level construction costs for wastewater facilities and associated infrastructure are typically estimated with one or more of the following approaches:

- Cost curve derived from as-builts costs of similar systems.
- Vendor-supplied costs for major equipment.
- Major-item quantity estimates with percentage allowances.

Estimated construction costs are presented in 2020 dollars. Indirect construction cost factors include:

- Estimator's contingency (40%).
- Contractor general conditions (15%).
- Contractor overhead and profit (20%).
- Bellingham, Washington, sales tax (8.7%).

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 the owner must bear, such as engineering services, planning/management services, permitting and agency support, owner labor, project contingency, and initiatives. Non-construction costs were estimated as percentage allowances of construction costs as follows:

- Engineering, legal, and administration (25%).
- Owner's reserve for change order (5%).

The capital cost improvements for the major cost elements are presented in Table 8-1. More information about the capital cost improvement is included in Appendix C.

Table 8-1. Scenario 1b and 3b Capital Cost Summary		
Major Element	Scenario 1b	Scenario 3b
Tertiary Process [1]	$92.3M	$83.1M
Ancillary System [2]	$10.0M	$10.0M
Site Work and Yard Piping	$10.3M	$9.4M
Constructability Constraints Allowance	$5.0M	$5.0M
Direct Costs	**$117.6M**	**$107.5M**
Total Estimated Construction Cost [3, 4]	**$247M**	**$226M**
Total Estimated Project Cost (2020$) [3, 5]	**$322M**	**$294M**
Total Estimated Project Cost Range Per AACE Class 5 (2020$) [6]	**$161M – $644M**	**$147M - $588M**

1. Tertiary process item includes costs for new BAF and Screening, BAF Pump Station, Conveyance to and from BAF, and Carbon Feed and Storage System.

2. Ancillary Systems item includes cost for new CEPT and Alkalinity, Standby Generator/Switchgear, and RAS Pump Station Upgrades,

3. Numbers rounded to the nearest $1.000,000.

4. Includes markups for contingency (40%), contractor general conditions (15%), contractor overhead and profit (20%), tax (8.7%).

5. Includes markups for engineering, legal and administration (25%), owners reserve for change orders (5%).

6. Total estimated project cost range is presented with an expected level of accuracy of -50% to +100% of the total estimated project cost.

8.2 Annual O&M Cost and Net Present Worth

To fully understand the cost associated with nitrogen removal scenarios, the basis of cost opinion for O&M costs were developed. The O&M cost summaries presented here include the two scenarios used for capital costing along with a third scenario (Scenario 3c). Scenarios 1b and 3b both require addition of an extra carbon source to achieve nitrogen limit goals, which was calculated to be a significant portion of the annual O&M cost in both scenarios. Scenario 3c was added to the O&M cost evaluation to understand the impact of carbon addition for nitrogen removal, since it requires significantly less carbon addition compared to the other two scenarios.

O&M costs have been developed for the additional power, labor, chemicals and consumables above the current and future biosolids improvement levels. Costs included in the estimate reflect the best understanding of planning level requirements, as they existed at the time the estimate was prepared. Cost estimates are subject to market pricing changes, and the cost of labor, materials, and equipment may vary as the project design matures or scope is modified. Although the project timeline is unknown, O&M costs are adjusted to year 2035 flows and load as a potential mid-year in a 20-year operational life span (planning period of 2025-2045).

O&M costs were based on:

- The Northeast Guide for Estimating Staffing at Publicly and Privately-Owned WWTPs published guide (2008).
- Vendor-supplied costs.
- Assumptions and calculations, as necessary, to supplement other sources.
- Historical costs from similar facilities.

Table 8-2 summarizes the estimated additional O&M costs for Scenarios 1b, 3b and 3c. An external carbon source is required to varying degrees for each of these alternatives. Since the O&M cost was heavily influenced by the carbon source cost fluctuations, a sensitivity analysis was performed and two costs were developed for each scenario: one with methanol priced at $1 per gallon and the second with methanol priced at $2.5 per gallon. This range in methanol prices reflects the range in historic prices for methanol and is included as part of Ancillary Systems. More information about the O&M cost improvement is included in Appendix D.

Table 8-2. Scenarios 1b, 3b, and 3c O&M Cost Summary

Major Element	Scenario 1b	Scenario 3b	Scenario 3c
Tertiary Process [1]	$550,000	$340,000	N/A
Intensification Process	N/A	N/A	$200,000
Ancillary Systems [2]	$1,600,000 - $3,010,000	$970,000 - $1,690,000	$660,000 - $940,000
Subtotal	**$2,150,000 - $3,560,000**	**$1,310,000 - $2,030,000**	**$860,000 - $1,140,000**
Contingency (40%) [3]	$470,000	$320,000	$256,000
Total Estimated O&M Cost (2020$) [4]	**$2,620,000 - $4,030,000**	**$1,630,000- $2,350,000**	**$1,116,000 - $1,396,000**

1. Tertiary Process item includes O&M costs for BAF-N/DN and BAF/DN Pump Station.

2. Ancillary System item includes O&M costs for CEPT and Alkalinity Upgrades, Standby Generator/Switchgear, RAS Pump Station Upgrade, Odor Control (if applicable), and a range for Carbon Feed and Storage Cost.

3. Contingency listed here excludes Carbon Feed and Storage cost.

4. Range in cost reflects range in methanol pricing of between $1 per gallon and $2.5 per gallon.

The life-cycle, or NPW costs include initial project capital costs and present worth of annual O&M costs, assuming a 20-year payback and a net discount rate of 3%. NPW estimates were developed for Scenarios 1b and 3b and are summarized in Table 8-3. The variation in NPW costs shown in Table 8-3 are driven largely by methanol price, with the variation in methanol price resulting in a $21M NPW cost difference for Scenario 1b and a $12M cost difference for Scenario 3b.

Table 8-3. Scenario 1b and 3b Net Present Worth [1, 2]

Major Element	Scenario 1b		Scenario 3b	
	Cost of Methanol per gallon			
	$1	$2.5	$1	$2.5
Annual O&M Cost	$2.6M	$4.0M	$1.6M	$2.4M
Present Worth Cost [3]	$38.7M	$59.6M	$23.9M	$35.8M
Capital Cost	$322M	$322M	$294M	$294M
Total [4]	$361M	$382M	$318M	$330M

1. Values shown in 2020 dollars.

2. Includes estimator's contingency (40%) and rounded to the nearest $100,000.

3. 20-year present worth calculated based on a net 3% discount rate.

4. Rounded up to the nearest $1M.

By comparison to Scenario 3b, the NPW of the O&M costs for Scenario 3c range from $16.7M to $20.8M depending on the methanol cost assumption. This suggests that for Scenario 3, an alternative that relied less heavily on an external carbon source could result in O&M savings of between $0.5M to $1M per year and between $7.2M to $15M over a 20-year period.

8.3 Costs for Deammonification

Given the City's initial discussions with Ecology that the biosolids project would return a portion of the nitrogen load to the liquid stream instead of being incinerated and discharged into the air, the BC/Carollo Team recommends that sidestream treatment be added to the biosolids costs in lieu of being allocated into the nitrogen impacts costs. Table 8-4 summarizes the capital and O&M costs associated with the sidestream deammonification treatment system. More information about the Deammonification cost improvement is included in Appendix E.

Table 8-4. Deammonification Planning Level Costs

Cost Element	Deammonification Process
Deammonification Process	$8.25M
Total Estimated Construction Cost (2020) [2, 4]	$17.4M
Total Estimated Project Cost (2020) [3, 4]	$22.7M
Total Estimated Project Cost Range Per AACE Class 5 (2020$) [5]	$11.4M – $45.4M
Annual O&M Costs [4]	$200,000

1. Item includes costs for a new Deammonification system and Site Work and Yard Piping.

2. Includes estimator's contingency (40%), General Conditions (15%), General Contractor Overhead and Profit (20%), and Sales Tax (8.7%).

3. Includes Engineering, Legal and Administration Fees (25%), and Owner's Reserve for Change Order (5%).

4. Rounded up to the nearest $100,000.

5. Total estimated project cost range is presented with an expected level of accuracy of -50% to +100% of the total estimated project cost.

Section 9: Conclusions

Ecology is in the process of developing and refining models to understand the impacts that WWTPs have on nitrogen input into Puget Sound and the Salish Sea. Their initial results have shown that the increased nitrogen has resulted in lower dissolved oxygen concentrations and lower water quality, which is detrimental to aquatic life in the region. Ecology has found that between 19% and 23% of Puget Sound area has fallen below water quality standards and substantial improvement if WWTP effluent TIN is reduced to less than 8 mg/L during the summer months. Based on a petition from an environmental group and these model results Ecology issued the draft general permit in January 2021 to address the nutrient issues by proposing "action levels" for the Plant. The team is reviewing the draft permit and action level and will provide comments prior to the March 15, 2021 comment due date.

Although the effluent limits of the general permit are unknown at this time, to inform the City's facility planning process, the BC/Carollo project team considered six potential nutrient reduction scenarios. The team recommended proceeding with two effluent nitrogen scenarios that would bookend the likely future range of nitrogen regulations:

- Worst Case: 3 mg/L TIN annual effluent limit as proposed in the NWEA petition.
- Moderate Case: 8 mg/L TIN summer only effluent limit as used by Ecology in the SSM.

For both effluent nitrogen scenarios at least two technologies were evaluated. These technologies included mainstream treatment and adding a tertiary nitrogen removal process. Due to the site constraints for the Worst Case scenario mainstream treatment was evaluated with MBR intensification. For the Moderate Case scenario, mainstream treatment was evaluated both with and without intensification with IFAS.

The implications of the technologies evaluated for the Worst Case and Moderate Case scenarios were estimated using a calibrated whole plant model and the results are summarized in Table 9.1. This table shows that Scenario 1b and 3b which meet the potential future nitrogen limits with minimal disruption to the existing process, require the greatest quantity of external carbon. While Scenarios 1a, 3a and 3c all require some degree of modification to the existing liquid stream process and additional activated sludge basins, they also require less external carbon. Although all scenario layouts fit within constraints of the site and would utilize the northern and southeastern available spaces at the plant, Scenarios 1a, 3b, and 3c required some construction within the heron rookery protection buffer or the vegetation retention and no distribution buffer. These layouts were viewed less favorably or not possible due to the environmental sensitivity and value of the heron rookery to the City and the local community. Scenarios 1b and 3a would not require construction within these buffers. The modeling found that Scenario 1b, which kept the existing short SRT liquid stream process and relied on external carbon source for denitrification year-round, would produce the greatest quantity of biosolids. For this reason, future biosolids processes will be sized to meet the estimated year 2045 biosolids production from Scenario 1b.

Capital, O&M and NPW costs were developed for Scenario 1b and 3b where a tertiary nitrification and denitrification process was added onto the existing liquid stream process to remove nitrogen. This analysis found that estimated capital costs for these two alternatives ranged from approximately $294M to $322M. Twenty-year NPW costs ranged from $318M to $382M.

While the implementation of Scenarios 1b and 3b to remove nitrogen with a tertiary process does not involve modifications to the existing liquid stream process, this comes at a high O&M cost due to its reliance on external carbon for denitrification. In contrast, to meet a summer only TIN limit of less 8 mg/L, selecting Scenario 3c over 3b could reduce nutrient removal program costs by approximately $0.5M to $1M per year and between $7.2M to $15M over a 20-year period.

References

Washington State Department of Ecology (Ecology) 2014. Fact Sheet for Post Point Wastewater Treatment Plant NPDES Permit WA0023744.

Ecology 2019a. Application Extension Letter for Post Point Wastewater Treatment Plant NPDES Permit (WA0023744). January 18, 2019

Ecology 2019b. Puget Sound Nutrient Source Reduction Project. https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Helping-Puget-Sound/Reducing-Puget-Sound-nutrients/Puget-Sound-Nutrient-Reduction-Project Website accessed October 2019.

Ecology 2019c. Puget Sound Nutrient Source Reduction Project, Volume 1: Model Updates and Bounding Scenarios. Publication No. 19-03-001. January 2019.

Ecology 2019d. Focus on Water Quality Permitting to Control Nutrients in Puget Sound. Water Quality Program Publication 19-10-033. August 2019.

Ecology 2019e. Puget Sound Nutrient Forum presentation materials, August 7, 2019.

Ecology 2019f. Denial of NWEA AKART Petition. Letter from Maia Bellon (Ecology) to Nina Bell (NWEA), January 11, 2019.

Northwest Environmental Advocates (NWEA) 2018. Petition for Rulemaking to Adopt a Presumptive Definition of "All Known, Available, and Reasonable Treatment" as Tertiary Treatment for Municipal Sewage Dischargers to Puget Sound and its Tributaries.

NWEA 2019a. Appeal to the Governor of the State of Washington regarding January 11, 2019 denial of NWEA AKART Petition. January 30, 2019.

NWEA 2019b. Petition for Review of Ecology's Denial of NWEA AKART Petition. Filed in the Superior Court of the State of Washington for Thurston County, February 8, 2019.

Appendix A: General Permit Comments

Post Point Resource Recovery Plant

Comments on the Puget Sound Nutrient General Permit Preliminary Draft

March 10, 2021

The City of Bellingham supports Ecology's initiative to reduce nitrogen in Puget Sound. Our community has a strong environmental ethic that has resulted in significant infrastructure investments to improve water quality, and we anticipate continued support as part of the upcoming nutrient reduction program.

Our ratepayers approved a $50 million dollar upgrade to the Post Point secondary treatment system in 2014. In 2017 we began working on a major resource recovery project to replace our aging sewage sludge incinerators for a more sustainable solids management process solution. This project has the full support of our Council and will significantly reduce the Sewer Utility's CO_2 emissions (60-80 percent).

The City is actively addressing salmon recovery (e.g., Diversion Dam removal, Padden Creek daylighting, Squalicum Creek daylighting) and supports initiatives to improve water quality in Bellingham Bay. To advance our shared interest in reducing nitrogen discharged to Bellingham Bay, we have begun assessing potential nitrogen removal projects at Post Point, including assessing the likely rate impacts.

This nitrogen review identified substantial Post Point upgrades that would be required to achieve nitrogen removal. The scale of the required nitrogen removal upgrades along with the resource recovery project would be unprecedented for the City and could ultimately result in tripling the sewer rates. These potential utility rate increases could create hardship and affect affordability for our community.

Therefore, we have a strong interest in making sure the general permit requirements are appropriate for our community so that the outcome is the highest water quality we can attain with rates that support economic sustainability. We offer the following comments to this end in partnering with you to implement appropriate nitrogen reduction efforts to preserve and enhance water quality in Bellingham Bay and the Puget Sound.

Action levels should be raised, or postponed until the next permit cycle

Despite the goals of this initial general permit to monitor and optimize (setting the stage for future permit nutrient cycles to incrementally lower effluent nitrogen concentrations), it appears the proposed tiered approach may prematurely trigger major capital investments. As such, we propose either removing the action levels (ALs) entirely from the general permit, or increasing them to provide the necessary flexibility for the following reasons:

- The monitoring, optimization, reporting and planning requirements are substantial, enforceable, and sufficient to achieve the primary goals of the general permit at this stage, which is to prevent increases in TIN loads beyond current levels.
- Ecology specifically states in the permit that it "is not intending to stop growth with the development and issuance of this permit". Regardless of this intent, the permit essentially treats growth punitively since even modest growth could easily push facilities above AL0 or AL1. At this regulatory stage (early phase of the general permit), growth-driven exceedances should not trigger additional requirements if the facility remains within its Ecology-approved design capacity and has optimized its treatment process.
- There are equity issues with the ALs:
  - Lower ALs for facilities that have already optimized or otherwise gotten better treatment. (Although there is some advantage given to facilities already achieving <10 mg/L.)
  - Lower ALs for facilities with better process control and less variability in the effluent.
  - A large inequity in how much of the unused, Ecology-approved design capacity is available to WWTPs.
- Uncertainty with the Salish Sea Model (SSM) predictions of dissolved oxygen (DO) excursions and the level of treatment plant nitrogen reduction that will be needed to meet DO criteria.
- Limited effluent data with which to draw justified conclusions.
- To date, officially released results of the SSM as part of Ecology Publication 19-03-001 (Puget Sound Nutrient Source Reduction Project, Volume 1: Model Updates and Bounding Scenarios, January 2019) has only looked at improvements using a seasonal (April-October) nitrogen removal for the wastewater facilities. However, the nitrogen loads provided in the PSNGP are on a year-round basis. Given the limited data and model results available to justify a year-round limit, a seasonal load cap would be more appropriate.

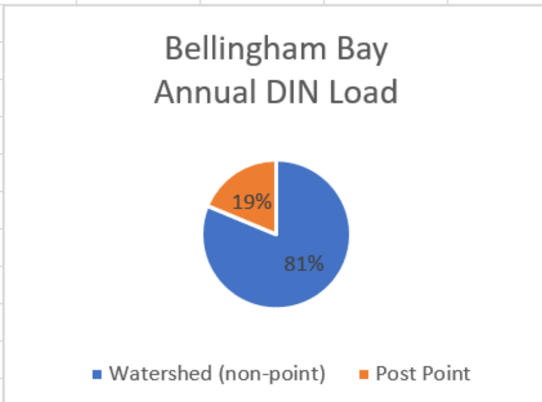
Other Comments

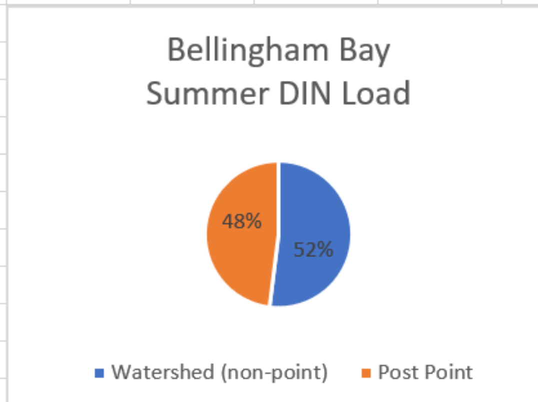
- By definition, optimization is getting the best treatment you can with the existing plant. Because all the plants are required to optimize, it is unclear that other additional (Tier 2 or Tier 3) actions will be practical at any given plant without major capital investments, which are premature at this stage of the regulation and waste load allocation (WLA) development.
- The requirement for Tier 2 or Tier 3 actions should include off-ramps for exceedances related to uncontrollable circumstances, such as wet weather events.
- Ecology Question on Page 9 of 35 of draft GP: We agree with the use of the 99th percentile as identified for each facility over the course of the permit cycle for calculating the baseline action levels. In Bellingham's case, the 95% confidence interval would be lower and fall below our current nitrogen loads.

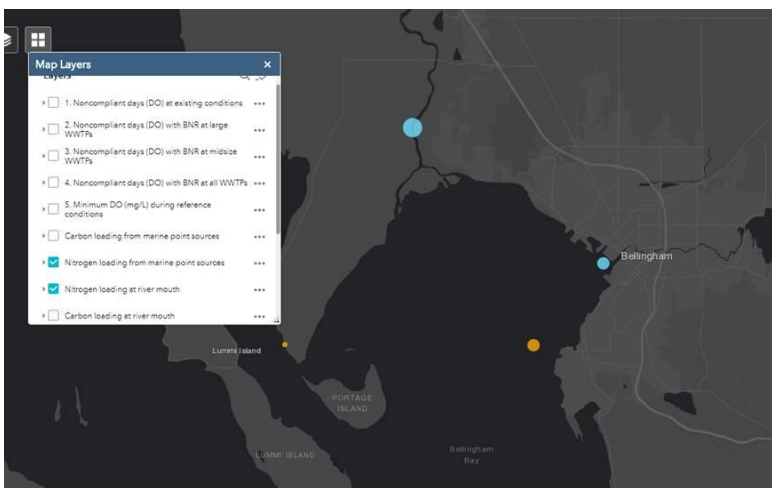
City of Bellingham
Public Works Department

Watershed nutrient-reduction strategies should receive more attention

Ecology's Bounce Scenarios report (BSR) indicates that even if WWTPs were "turned off", anthropogenic watershed sources alone produce DO depletions in Bellingham Bay. Based on Ecology's data (https://waecy.maps.arcgis.com/apps/webappviewer/index.html), most of the nitrogen loading into Bellingham Bay is from non-point sources (NPS) as indicated in the graphics below.







Therefore, we propose that Ecology allows for evaluation of watershed solutions as part of the general permit to address these other obvious sources of nitrogen into Bellingham Bay. These evaluations should include a non-point source offset feasibility study to review the NPSs in the watershed and what treatment measures could be implemented. In addition, we request that Ecology consider the implementation of a NPS nutrient trading program in parallel to investing in upgrades at Post Point. These NPS actions could be part of Tier 3 and ultimately help achieve nutrient reduction more quickly and at the highest cost/benefit ratio than solely focusing on point source dischargers.

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Sampling requirements should be less stringent for medium-sized plants

The minimum sampling and analysis schedule detailed in section IV the draft PSNGP is overly ambitious for a treatment plant in a community the size of Bellingham. While we appreciate the tiered monitoring approach as it recognizes the economies/personnel of scale at the state's treatment plants, we believe the monitoring should also be consistent with the wastewater treatment plant impact categories as set forth and modeled in the Salish Sea Model (SSM) as part of Ecology Publication 19-03-001 (Puget Sound Nutrient Source Reduction Project, Volume 1: Model Updates and Bounding Scenarios, January 2019). The draft PSNGP currently proposes to have Bellingham (categorized in the Ecology publication as a mid-sized treatment plant) with our treatment plant's average flow (2018-2020) of <12 mgd, a maximum month flow of <20 mgd, and a population of 91,000, performing the same level of monitoring as large plants (Ecology, 2019) in Seattle (3.4 million persons).

Clarify maximum month daily flow

In addition, should the sample frequency continue to be based on maximum month daily flow [question: is the intent (1) the maximum month *daily* flow as cited at Table 5 or (2) the maximum month *design* flow as cited in ECY's Potential Permittee List for a Puget Sound Nutrients General Permit?], the intended value will need to be clarified.

- <u>If as written in the draft PSNGP</u>: Section III details the nutrient action levels that have been calculated for each facility based on actual representative flows and so the rationale for then using sampling tiers based on maximum flows is needed.
- <u>If sampling and analysis tier categories are based on design flows</u>: this defies the stated goal of collecting empirical data on nutrient loading. Design flow values apply an artificially high flow value to present loading contributions and, in a way, penalize plants that have worked to build future capacity into their current treatment systems (not utilized). In Bellingham's case, our maximum month design flow is 14.5 mgd above our actual maximum month – which will not be realized in many of our lifetimes. This capacity is advantageous to receiving water quality under extreme-weather events and should be lauded and not made a basis for increased monitoring obligations.

Sampling tiers should be based on average annual plant flows which corresponds to the actual loading to the Puget Sound. If the desire is to make predictions about future loading to Puget Sound, like the approach taken in establishing the nutrient action levels, actual average flow data best represents possible future observations in the absence of changing conditions, and any predictions about future loadings are best made using the current hydraulic distributions. Furthermore, with 5-year permit cycles, there is a mechanism for adjusting monitoring obligations based on increases in the actual flow and loading from Washington's treatment plants through time.

Make Sampling Frequency Consistent with Ecology's Bounding Report

It would be consistent with the SSM if the monitoring and analysis were revised to be based on the issued results (Ecology, 2019) which classified Bellingham as a mid-sized plant (see table below):

Tier / Size	Average Annual Flow (mgd)	CBOD (influent & effluent)	Total Ammonia (influent & effluent)	NO3+NO2 (influent & effluent)	TKN (influent & effluent)	TOC (effluent)
I Large	≥ 25 mgd	4/week	4/week	4/week	4/week	1/week
II Mid*	3- 25 mgd	1/week	1/week	1/week	1/week	1/week
III Small	< 3 mgd	2/month	2/month	2/month	2/month	1/month

* Bellingham's Post Point plant as categorized in the SSM (Ecology, 2019)

Requiring a minimum of 2 years sampling at the interval detailed in Table 5 of the draft PSNGP (plus sampling to be determined for the following years) will create a hardship for the bulk of treatment plants that do not have the ratepayer base of more highly urbanized communities. Currently Bellingham staff are taking unpaid furlough days in 2021 and there is a freeze on any new positions. Bellingham will need to sub out the required analysis and the nearest laboratory on the state contract for such a large sampling effort is located over 100 miles away. Staff time and expenses will be incurred from the proposed sampling schedule not the least of which is from transporting samples offsite to a ground courier. Also realize there will be a delay in the receipt of sample results which needs to be factored into submittal deadlines in the general permit. Electronic permit reporting would be beneficial here.

A conservative estimate of the costs of sampling influent and effluent as proposed currently in Table 5 of the PSNGP are broken down below. The table below represents 2020 lab prices in the state lab contract that Bellingham can utilize. Note the cost presented do not include cost associated with employee sample processing, data processing, data management, database reconfigurations, sampling issues resulting in resample, transport issues, quality assurance samples, future increases in lab analysis costs, tax, or any samples in addition to what is detailed as those minimum requirements in Table 5.

City of Bellingham
Public Works Department

Analyte	Cost Range per Sample	Draft PNSP Sampling for Large Plant (yearly cost for 4/week)	Proposed Mid-Sized Plant Categorization for Post Point** (yearly cost for 1/week)
CBOD	$40-$55	$16-23k	$4-6k
NH3	$22-$25	$9-11k	$2-3k
NO2/NO3	$25-$35	$10-15k	$2-4k
TKN	$35-$69	$14-29k	$3-7k
TOC	$45-$55	$2-3k	$2-3k
Transport*	$65	$3-4k	$3-4k
DMR-QA	$100	$100	$100
Total		**$55-80k**	**$19-25k**

*includes conservative estimate of city employee driving samples to transportation courier and cost to ship via next day ground
** Bellingham's Post Point plant as categorized in the SSM (Ecology, 2019)

Reduce Influent Sampling Frequency

Because the PSNGP action levels apply only to the treated effluent at 60 public wastewater plants, mandating sampling on the untreated influent is unnecessary. All treatment plants will undoubtedly conduct additional sampling either at the influent of the plant and/or at the influent to unit processes at targeted intervals to assess TIN-removal effectiveness. The state's objective for mandating such a high interval of sampling at the untreated influent needs to be detailed or this requirement reduced or eliminated altogether. Treatment plants should be given the autonomy to assess when best to target efforts at non-effluent monitoring for those times that removal or optimization data are pertinent to nitrogen-reduction objectives.

Reduce TKN Sampling Frequency

With respect to effluent TKN sampling requirements, the TKN test represents a large fraction of the cost for nitrogen monitoring and eliminating the effluent monitoring for TKN would save significant costs. Furthermore, TKN is a measure of combined ammonia and organic nitrogen in the effluent, with the large majority being in the ammonia form. As the permit is written to address TIN, which Ecology has stated is used as a surrogate for dissolved inorganic nitrogen (DIN) of concern in Puget Sound, the ammonia and nitrate/nitrite species sampling would be sufficient to meet this requirement. Therefore, we would recommend reducing the sampling frequency for effluent TKN to 1x/month from the current limit. This would provide Ecology with information on the effluent organic nitrogen load without adding

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to the sampling and monitoring burden of treatment facilities for a parameter that is not needed for the current PSNGP limits.

If action levels are kept in the permit, Post Point action levels should be recalculated

We have three comments related to the AL0 calculation for Post Point.

1. **We think the current timeframe used for the load cap analysis should be extended to include February and March of 2020.** The current AL0 was established using data collected between 2017 through January 2020, conservatively excluding data after January 2020 to avoid potential pandemic related effluent impacts. However, we believe that the Post Point nitrogen loading data should extend to include the February 4th and March 2nd 2020 samples considering these samples were taken prior to local pandemic related events which unfolded in the weeks thereafter:
    a. The World Health Organization declared pandemic status on March 11, 2020.
    b. The Washington State Stay-At-Home order was put into place on March 23, 2020.
    c. Bellingham followed with a public urge for stay-at-home on March 26th, 2020.
2. **We believe all effluent TIN data should be represented with equal frequency.** Currently, the AL0 for Post Point has been established in such a way such that January loadings have less weight (limiting frequency to 1/12) based on the observation that two of the three highest effluent nitrogen loads occurred during the month of January (1/6/2020 and 1/7/2019). However, we believe that this observation is coincidental from the limited once per month sampling and not due to inherent increased likelihood for peak loadings to occur during the month of January.
    a. With the proposed extended AL0 data set (including February and March 2020), the four highest daily effluent TIN loads become:
        i. **1/6/2020 (3,855 ppd)**
        ii. 3/2/2020 (3,245 ppd)
        iii. **1/7/2019 (3,143 ppd)**
        iv. 10/7/2019 (2,818 ppd)
    b. However, the four lowest daily effluent TIN loads also include two January periods
        i. 12/5/2017 (1,541 ppd)
        ii. 2/6/2017 (1,649 ppd)
        iii. **1/2/2017 (1,708 ppd)**
        iv. **1/1/2018 (1,716 ppd)**
    c. Insufficient data is available to correlate peak effluent TIN loads with effluent BOD loads since effluent BOD loads were only collected on the same day as two of the top five effluent TIN load days. However, it should be noted that the highest 2nd percentile effluent BOD load days occurred in the months of January, February, March, May, September, October and December.

3. **We would like the City to be granted a one-year review period for the AL0 calculation.** With the increased nitrogen sampling occurring as part of the General Permit, the City will have a better understanding of their true current loads than can be captured from the current once per month sampling. We would like the AL0 calculation to be revisited after one year to determine whether a higher or lower level is warranted.

Thank you for the opportunity to comment on the Puget Sound Nutrient General Permit. Moving forward we support continuing collaboration to reduce nitrogen loading and improve water quality in our communities.

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Appendix B: Nitrogen Removal Impacts

Core Meeting Presentation on May 2020

Brown AND Caldwell

carollo

Biosolids Planning – Nitrogen Removal Impacts

May 21, 2020

CITY OF BELLINGHAM WASHINGTON

1

Agenda

Topic	Description	Leader
Introduction (5 mins)	Meeting objectives 1) Review preliminary results of nitrogen study 2) Confirm decisions on solids mass balance/sizing criteria	Tadd
Project Status Up-date (10 mins)	• Nutrient study • Biosolids Facility Plan o Ecology requirement (current plan based on FBI) o Heat utilization evaluation o Biogas upgrading evaluation o Biosolids market outreach	Tadd
Nitrogen Cap (15 mins)	• Ecology interactions and direction • Linkage to biosolids project and buildout capacity of Post Point	Tadd
Nitrogen Removal Scenarios (15 mins)	• Overview of scenarios – "worst case" and "moderate" • Process modeling results	Anne
Break? (5 mins)		
Post Point Nitrogen Impacts (60 mins)	• Summary of layout options for nitrogen removal scenarios • Confirm "representative" layout option for cost estimation pur-poses • Identify implications – risks (e.g., environmentally sensitive ar-eas), Post Point build out capacity,	Steve/ Susanna
Break? (5 mins)		
Solids Mass Bal-ance (20 mins)	• Current status • Recommendation for moving ahead with flow/loading criteria	Susanna
Next steps (5 mins)	• Draft cost estimate for internal review – early June • Continue development of Facility Plan	Tadd

Project Status Update

Tadd

3

Overview of Current and Ongoing Project Activities

- Nutrient Study
- Biosolids Facility Plan
  - Ecology requirement (current plan based on FBI)
  - **Heat utilization evaluation** – review alternatives for using heat and gas resources
    - Heat recovery from the cooling step between thermo and meso digestion
    - Effluent heat extraction and heat recovery
  - **Biogas upgrading evaluation** – review alternatives for scrubbing digester gas to meet gas quality requirements for pipeline injection
  - **Biosolids market outreach** – build on earlier outreach to identify national, regional, and local markets and gauge interest in partnering

Nitrogen Cap

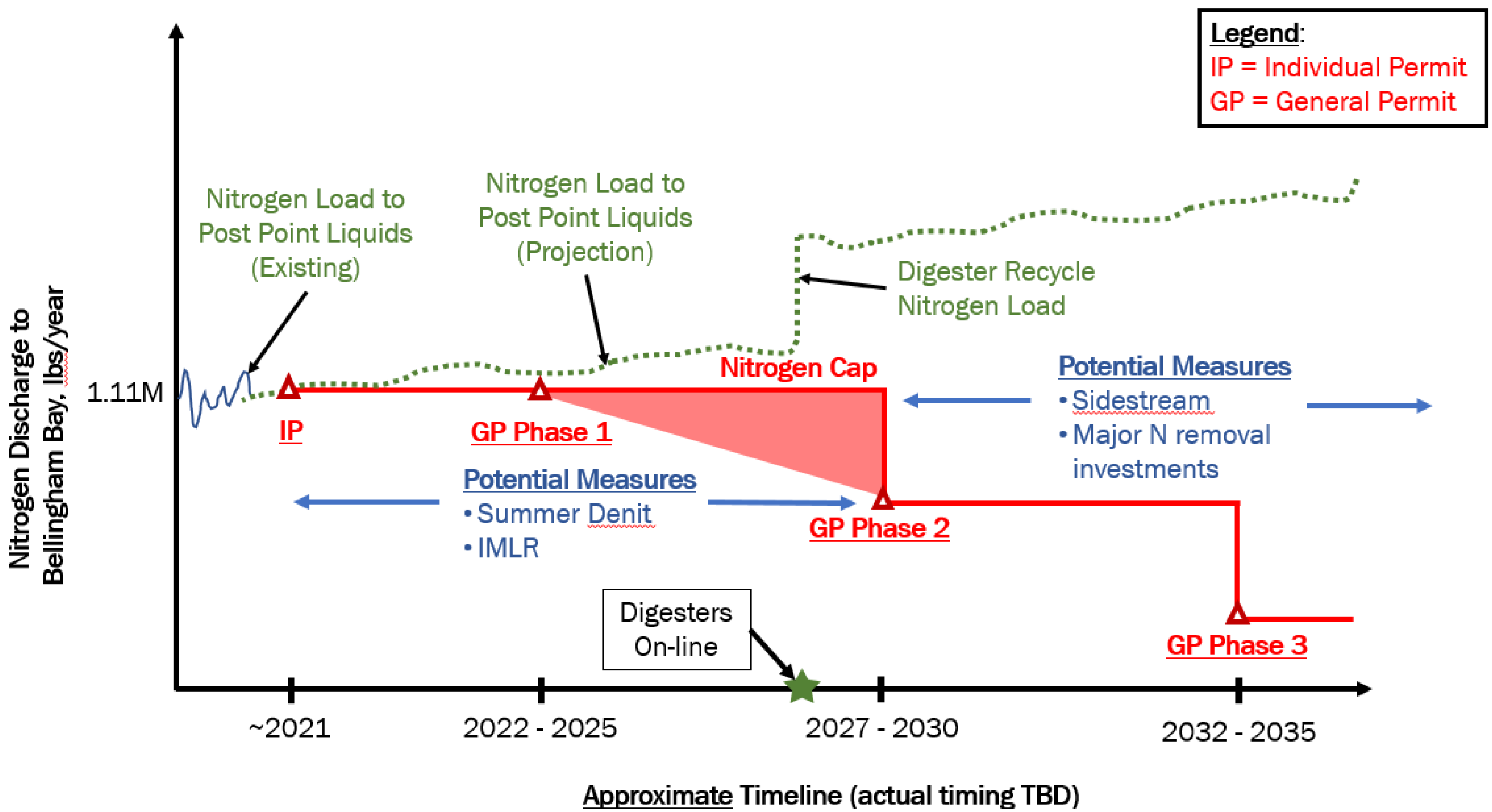
Tadd

5

What we know from Ecology

- Individual Permit Nutrient Cap
  - Basic goal – "don't allow any more N discharge than what facility is currently doing"
  - Likely within a year (?)
  - 1,110,000 lbs/year annual loading limit (+16% compared to initial Ecology calculation)
- General Permit
  - Timing = ?? (2-3 years out?)
  - Increasingly stringent reductions over a compliance period (10 years?)
  - Anti backsliding provisions

CONCEPTUAL timeline of nutrient reductions and biosolids project



Brown and Caldwell

Highlights of City proposition to Ecology

1. Include the N load in the digester recycle stream as part of base load calculations for the Individual Permit nutrient cap
   - 25-30% N load addition in digestion recycle
   - Can address, but requires capital, OM $ and footprint
2. Implement a cap only during critical months (summer)
3. Explore alternative means of achieving nitrogen limits besides strictly infrastructure upgrades at Post Point

Nitrogen Removal Scenarios

Anne

Two nutrient removal scenarios were modeled

- Worst case (Scenario 1):
  - effluent TIN ≤ 3 mg/L year round (~170,000 lbs/year)
  - Based on NWEA's 2019 AKART petition
  - Approaches limits of technology removal
- Moderate case (Scenario 3):
  - Effluent TIN ≤ 8 mg/L between April – October (~1.1M lbs/year)
  - Based on Ecology's 2019 Bounding Scenarios Report

Major Modeling Assumptions

- Liquid stream capacity = 2045 biosolids planning (max month flow of 37 mgd)
- Peak secondary treatment capacity increases to 51 mgd
- CEPT implemented for almost all cases
- 2-3 representative technologies modeled for each case

Scenarios which modify the existing process

Required NEW infrastructure	Scenario 1a: Worst Case	Scenario 3a/c: Moderate Case
Primary treatment	Convert 1-SC to PC	CEPT
New Fine Screening	Yes	No
Additional Aeration Basins	1	2 (with media) / 4
New Clarification	Replace secondary clarifiers with 10 MBR tanks and support building	No
New Blowers	Swap out smaller blowers for larger blowers	Swap out smaller blowers for larger blowers
New Chemical facilities (Carbon, Alkalinity)	yes	yes
New Side stream treatment (e.g. DEMON process)	yes	yes

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Scenarios which add tertiary nitrogen removal filters

Required new infrastructure	Scenario 1b: Worst Case	Scenario 3b: Moderate Case
Primary treatment	CEPT	CEPT
Fine Screening	Yes	Yes
Aeration Basins	No	No
Clarifiers	No	No
Blowers	No	No
BAF pump station	yes	Yes
BAF –Nitrification filters	12 (32' x 50' x 21')	8 (32' x 50' x 21')
BAF – Denitrification filters	6 (25' x 46' x 19')	6 (25' x 32' 19')
Chemical facilities (Carbon, Alkalinity)	yes	yes
Side stream treatment (e.g. DEMON process)	yes	yes

Key O&M considerations

- Additional processes to maintain
- Heavy reliance in chemical usage
  - Aluminum and polymer for chemically enhanced primary treatment
  - Carbon and alkalinity supplements
- Large increase in power usage
- Increased equipment replacement (e.g. membranes, media, odor control)
- More process monitoring and laboratory testing

Modeling Assumptions to Confirm

1. Level of secondary redundancy: Reduced aeration basin or clarifier out of service during average vs maximum month conditions

- Post Point is currently designed for maximum month
- Minimum recommended industry standard is for average

Nitrogen Impacts

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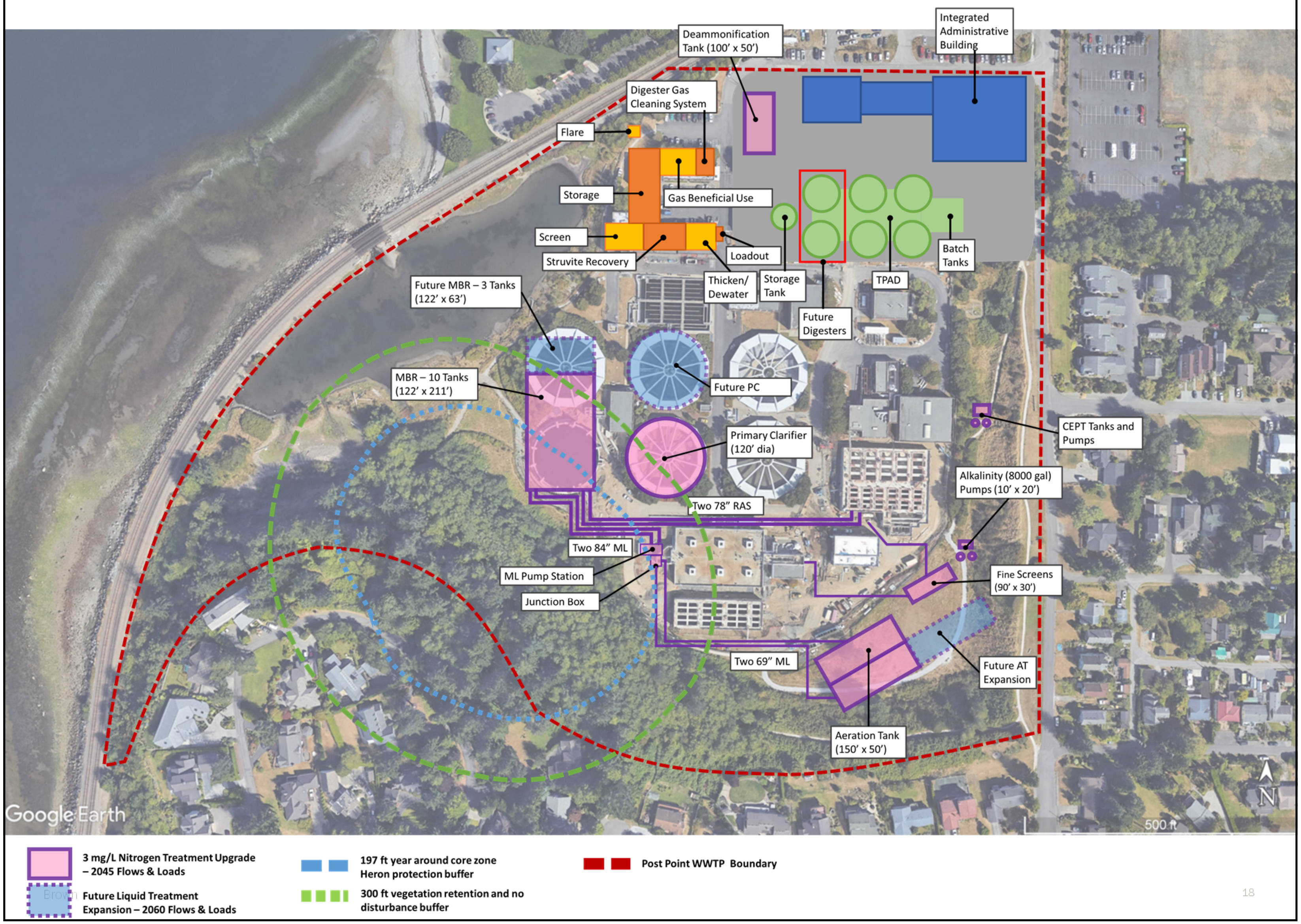
Summary of Implications

- Worst Case (3 mg/L TIN effluent limit year round)
  - Depending on treatment process selected, may require demolishing secondary clarifiers and implementation of a high-rate treatment process (e.g., membrane bioreactors (MBRs))
  - Requires using the current off-leash area and portions of the loop trail for treatment process
  - Would likely have some impact to environmentally sensitive areas (heron rookery, Class A wetlands) to the southwest of Post Point that would need to be managed.
  - Significant cost (cost estimates currently being developed) and complicated construction
  - Post Point site would likely have capacity to about year 2050 (possibly longer with MBRs). However, depending on growth and constructability issues, a second WWTP may be required earlier.
- Moderate Case (8 mg/L TIN effluent limit April through October)
  - Options exist that preserve existing secondary clarifiers
  - "Intensify/enhance" treatment process (by MLE, IFAS, etc.)
  - Requires using the current off-leash area and portions of the loop trail for treatment process
  - Less costly than Worst Case, but still complicated construction and a significant investment
  - Post Point site would likely have capacity to about year 2050. However, depending on growth and constructability issues, a second WWTP may be required earlier.

Scenario 1A – 3mg/L TIN Annual Limit, 4SMB and MBR



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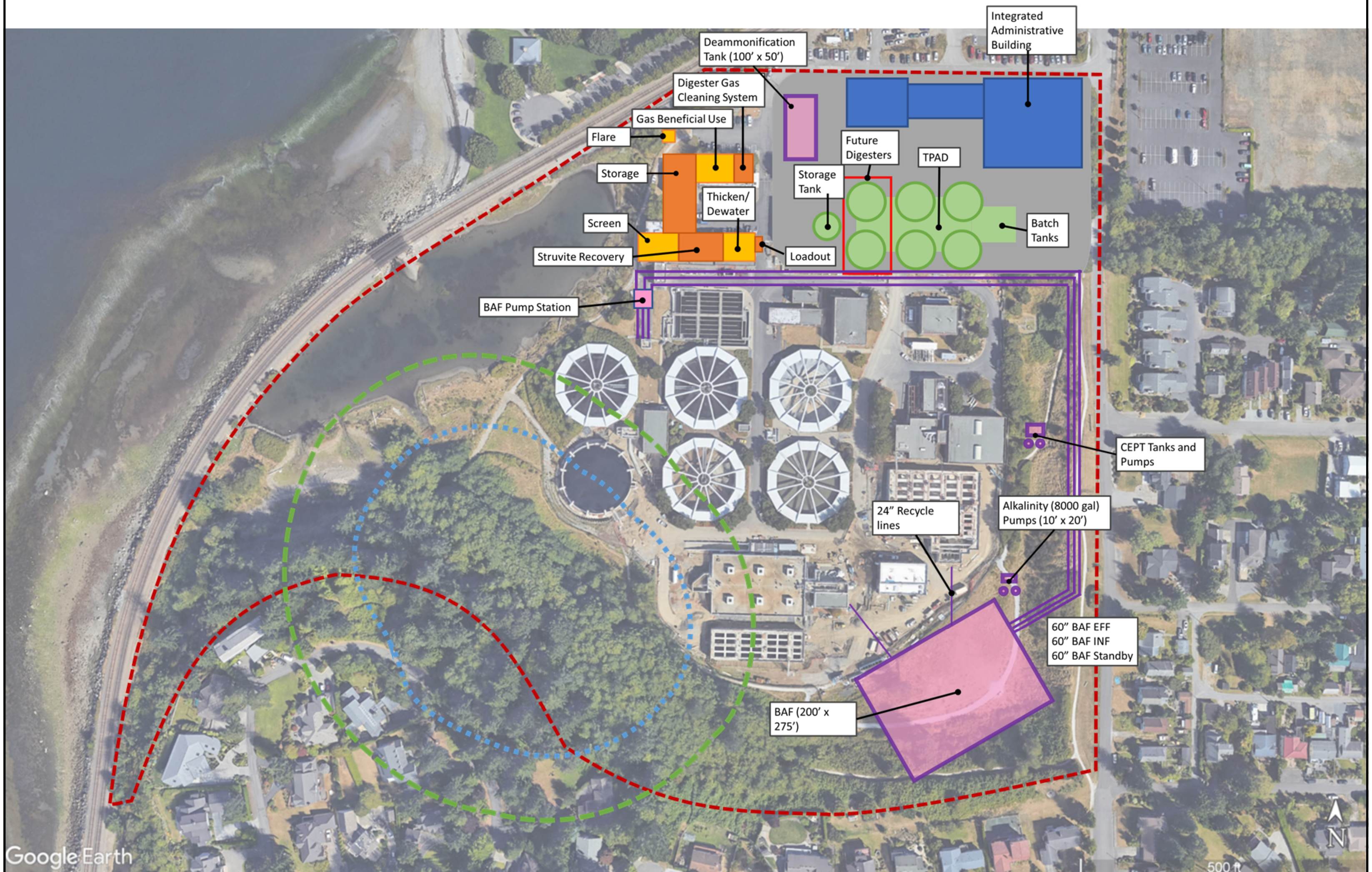
Scenario 1B – 3mg/L TIN Annual Limit, 4SMB and BAF/DNF



3 mg/L Nitrogen Treatment Upgrade – 2045 Flows & Loads

Future Liquid Treatment Expansion – 2060 Flows & Loads

197 ft year around core zone Heron protection buffer

300 ft vegetation retention and no disturbance buffer

Post Point WWTP Boundary

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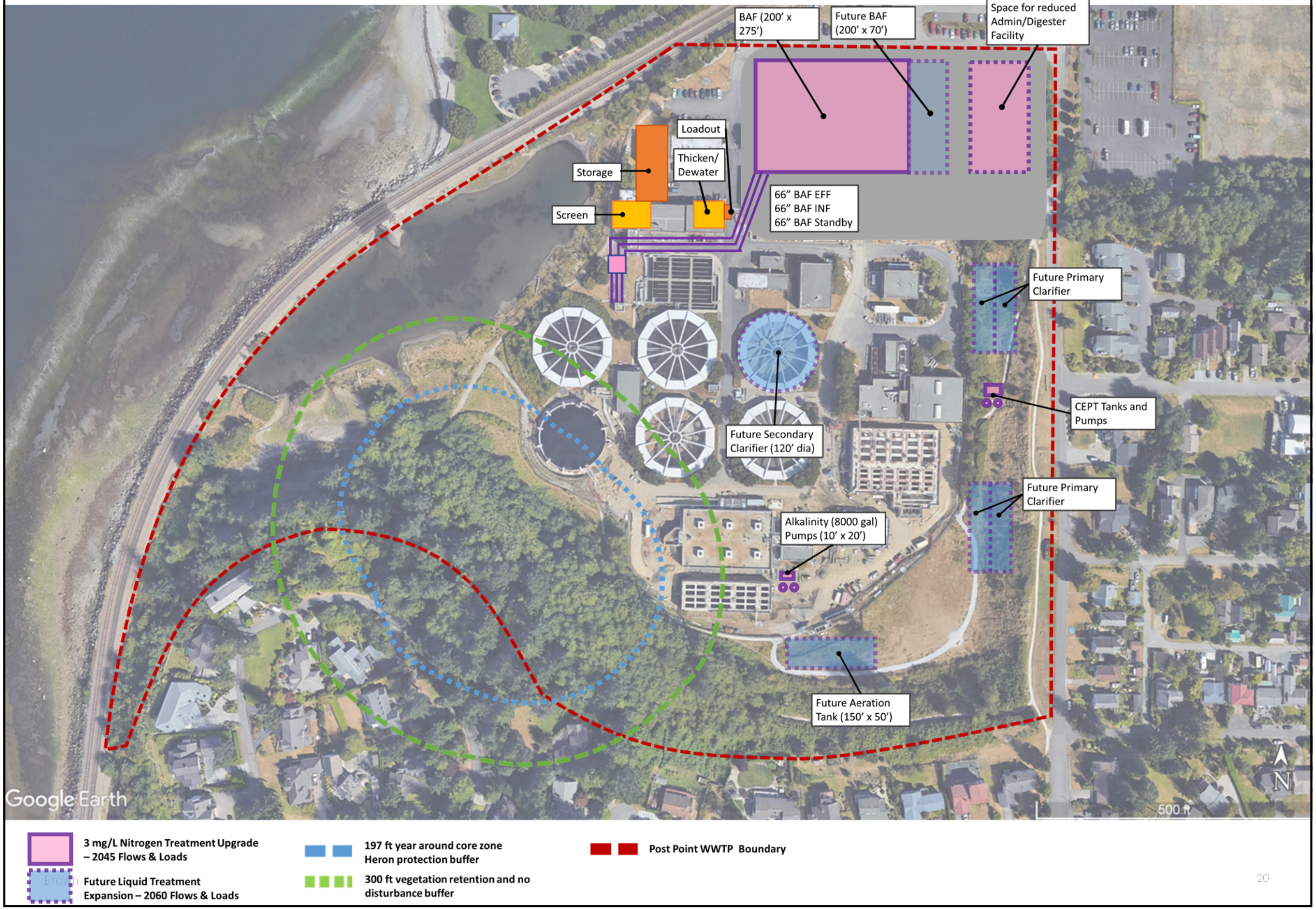
Scenario 1B' – 3mg/L TIN Annual Limit, 4SMB and BAF/DNF, No Admin Building, no digester



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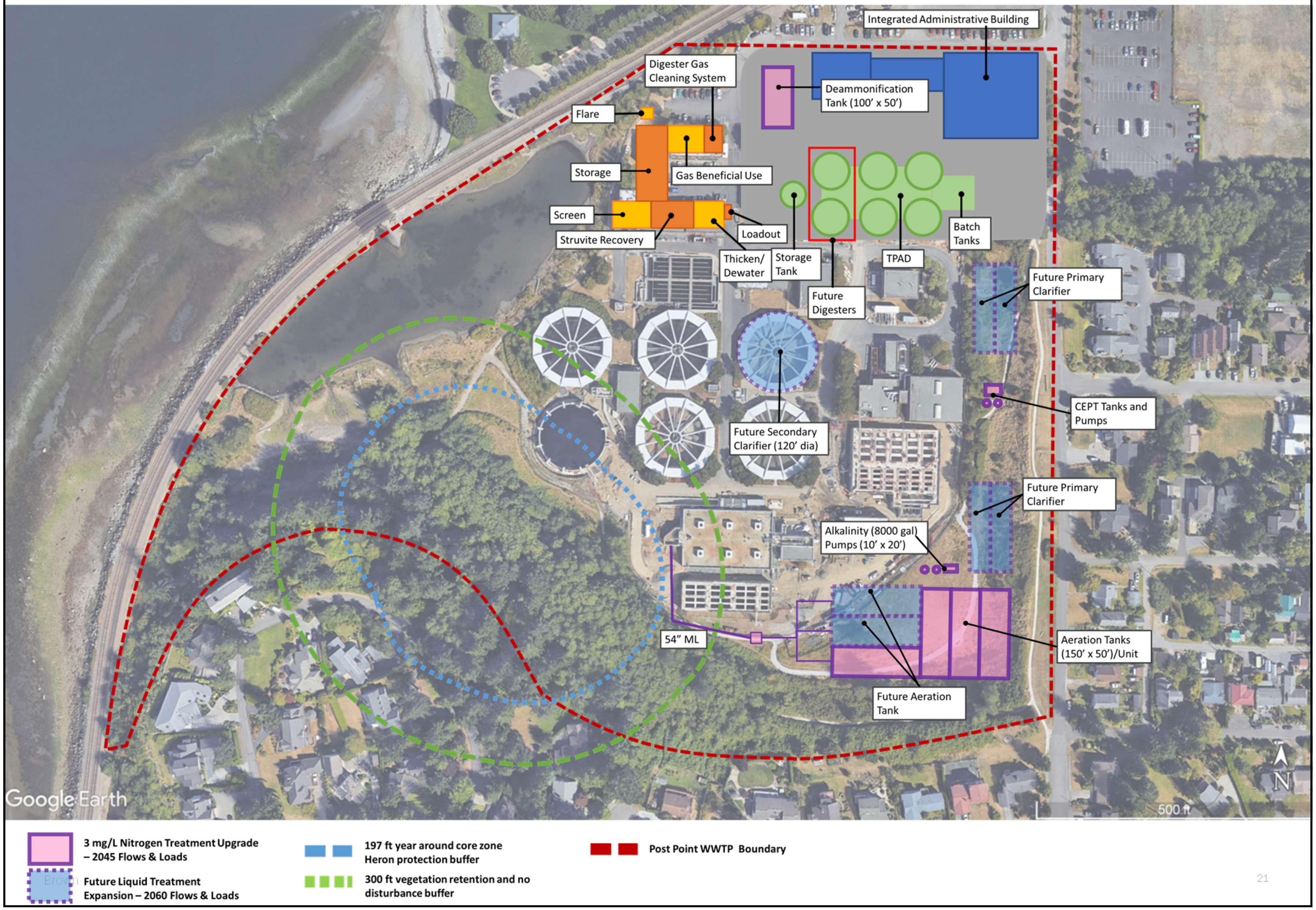
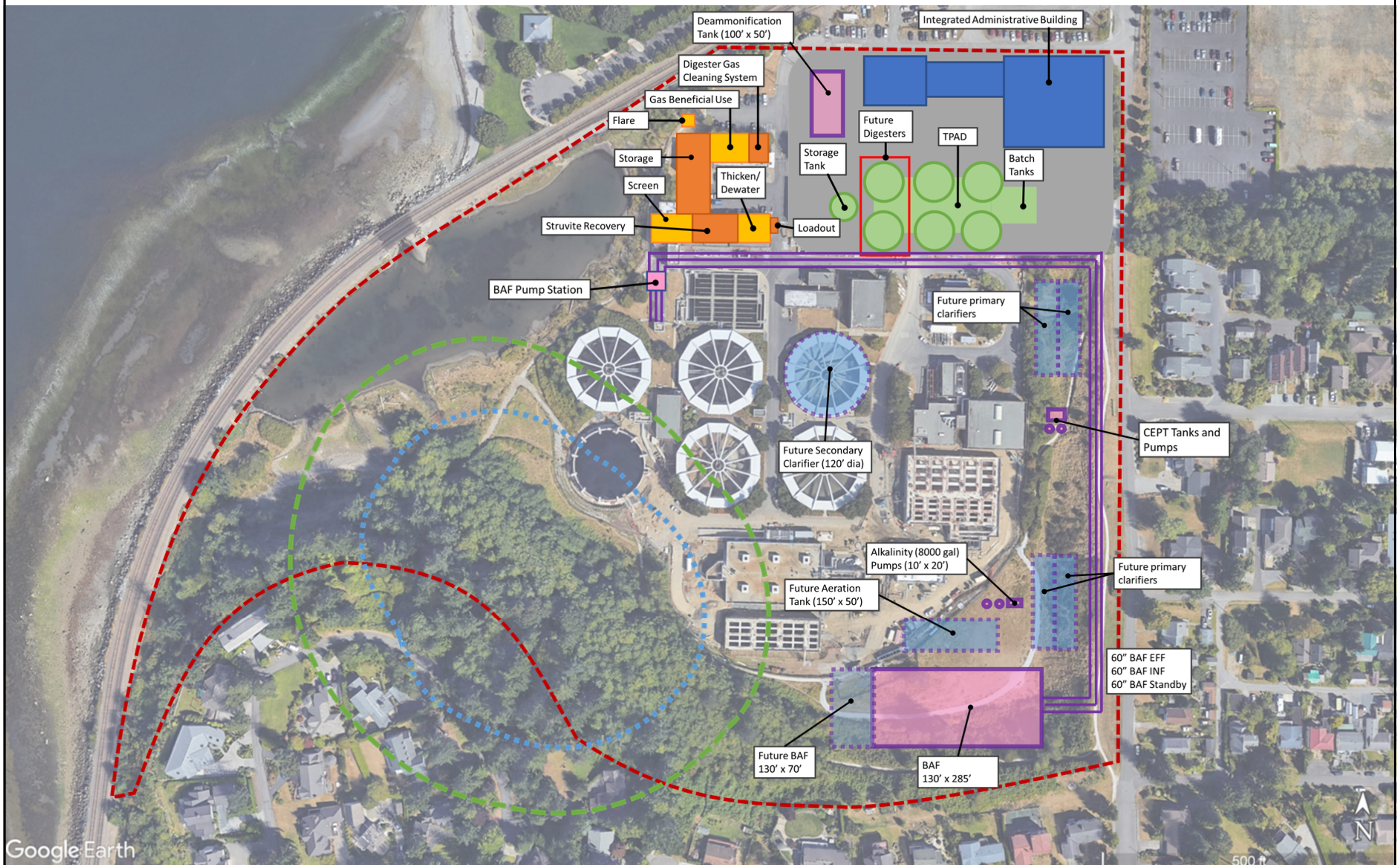
Scenario 3A – 8 mg/L TIN Summer Only, MLE with summer nitrification



Scenario 3B – 8 mg/L TIN Summer Only, existing plant config, BAF/DNF



3 mg/L Nitrogen Treatment Upgrade – 2045 Flows & Loads

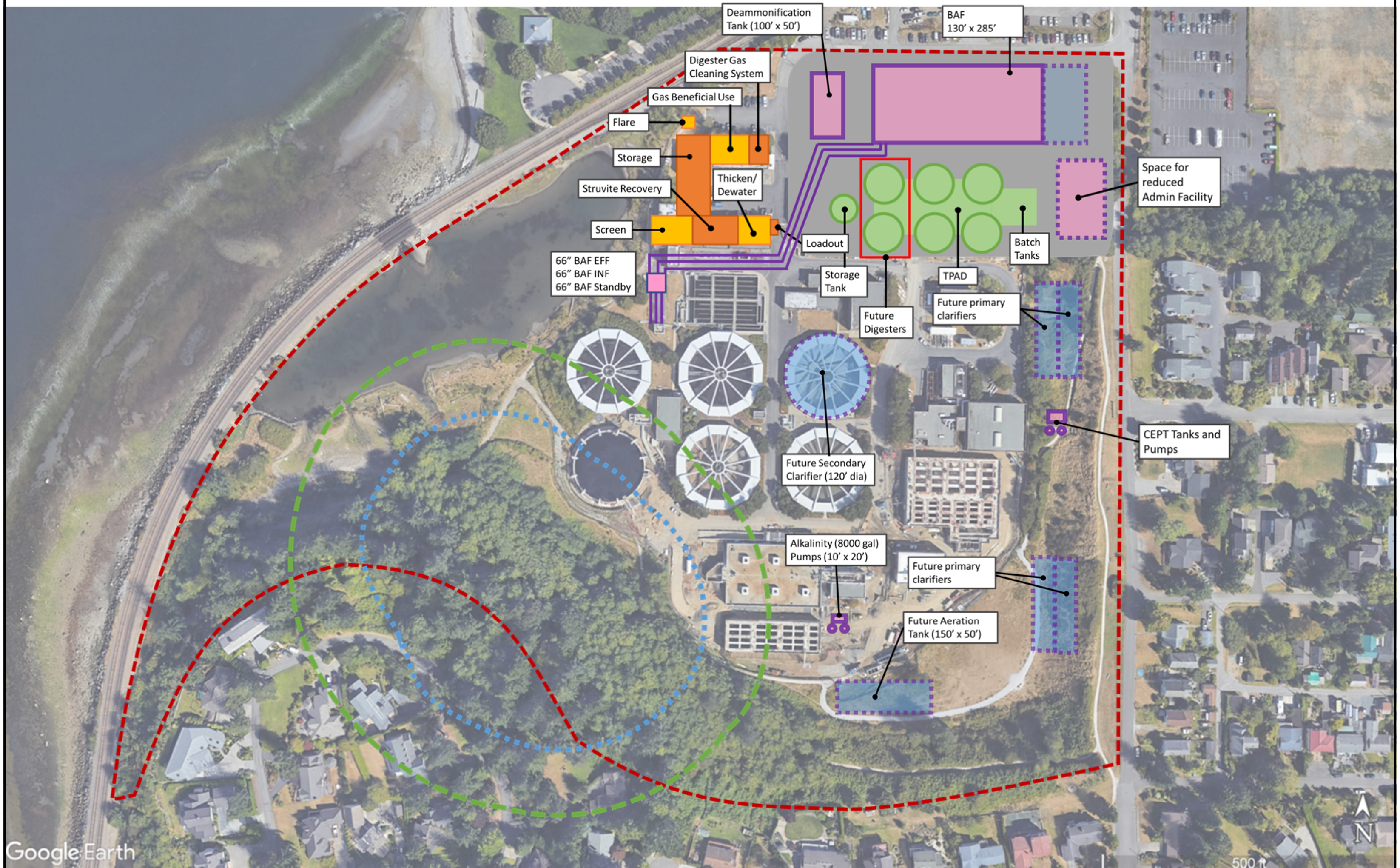
Future Liquid Treatment Expansion – 2060 Flows & Loads

197 ft year around core zone Heron protection buffer

300 ft vegetation retention and no disturbance buffer

Post Point WWTP Boundary

Scenario 3B' – 8 mg/L TIN Summer Only, existing plant config, BAF/DNF, no admin



3 mg/L Nitrogen Treatment Upgrade – 2045 Flows & Loads

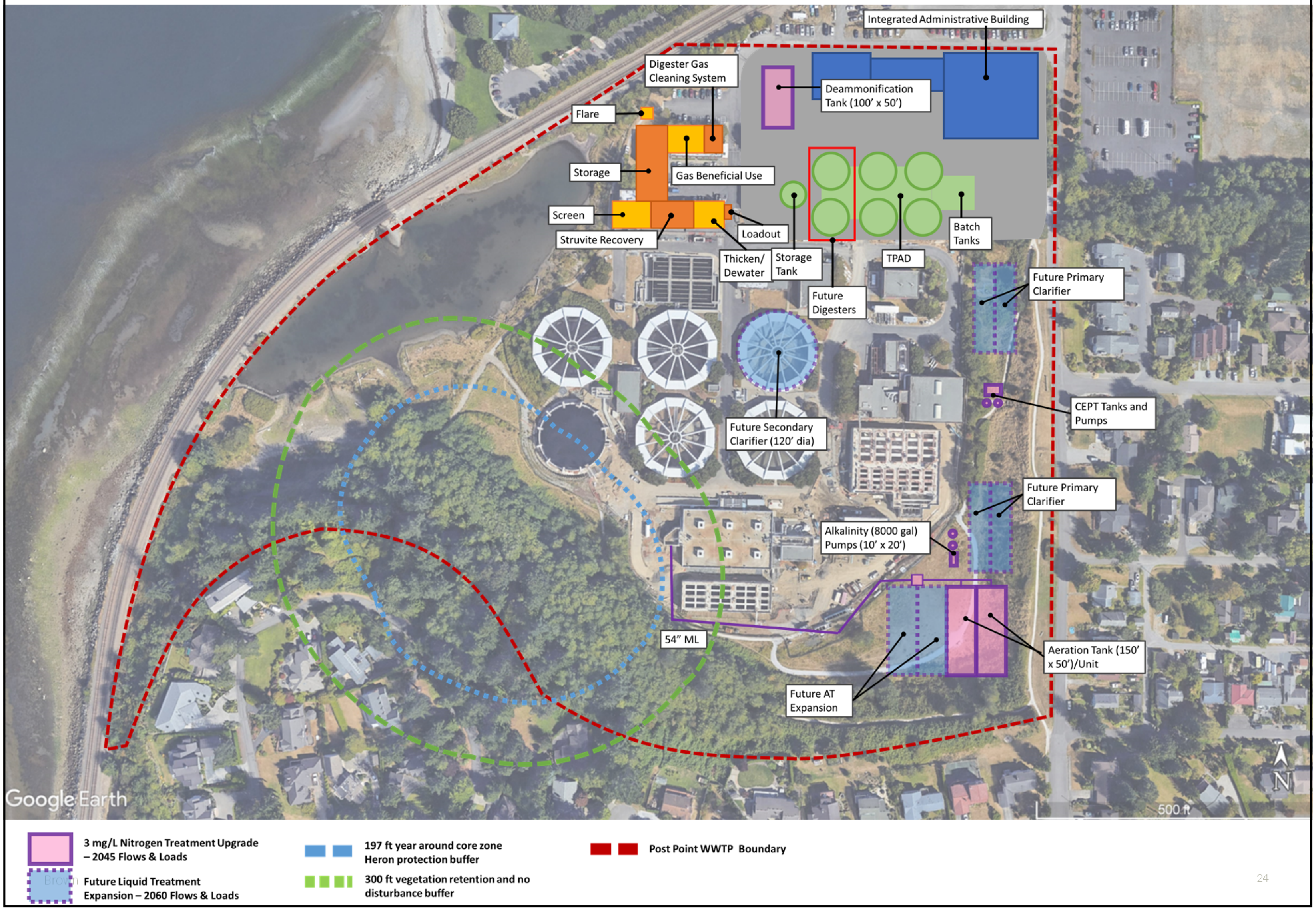
Future Liquid Treatment Expansion – 2060 Flows & Loads

197 ft year around core zone Heron protection buffer

300 ft vegetation retention and no disturbance buffer

Post Point WWTP Boundary

Scenario 3C – 8 mg/L TIN Summer Only, w/intensification



Summary of Layouts

Scenario	Limit Type	No Major Impacts to Existing Infra./ Rehabs	Outside Heron Protection Boundary	Outside Off-Leash Area	Digester Space Not Impacted	O&M Building Space Not Impacted
			Construction and New Facilities up till 2045			
1A	3 mg/L All Year	X	X	X	✓	✓
1B		✓	✓	X	✓	✓
1B'		✓	✓	✓	X	X
3A	8 mg/L Summer only	✓	✓[1]	X	✓	✓
3B		✓	✓	X	✓	✓
3B'		✓	✓	✓	✓	X
3C		✓	✓[1]	X	✓	✓

[1]Some impacts within 300 ft vegetation retention and no disturbance buffer

Appendix C: Capital Improvements Cost Estimate

Scenario 1b – Adds a tertiary nitrogen removal process to achieve 3 mg/L TIN discharge (year round)

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options
City of Bellingham
Prepared by: M. Neyestani and A. Conklin

Date Issued: 7/7/2020
Reviewed by: S. Leung

CAPITAL COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
a	BAF-N/DN and screening[3]	LS	1	$ 68,300,000	$ 68,300,000
b	Conveyance to and from the BAF-N/DN PS	LS	1	$ 18,700,000	$ 18,700,000
c	CEPT and Alkalinity Upgrades[3]	LS	1	$ 2,100,000	$ 2,100,000
d	BAF/DNF Pump Station[3]	LS	1	$ 3,300,000	$ 3,300,000
e	*Deammonification*[3,4]	LS	1	$ 7,500,000	--------
f	Carbon Feed[3]	LS	1	$ 2,000,000	$ 2,000,000
g	Standby Generator/Switchgear[3]	LS	1	$ 6,600,000	$ 6,600,000
h	RAS Pump Station Upgrade[3]	allowance	1	$ 1,300,000	$ 1,300,000
i	Site Work and Yard Piping	Percent of above	10%		$ 10,300,000
j	Constructability Constraints	allowance	1	$ 5,000,000	$ 5,000,000
k				**Subtotal**	$ 117,600,000
l				Estimator's Contingency[5] (40%)	$ 47,040,000
m				**Subtotal**	$ 164,640,000
n				General Conditions (15%)	$ 24,696,000
o				**Subtotal**	$ 189,336,000
p				Owner's Contingency[6] (0%)	$ -
q				**Subtotal**	$ 189,336,000
r				General Contractor OH&P (20%)	$ 37,867,200
s				**Subtotal**	$ 227,203,200
t				Sales Tax (Based on City of Bellingham @ 8.7%)	$ 19,767,000
u				**TOTAL ESTIMATED CONSTRUCTION COST (2020$)[1,2]**	**$247,000,000**
v				Engineering, Legal & Administration Fees (25%)	$61,750,000
w				Owner's Reserve for Change Orders - post-bid change of conditions[7] (5%)	$12,350,000
x				**TOTAL ESTIMATED PROJECT COST (2020$)[1,2]**	**$322,000,000**
y				Escalation (2030$- 3% per year)	$111,000,000
z				**TOTAL ESTIMATED PROJECT COST (2030$)[1,2]**	**$433,000,000**

1.The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1. Although the project timeline is unknown, Year 2020 costs (Line x) have been adjusted to Year 2030 (line z) as a potential mid-point of construction.

2. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

3. Includes a 30% allowance of each installed unit process for electrical, instrumentation and controls.

4. Sidestream treatment (line e) and associated site work (line i) should be added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process. The project cost at the biosolids midpoint of construction (2023) is estimated at approximately $24,800,000 for these two items.

5. Estimator's contingency includes: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate (e.g. ancillary equipment to identified processes).

6. Owner's Contingency: Reserve for bidding environment uncertainties and other potential Owner undetermined scope and cost changes.

7. Owner's Reserve for Change Orders: Reserve for post-bid change of conditions. Percentage is NOT applied to the Engineering, Legal & Admin. Fees.

Scenario 3b – Adds a tertiary nitrogen removal process to achieve 8 mg/L TIN discharge (summer only)

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options
City of Bellingham
Prepared by: M. Neyestani and A. Conklin

Date Issued: 7/7/2020
Reviewed by: S. Leung

CAPITAL COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
a	BAF-N/DN and screening[3]	LS	1	$ 59,300,000	$ 59,300,000
b	Conveyance to and from the BAF-N/DN PS	LS	1	$ 18,700,000	$ 18,700,000
c	CEPT and Alkalinity Upgrades[3]	LS	1	$ 2,100,000	$ 2,100,000
d	BAF/DNF Pump Station[3]	LS	1	$ 3,300,000	$ 3,300,000
e	*Deammonification* [3,4]	LS	1	$ 7,500,000	--------
f	Carbon Feed[3]	LS	1	$ 1,800,000	$ 1,800,000
g	Standby Generator/Switchgear[3]	LS	1	$ 6,600,000	$ 6,600,000
h	RAS Pump Station Upgrade[3]	allowance	1	$ 1,300,000	$ 1,300,000
i	Site Work and Yard Piping	Percent of above	10%		$ 9,400,000
j	Constructability Constraints	allowance	1	$ 5,000,000	$ 5,000,000
k				**Subtotal**	$ 107,500,000
l				Estimator's Contingency[5] (40%)	$ 43,000,000
m				**Subtotal**	$ 150,500,000
n				General Conditions (15%)	$ 22,575,000
o				**Subtotal**	$ 173,075,000
p				Owner's Contingency[6] (0%)	$ -
q				**Subtotal**	$ 173,075,000
r				General Contractor OH&P (20%)	$ 34,615,000
s				**Subtotal**	$ 207,690,000
t				Sales Tax (Based on City of Bellingham @ 8.7%)	$ 18,069,000
u				**TOTAL ESTIMATED CONSTRUCTION COST (2020$)[1,2]**	**$226,000,000**
v				Engineering, Legal & Administration Fees (25%)	$56,500,000
w				Owner's Reserve for Change Orders - post-bid change of conditions[7] (5%)	$11,300,000
x				**TOTAL ESTIMATED PROJECT COST (2020$)[1,2]**	**$294,000,000**
y				Escalation (2030$- 3% per year)	$101,000,000
z				**TOTAL ESTIMATED PROJECT COST (2030$)[1,2]**	**$395,000,000**

1.The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1. Although the project timeline is unknown, Year 2020 costs (Line x) have been adjusted to Year 2030 (line z) as a potential mid-point of construction.

2. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as

3. Includes a 30% allowance of each installed unit process for electrical, instrumentation and controls.

4. Sidestream treatment (line e) and associated site work (line i) should be added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process. The project cost at the biosolids midpoint of construction (2023) is estimated at approximately $24,800,000 for these two items.

5. Estimator's contingency includes: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate (e.g. ancillary equipment to identified processes).

6. Owner's Contingency: Reserve for bidding environment uncertainties and other potential Owner undetermined scope and cost changes.

7. Owner's Reserve for Change Orders: Reserve for post-bid change of conditions. Percentage is NOT applied to the Engineering, Legal & Admin. Fees.

Appendix D: O&M Cost Estimate

Scenario 1b – Adds a tertiary nitrogen removal process to achieve 3 mg/L TIN discharge (year round)

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options

City of Bellingham — Date Issued: 7/7/2020

Prepared by: M. Neyestani and A. Conklin — Reviewed by: S. Leung

O&M COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	
a	BAF-N/DN	LS	1	$ 350,000	$ 350,000	
b	CEPT and Alkalinity Upgrades	LS	1	$ 400,000	$ 400,000	
c	BAF Pump Station	LS	1	$ 200,000	$ 200,000	
d[1]	Deammonification	LS	1	$ 130,000	-----	
e	Standby Generator/Switchgear	LS	1	$ 30,000	$ 30,000	
f	RAS Pump Station Upgrade	LS	1	$ 20,000	$ 20,000	
g	Solids Handling Increases and Screening	LS	1	$ 170,000	$ 170,000	
				Subtotal	$ 1,170,000	
				Estimator's Contingency[2] (40%)	$ 470,000	
				Carbon Feed	$ 980,000	$ 2,390,000
				Subtotal	$ 2,620,000	$ 4,030,000
				TOTAL ESTIMATED O&M COST (2020$)[3,4]	**$2,600,000**	**$4,000,000**

1. Sidestream treatment (line d) was added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process.

2. Estimator's contingency: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate.

3. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

4. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1.

Scenario 3b – Adds a tertiary nitrogen removal process to achieve 8 mg/L TIN discharge (summer only)

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options
City of Bellingham
Prepared by: M. Neyestani and A. Conklin

Date Issued: 7/7/2020
Reviewed by: S. Leung

O&M COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	
a	BAF-N/DN	LS	1	$ 220,000	$ 220,000	
b	CEPT and Alkalinity Upgrades	LS	1	$ 320,000	$ 320,000	
c	BAF/DNF Pump Station	LS	1	$ 120,000	$ 120,000	
d[1]	Deammonification	LS	1	$ 130,000	-----	
e	Standby Generator/Switchgear	LS	1	$ 30,000	$ 30,000	
f	RAS Pump Station Upgrade	LS	1	$ 20,000	$ 20,000	
g	Solids Handling Increases and Screening	LS	1	$ 90,000	$ 90,000	
				Subtotal	$ 800,000	
				Estimator's Contingency[2] (40%)	$ 320,000	
				Carbon Feed	$ 510,000	$ 1,230,000
				Subtotal	$ 1,630,000	$ 2,350,000
				TOTAL ESTIMATED O&M COST (2020$)[3,4]	**$1,600,000**	**$2,400,000**

1. Sidestream treatment (line d) was added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process.

2. Estimator's contingency: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate.

3. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

4. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1.

Scenario 3c – IFAS Intensification to achieve 8 mg/L TIN discharge (summer only)

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options
City of Bellingham
Prepared by: M. Neyestani and A. Conklin

Date Issued: 7/7/2020
Reviewed by: S. Leung

O&M COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	
a	IFAS	LS	1	$ 200,000	$ 200,000	
b	CEPT and Alkalinity Upgrades	LS	1	$ 320,000	$ 320,000	
c[1]	Deammonification	LS	1	$ 130,000	-----	
d	Standby Generator/Switchgear	LS	1	$ 30,000	$ 30,000	
e	RAS Pump Station Upgrade	LS	1	$ 20,000	$ 20,000	
f	Odor Control	LS	1	$ 30,000	$ 30,000	
g	Solids Handling Increases and Screening	LS	1	$ 40,000	$ 40,000	
				Subtotal	$ 640,000	
				Estimator's Contingency[2] (40%)	$ 256,000	
				Carbon Feed	$ 220,000	$ 500,000
				Subtotal	$ 1,116,000	$ 1,396,000
				TOTAL ESTIMATED O&M COST (2020$)[3,4]	**$1,100,000**	**$1,400,000**

1. Sidestream treatment (line c) was added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process.

2. Estimator's contingency: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate.

3. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

4. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1.

Appendix E: Deammonification Capital and O&M Cost Estimate

Deammonification

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options
City of Bellingham
Prepared by: M. Neyestani and A. Conklin

Date Issued: 7/7/2020
Reviewed by: S. Leung

CAPITAL COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
a	Deammonification[3,4]	LS	1	$ 7,500,000	$ 7,500,000
b	Site Work and Yard Piping	Percent of above	10%		$ 750,000
c	Constructability Constraints	allowance		not included	
d				**Subtotal**	$ 8,250,000
e				Estimator's Contingency[5] (40%)	$ 3,300,000
f				**Subtotal**	$ 11,550,000
g				General Conditions (15%)	$ 1,732,500
h				**Subtotal**	$ 13,282,500
i				Owner's Contingency[6] (0%)	$ -
j				**Subtotal**	$ 13,282,500
k				General Contractor OH&P (20%)	$ 2,656,500
l				**Subtotal**	$ 15,939,000
m				Sales Tax (Based on City of Bellingham @ 8.7%)	$ 1,387,000
n				**TOTAL ESTIMATED CONSTRUCTION COST (2020$)[1,2]**	**$17,400,000**
o				Engineering, Legal & Administration Fees (25%)	$4,350,000
p				Owner's Reserve for Change Orders - post-bid change of conditions[7] (5%)	$870,000
q				**TOTAL ESTIMATED PROJECT COST (2020$)[1,2]**	**$22,700,000**
r				Escalation (2023$- 3% per year)	$2,100,000
s				**TOTAL ESTIMATED PROJECT COST (2023$)[1,2]**	**$24,800,000**

1.The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1. Year 2020 costs (Line q) have been adjusted to Year 2023 (line s) as a potential mid-point of construction.

2. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

3. Includes a 30% allowance of each installed unit process for electrical, instrumentation and controls.

4. Sidestream treatment (line e) and associated site work (line i) should be added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process. The project cost at the biosolids midpoint of construction (2023) is estimated at approximately $24,800,000 for these two items.

5. Estimator's contingency includes: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate (e.g. ancillary equipment to identified processes).

6. Owner's Contingency: Reserve for bidding environment uncertainties and other potential Owner undetermined scope and cost changes.

7. Owner's Reserve for Change Orders: Reserve for post-bid change of conditions. Percentage is NOT applied to the Engineering, Legal & Admin. Fees.

Sidestream Treatment - Deammonification

Post Point Biosolids Project - Task 371 Assessment of Nitrogen Removal Options
City of Bellingham
Prepared by: M. Neyestani and A. Conklin

Date Issued: 7/7/2020
Reviewed by: S. Leung

O&M COST OPINION

LINE	DESCRIPTION OF ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT
a[1]	Deammonification	LS	1	$ 130,000	$ 130,000
				Subtotal	$ 130,000
				Estimator's Contingency[2] (40%)	$ 52,000
				TOTAL ESTIMATED O&M COST (2020$)[3,4]	**$200,000**

1. Sidestream treatment (line a) was added to the biosolids recovery project to remove the majority of the nitrogen returned from the digestion process.

2. Estimator's contingency: Allows for changes within the current scope of the design that experience shows will likely be required but is not yet developed in this estimate.

3. The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

4. The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 5" estimate with an expected level of accuracy of -50% to +100% of the cost presented. Estimated project costs are prepared in April 2020 dollars, consistent with the 20-City Engineering News-Record (ENR) value of 11413 and a location factor for the City of 1.1.