Nutrient Alternatives Evaluation

San Leandro Water Pollution Control Plant

Technical Memorandum

Walnut Creek, CA
October 31, 2025
February 6, 2026
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Abbreviations

AACE	Advancement of Cost Engineering International
AD	Anaerobic Digester
ADWF	Average Dry Weather Flow
AOB	Ammonia Oxidizing Bacteria
BFP	Belt Filter Press
cBOD	Carbonaceous Biochemical Oxygen Demand
City	City of San Leandro
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EBDA	East Bay Dischargers Authority
FFR	Fixed Film Reactor
IMLR	Internal Mixed Liquor Recycling
lb/d	Pound(s) per Day
LS	Lift Station
MABR	Membrane Aerated Biofilm Reactor
MG	Million Gallon
MGD	Million Gallons per Day
MLSS	Mixed Liquor Suspended Solids
N	Nitrogen
NbS	Nature-based Solution
NO_x^-	Nitrate (NO_3^-) and Nitrite (NO_2^-)
NPDES	National Pollutant Discharge Elimination System
PE	Primary Effluent
PFD	Process Flow Diagram
RAS	Return Activated Sludge
RDT	Rotary Drum Thickener
sBOD	Soluble BOD
SRT	Sludge Retention Time
TIN	Total Inorganic Nitrogen
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TSS	Total Suspended Solids
WAS	Waste Activated Sludge
WPCP	Water Pollution Control Plant

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Executive Summary

The City of San Leandro's Water Pollution Control Plant (WPCP) owns and operates a trickling filter/solids contact secondary treatment facility that treats an average dry weather flow (ADWF) of approximately 4.5 MGD. The WPCP currently discharges approximately 95% of its effluent out of the East Bay Dischargers Authority (EBDA) common outfall. The remaining 5% is diverted for golf course irrigation prior to EBDA. For context, the WPCP represents a small percentage of the nitrogen load discharged from EBDA to San Francisco Bay (less than 10%).

In July 2024, San Francisco Bay Regional Water Quality Control Board adopted the Third Nutrient Watershed Permit (R2-2024-0013), which requires a baywide 40% reduction in total inorganic nitrogen loads (TIN; TIN = sum of ammonia, nitrite, and nitrate). The Third Permit requirements apply during the May 1 – September 30 dry season starting in 2035. The TIN load allocation within EBDA is flexible and collectively determined by EBDA member agencies. The current TIN reduction at the WPCP is limited to biomass assimilation.

This technical memorandum (TM) includes the following steps/objectives:

- Evaluate historical and current WPCP performance, including influent characteristics, biological process conditions, and nutrient behavior.
- Calibrate and apply a SUMO® process model to simulate baseline operations and assess nitrogen-reduction alternatives.
- Develop a nutrient roadmap outlining incremental, achievable strategies for reducing TIN loads.
- Evaluate supplemental August 2025 sampling results and confirm/refine modeling assumptions.
- Estimate planning level costs (AACE Class 4) for each TIN reduction alternative.

Table ES-1 lists the eight (8) different alternatives, provides a brief description of each, and lists the cost and corresponding TIN reduction. Note: the TIN reduction includes with and without the on-going nature-based solution (NbS) alternative that is expected to be operational by year 2028. A visual depiction of Table ES-1 is presented in Figure ES-1.

The key take aways from the table/figure is the WPCP has the potential to achieve 40% or greater TIN reduction by a combination of NbS coupled with alternatives 3A, 2B, and 3B are projected to achieve ~40%+ TIN reduction. Alternative 3A is attractive for the following reasons:

- Provides a means to achieve the initial 40% TIN reduction goal (albeit with NbS),
- Comes at a modest cost (compared to #2B and #3B),
- Leverages existing plant equipment (hence the modest cost), and
- Provides an opportunity to rehabilitate assets in need within the existing aeration basins.

Overall, it is recommended that the City advance Alternative #3A while confirming flows and loads and evaluating sidestream treatment technologies. This approach should result in a "no regrets" situation as this should address rehabilitation in the aeration basins and reliably meet the goal of at least 40% TIN reduction.

Table ES-1. Summary of the Cost Elements and Corresponding TIN Load Reductions

Alternative (Alt)	Alt Number	Description	Cost Estimate*	Projected TIN Reduction (w/NbS)
Nature-based Solution (NbS)	0	Diverting upwards of 0.95 mgd of secondary effluent to an NbS	**$13M**	10%
Mainstream Improvements	1A	Use All Existing Tankage	--	10-15%
	2A	FFR Bypass and Parallel Operation of Two Trains	**≤$10M**	20-30%
	3A	FFR Bypass, Series Operation of Two Trains and RAS Reaeration	**≤$12M**	40-50%
Sidestream Improvements PLUS Mainstream Improvements	1B	Sidestream Treatment and Parallel Operation of Two Trains	**≤$30M**	35-45%
	2B	Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains	**≤$30M**	55-65%
	3B	Sidestream Treatment, FFR Bypass, Series Operation of Two Trains, and RAS Reaeration	**≤$32M**	60-70%
Mainstream Expansion	4	Mainstream Tankage Expansion	**>$40M**	60-70%

* The cost estimates includes the equipment that should be replaced/repurposed as part of any such improvements (emphasis on secondary treatment assets; details in Section 7).

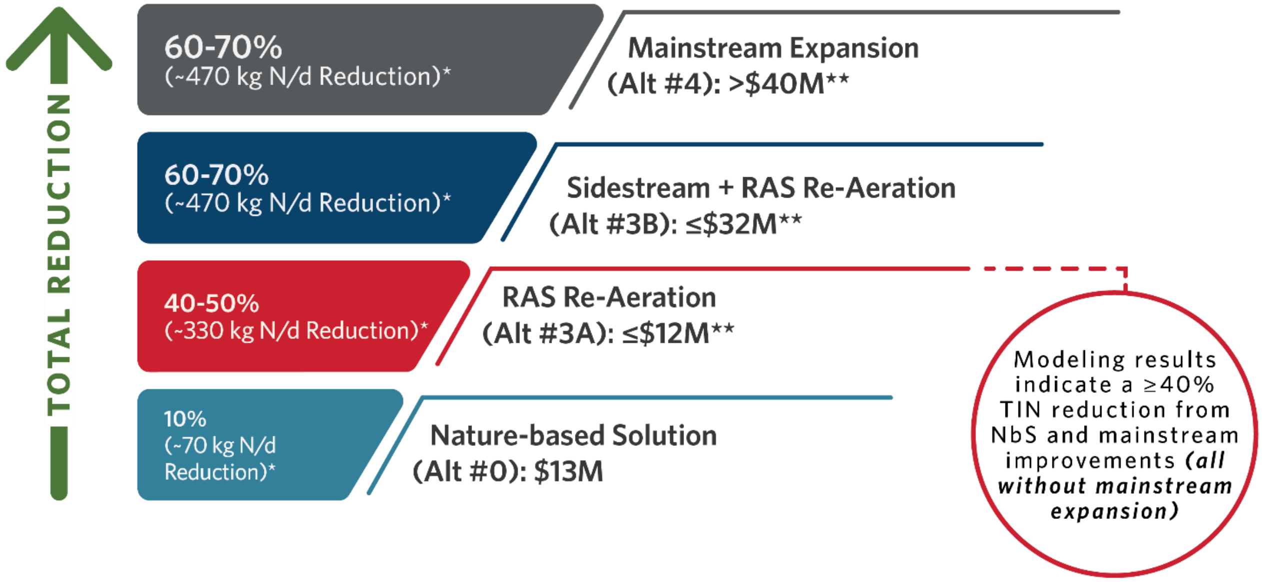

Figure ES-1. Nutrient Roadmap for Reducing TIN Loads and the Corresponding Costs

* The TIN reduction values (both percent and load) include NbS reductions

** The cost estimates includes the equipment that should be replaced/repurposed as part of any such improvements (emphasis on secondary treatment assets; details in Section 7).

1 Introduction

The City of San Leandro (City) Water Pollution and Control Plant (WPCP) requested a proposal from HDR to evaluate nitrogen reduction strategies at the wastewater treatment plant. This planning level exercise has an overarching goal of developing a nutrient roadmap that identifies opportunities for incremental reductions in nitrogen over time. The nutrient of interest is total inorganic nitrogen, which is the sum of ammonia, nitrite, and nitrate.

This technical memorandum (TM) summarizes the findings.

2 Basis for Nitrogen Reduction

The City's WPCP discharges effluent to the East Bay Discharger's Authority (EBDA) common outfall. Utilities that Contribute to EBDA include the following: City of Hayward, Oro Loma/Castro Valley Sanitary District, City of San Leandro, and Union Sanitary District, and Livermore-Amador Valley Water Management Agency members City of Livermore and Dublin-San Ramon Services District.

The Regional Water Quality Control Board (Water Board) adopted in July 2024 a total inorganic nitrogen TIN; TIN = sum of ammonia, nitrite, and nitrate) discharge load limits for municipal Publicly Owned Treatment Works (POTWs or Dischargers) to San Francisco Bay through a collective National Pollutant Discharge Elimination System (NPDES) permit (Permit No. CA0038873; R2-2024-0013). The permit is the third iteration of the Nutrient Watershed Permit (2024 Permit), which became effective on October 1, 2024, replacing the 2019 Permit (Order No. R2-2019-0017).

A summary of the 2024 Permit based discharge loads for the City's WPCP and EBDA is provided in Table 2-1. The 2022 TIN discharge loads that informed the interim and final TIN discharge limits suggest that the City's WPCP represents approximately 10 percent of EBDA's TIN discharge load.

Table 2-1. Discharge TIN Loads for EBDA and the City's WPCP for the 2024 Permit

Parameter*	2022 TIN Discharge Load (kg N/d)*	Interim TIN Discharge Load (kg N/d)**	Final TIN Discharge Load (kg N/d)**
City's WPCP (A)	699 kg N/d	Not Calculated	~324 kg N/d ***
EBDA (B)	6,900 kg N/d	9,000 kg N/d	4,200 kg N/d
EBDA Contribution from the City's WPCP (C = A ÷ B)	~10%	Not Calculated	~8%

* 2022 TIN loads included as they used as the baseline for the 2024 Regional Nutrient Permit (R2-2024-0013).

** The interim effluent TIN limits have been enforceable since the 2024 Permit became effective (October 1, 2024) and will apply to the dry seasons (May 1 through September 30) from 2025 through 2034. The final effluent TIN limits are enforceable starting October 1, 2034, and will apply beginning in the 2035 dry season.

*** Allocations for EBDA's member agencies are not final. The 324 kg N/d is based on the concentration equivalent in the third watershed permit (i.e., 20.5 mg N/L) and the corresponding effluent flow for the WPCP during the 2022 dry season.

The 2024 Permit does not prescribe the distribution of TIN discharge loads amongst EBDA members. Rather, the 2024 Permit provides flexibility for EBDA and its member agencies to dictate the TIN discharge load distribution. As such, the 324 kg N/d listed for the WPCP in Table 2-1 is an estimate at this stage.

The 2024 Permit requires Dischargers to comply with individual interim performance-based limits while taking steps to comply with their final individual load limitations by the 2035 dry season (May 1 through September 30). If a Discharger cannot comply within 10 years, the Regional Water Board will consider regulatory mechanisms as warranted and as available to grant more time (see Fact Sheet sections 6.3.5 and 6.3.6 in the 2024 Permit).

3 Objectives

The objectives of the study as included in this TM are as follows:

- Evaluate the existing conditions and historical performance of the WPCP. This initial exercise will serve as a baseline to confirm unit process performance and identify any potential process concerns.
- Present the modeling results (performing with the modeling software package SUMO). These results include the baseline model calibration and model outputs for the various TIN reduction simulations performed.
- Develop a nutrient roadmap that identifies a logical progression of incremental improvements to TIN reductions across the WPCP.
- Analyze the supplemental data sampled in August 2025 and provide perspective on whether or not the initial findings are modified.
- Provide a cost assessment of the recommended nutrient alternatives. Note: the cost estimate is based on a Level 4 cost estimate based on the Advancement of Cost Engineering International (AACE International). Level 4 has a project definition of 1-15% and is typically used for study or feasibility applications such as this effort. The expected accuracy range for Level 4 estimates are -30 to +50%.

4 Background and Existing Conditions

This section describes the project background, an overview of the WPCP, and summarizes the plant’s historical performance (emphasis on solids, organics, and nutrients).

4.1 Background

The City of San Leandro WPCP, located in eastern San Francisco Bay area, has a design and permitted capacity of 7.6 million gallons per day (MGD) average dry weather flow (ADWF) and a wet weather capacity of 22.3 MGD[1]. The plant receives both residential and industrial wastewater, including a high strength waste stream from a nearby dairy bottling facility. Final disinfected effluent is dechlorinated and discharged at the common East Bay Dischargers Authority (EBDA) outfall, which is shared with five other member agencies. National Pollutant Discharge Elimination System (NPDES) compliance is monitored at the EBDA outfall based on the combined discharge flow from all agencies.

On July 10th, 2024, the San Francisco Bay Regional Water Quality Control Board adopted the third Nutrient Watershed Permit, R2-2024-0013;
https://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2024/R2-2024-0013.pdf

which requires major dischargers to reduce dry season TIN loads to San Francisco Bay by 40% regionwide compared to 2022 dry season levels. Each wastewater treatment plant has until October 2034 to meet the requirements (i.e., 10-year period). Given that the WPCP is a Member Agency of the EBDA common outfall, the EBDA members are evaluating strategies to reduce their loads to meet the third Nutrient Watershed Permit.

Currently, the WPCP does not remove TIN beyond assimilation as it provides secondary treatment (i.e., removes Carbonaceous Biochemical Oxygen Demand (cBOD)). The City is exploring opportunities via this study to meet and/or exceed TIN load limits without major plant expansions.

4.2 Project Meetings

The WPCP hosted several meetings with HDR to discuss the objectives, review data, perform site walks, and engage throughout the process. The meeting agenda/minutes and the corresponding slide decks used as part of the project are provided in Appendix A.

4.3 Existing Plant Overview

Figure 4-1 presents a process flow diagram (PFD) of the WPCP. A description of the WPCP is divided up by liquid and solids streams as follows. An aerial photo of major facilities at the WPCP is presented in Figure 4-2.

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[1] Carollo. (2009). *Water Pollution Control Plant Rehabilitation Project: Predesign Report*

4.3.1 Liquid Stream

Raw wastewater is screened before entering the influent pump station. The Pumped influent then flows into the grit facility, followed by primary clarifiers. There are three circular primary clarifiers: clarifiers # 2 and # 3 have the same diameter (70'), whereas clarifier #1 is smaller (65' diameter). Primary Effluent (PE) is subsequently lifted by the Fixed Film Reactor (FFR) lift station and directed to the FFR. Effluent from the FFR is conveyed to the FFR effluent junction box. A portion of FFR effluent is recirculated from the junction box back to the FFR Lift Station.

Return activated sludge (RAS) combines with the remaining portion of FFR effluent after the junction box and enters one of the aeration basins. There are two aeration basins, each with a volume of 0.66 million gallon (MG) and dimensions of 210' x 30' x 14' (L x W x D). Note: only one aeration basin is operated at a time which offers 100% redundancy in the aeration basins. The FFR and the activated sludge system are operated as trickling filter/solid contact process, in which the FFR removes a substantial portion of cBOD whereas the aeration tanks remove the remaining cBOD and flocculate/condition the mixed liquor for better sludge settleability[1]. The aeration basin effluent is separated in two secondary clarifiers (one at 90' diameter and one at 110' diameter). Secondary effluent is sent to the chlorine contact tank for disinfection and subsequently conveyed to EBDA for dechlorination.

4.3.2 Solids Stream

For the solid stream, waste activated sludge (WAS) is thickened using a rotary drum thickener (RDT), then combined with primary sludge and directed to the anaerobic digesters (AD). There are four ADs at the WPCP. ADs 1, 2, and 4 are redundant digesters. AD 3 has been out of service for over 30 years. Return streams from the thickening and dewatering processes are combined before being sent back to the headworks. Digested sludge is dewatered using a belt filter press (BFP).

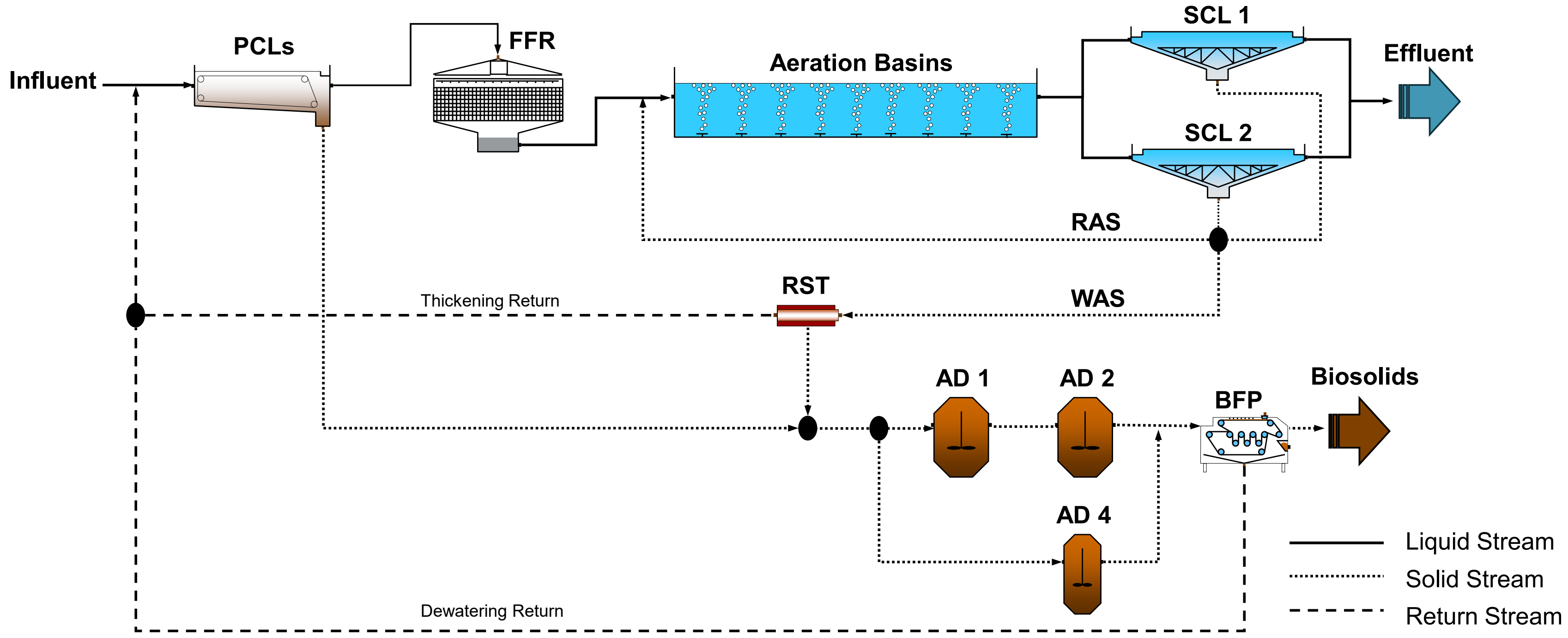
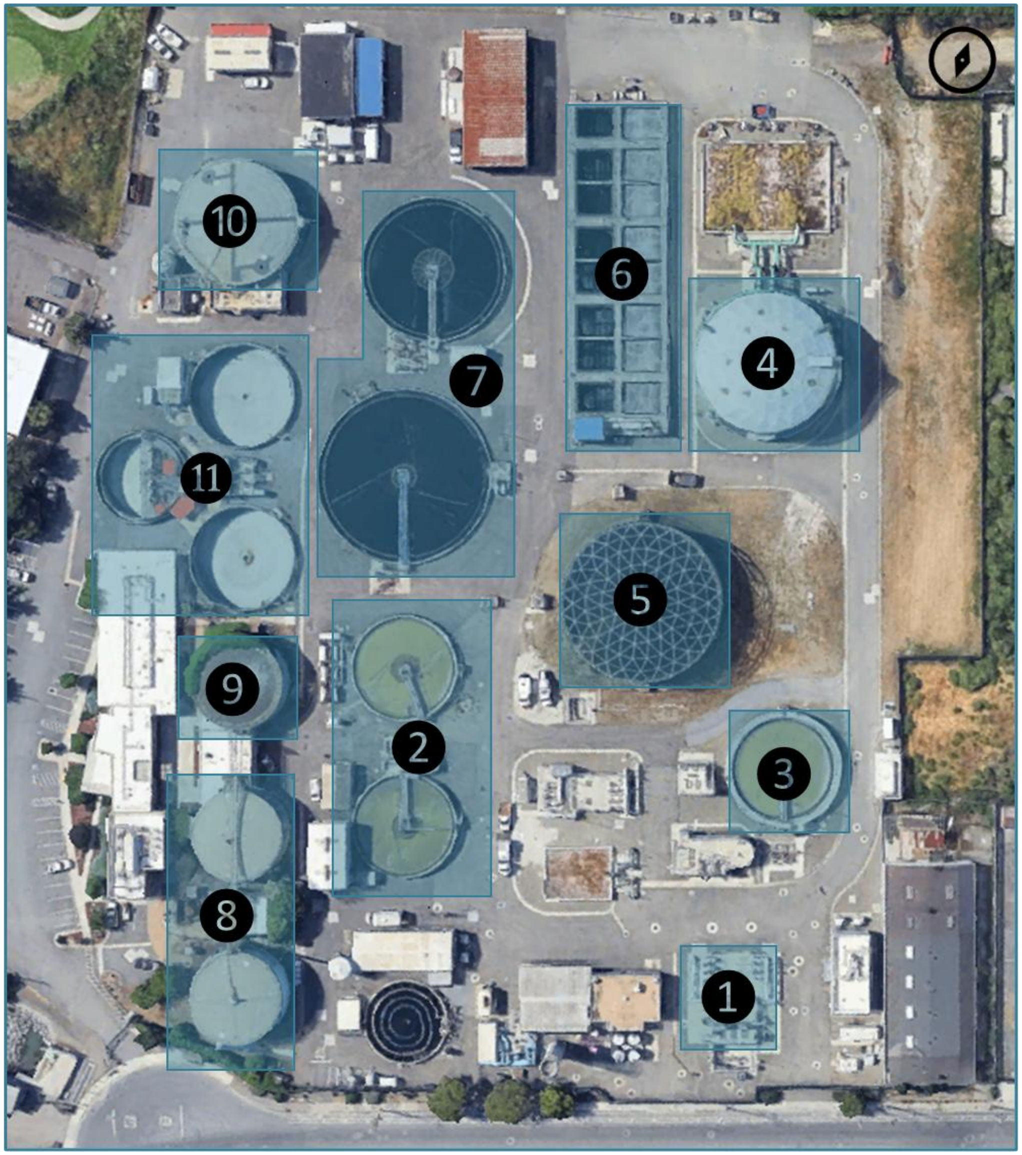


Figure 4-1. Existing Plant Process Flow Diagram

Note: The equalization basin, equalization tanks, and disinfection process are not shown in the PFD



1	Headworks
2	Primary Clarifiers No.1 & 2
3	Primary Clarifier No.3
4	Fixed Growth Reactor (FFR, In Service)
5	Old FFR (OOS)
6	Two Aeration Tanks (0.66 MG each, Only One Tank in Use)
7	Secondary Clarifiers No.1 & 2
8	Anaerobic Digester No.1 & 2
9	Anaerobic Digester No.3 (OOS)
10	Anaerobic Digester No.4
11	Flow Diversion Tanks (One of the Tanks Can be Repurposed)

Figure 4-2. Major Facilities at the WPCP

4.4 Historical Performance

This section evaluates the WPCP's historical performance based on composite samples collected from 2022 through 2025. These data provide the basis for the Sumo process modeling discussed in Section 5. Note: subsequent sampling was performed in August 2025 which will be covered in Section 9.

4.4.1 Influent Characteristics

Figure 4-3 to Figure 4-9 present raw influent characteristics. The influent sampling point is located upstream of the thickening and dewatering return streams, and it thus reflects the characteristics of the raw influent. Key observations are as follows:

- Daily influent flow (refer to Figure 4-3):
    - Averages 5.1 MGD with occasional elevated excursions (typically limited to wet weather precipitation events).
    - A high storm event occurred in December 2022 where the flow reached 25 mgd.
- Daily influent cBOD concentration (refer to Figure 4-4) and loading (refer to Figure 4-5):
    - Average is 640 mg/L, which is considered high strength for municipal wastewater. For perspective, the typical industry accepted benchmark for high strength category is approximately 400 mg cBOD/L)[2]. Note: cBOD is slightly lower than BOD as it includes the nitrifier inhibitory compound in the cBOD analysis.
    - Elevated cBOD level is likely attributed to industrial loading from the dairy bottling facility, as well as other industrial contributors (e.g., breweries in the service area).
    - The cBOD loading to the plant averages 27,300 lb/day.
- Daily influent total suspended solids (TSS) concentration (refer to Figure 4-6) and loadings (refer to Figure 4-7):
    - Average is 345 mg/L, which is not as high-strength as cBOD per se, but close to the industry accepted high-strength wastewater benchmark (approximately 400 mg/L TSS).
    - The TSS loading to the plant averages 14,700 lb/day.
- The influent ammonia concentration ranges from 14 to 40 mg N/L, with an average of 30 mg N/L (refer to Figure 4-8). Note: the lower concentrations occur during peak wet weather events when values are diluted due to inflow and infiltration.
- Influent Total Kjeldahl Nitrogen (TKN; TKN = ammonia plus organic nitrogen) concentrations are included (refer to Figure 4-9). For context, TKN provides a strong

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[2] Metcalf & Eddy (2014). *Wastewater engineering: Treatment and resource recovery (5th ed.)*. McGraw-Hill Education

representation of total nitrogen in the influent as ammonia and organic nitrogen typically make up 95% or greater of the influent. The majority of the organic nitrogen within TKN is converted to ammonia within the treatment plant. As such, it is a more accurate depiction of the influent TIN load (over simply ammonia).

- The TKN dataset is different from the previously presented datasets (i.e., longer duration; lower sampling frequency). That is attributed to TKN sampling being required in 2019 as part of the Third Permit. As such, the ammonia and TKN samples from 2019 are presented in Figure 4-9.
- TKN concentrations range from 50 to 77 mg N/L (average value of 59 mg N/L).
- The ammonia:TKN ratio is also included as it can serve as a metric for translating between influent ammonia sampling and TKN. That average ammonia:TKN value is 0.57, which is close to the industry accepted value of 0.67.

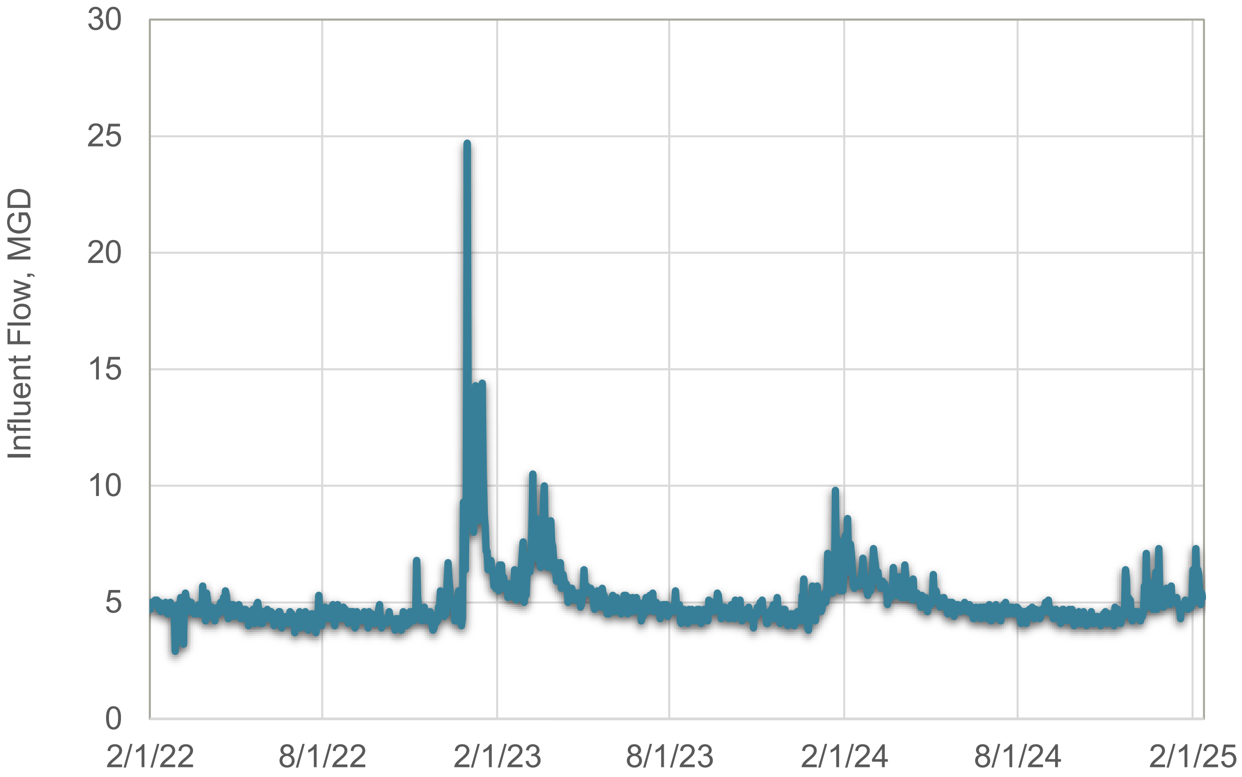

Figure 4-3. Influent Daily Average Influent Flow

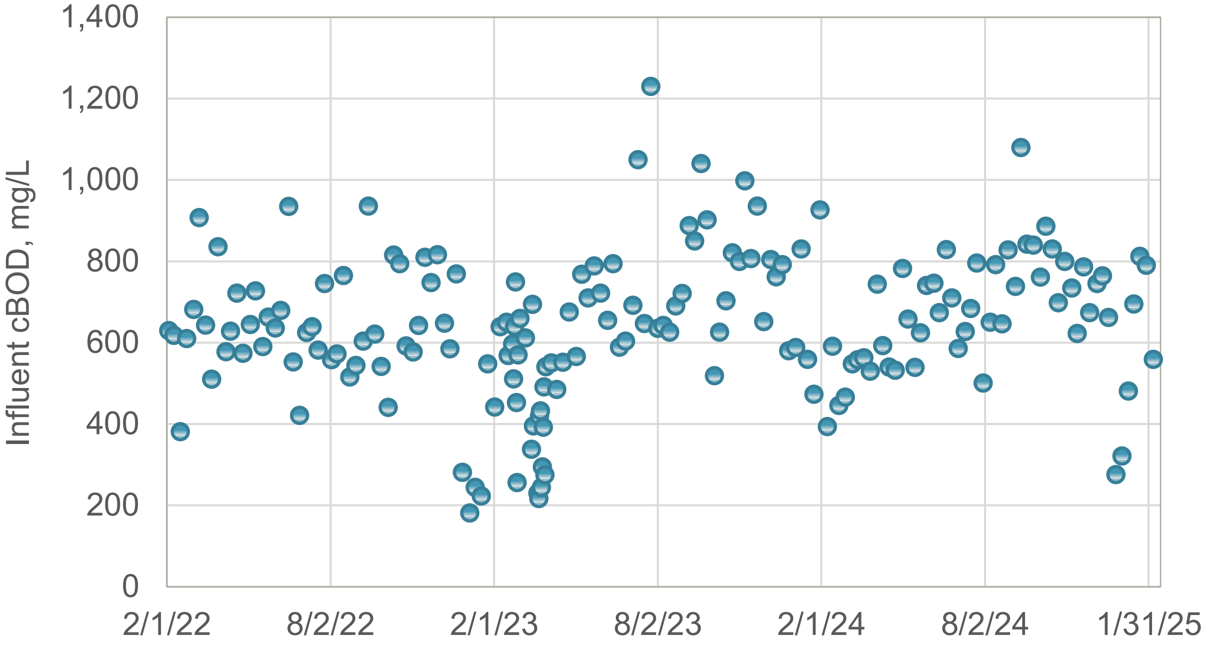

Figure 4-4. Influent cBOD Concentration

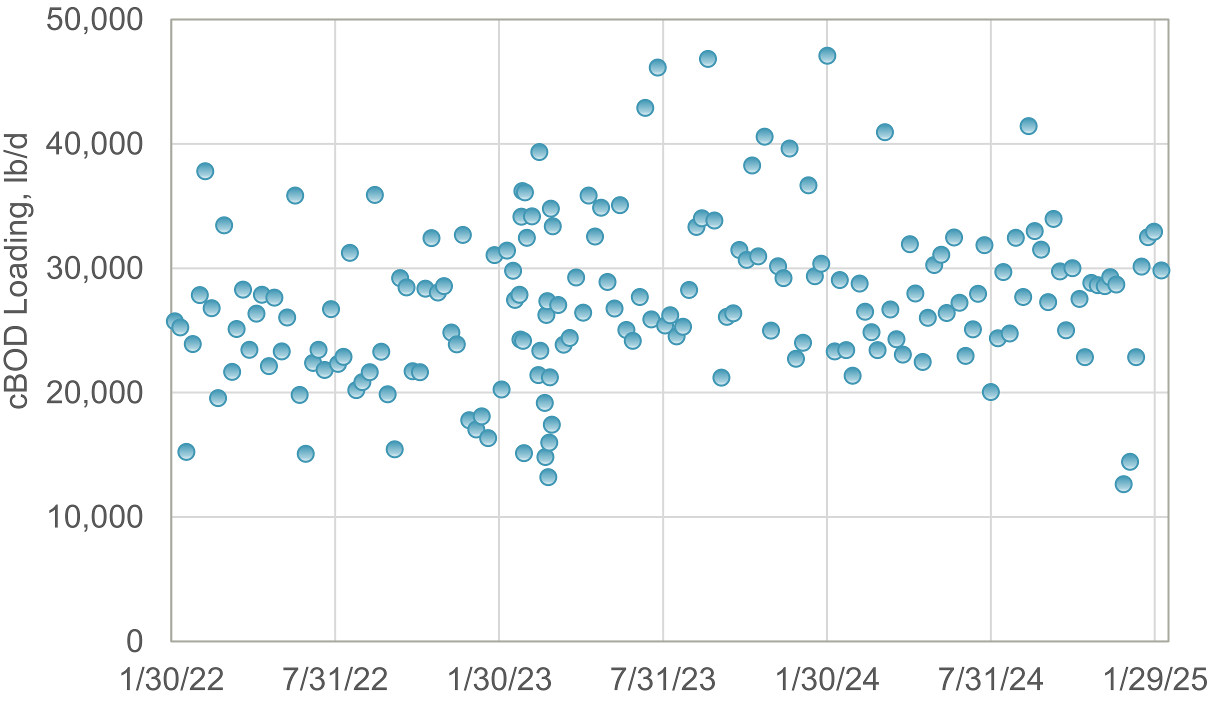

Figure 4-5. Influent cBOD Loading

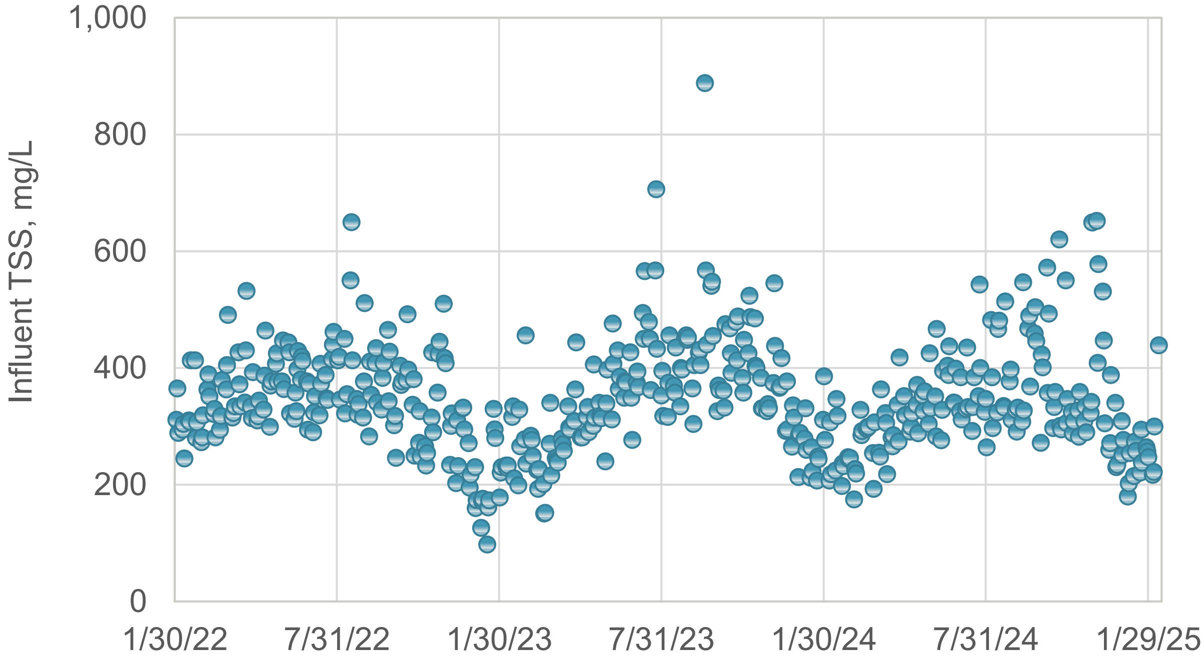

Figure 4-6. Influent TSS Concentration

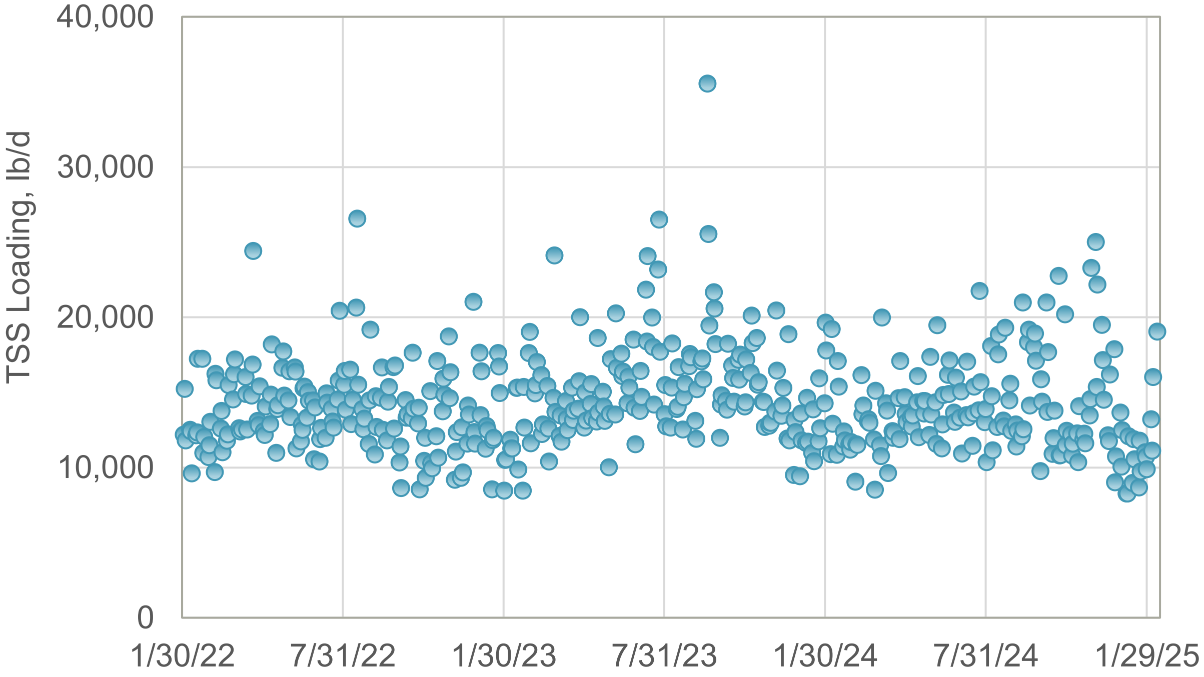

Figure 4-7. Influent TSS Loading

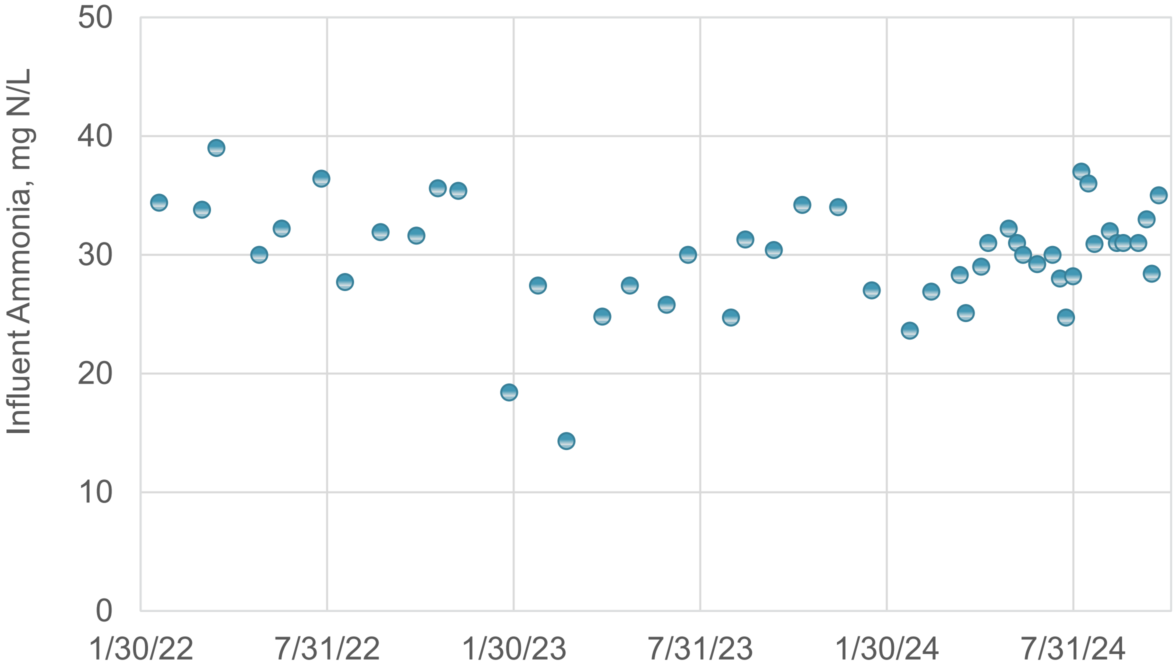

Figure 4-8. Influent Ammonia Concentration

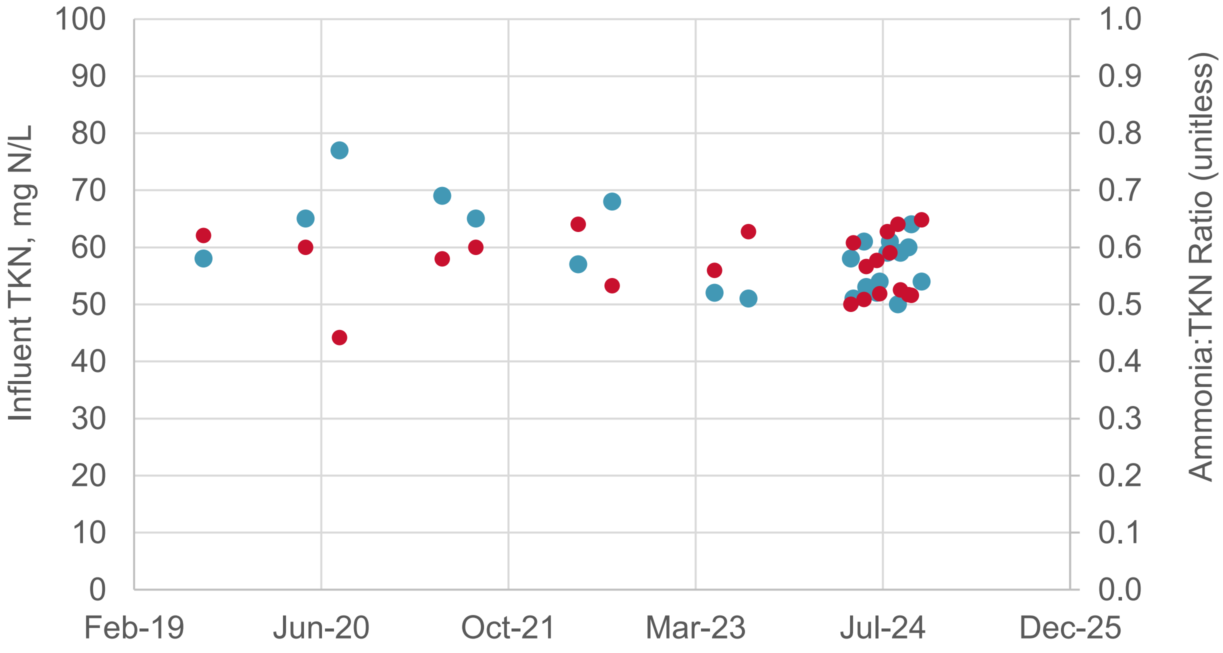

Figure 4-9. Influent TKN Concentration

4.4.2 Treatment Performance across the Plant

This section presents the concentrations for cBOD, soluble cBOD (sBOD), and nitrogen across the plant. The TSS levels are not included as such information is not that relevant as the primaries reliably remove 60 to 80% of the influent loads, and the secondaries have effluent TSS levels reliably less than 20 mg/L.

The cBOD levels across different treatment processes are presented in Figure 4-10. The average values suggest that the FFR's effectively remove about 280 mg/L cBOD, accounting for 42% of the total cBOD in the wastewater. This finding was expected as the plant refers to the FFR's as the "work horse" of the WPCP. The FFR's typically focus on removal of sBOD with the understanding that not all of the sBOD is readily degradable. The non-readily degradable sBOD contribution should be captured as FFR effluent. In the case of the WPCP, it appears that approximately 57 mg/L of sBOD is non-readily degradable sBOD as it measured in FFR Out. This non-readily degradable fraction appears to be removed prior to final effluent.

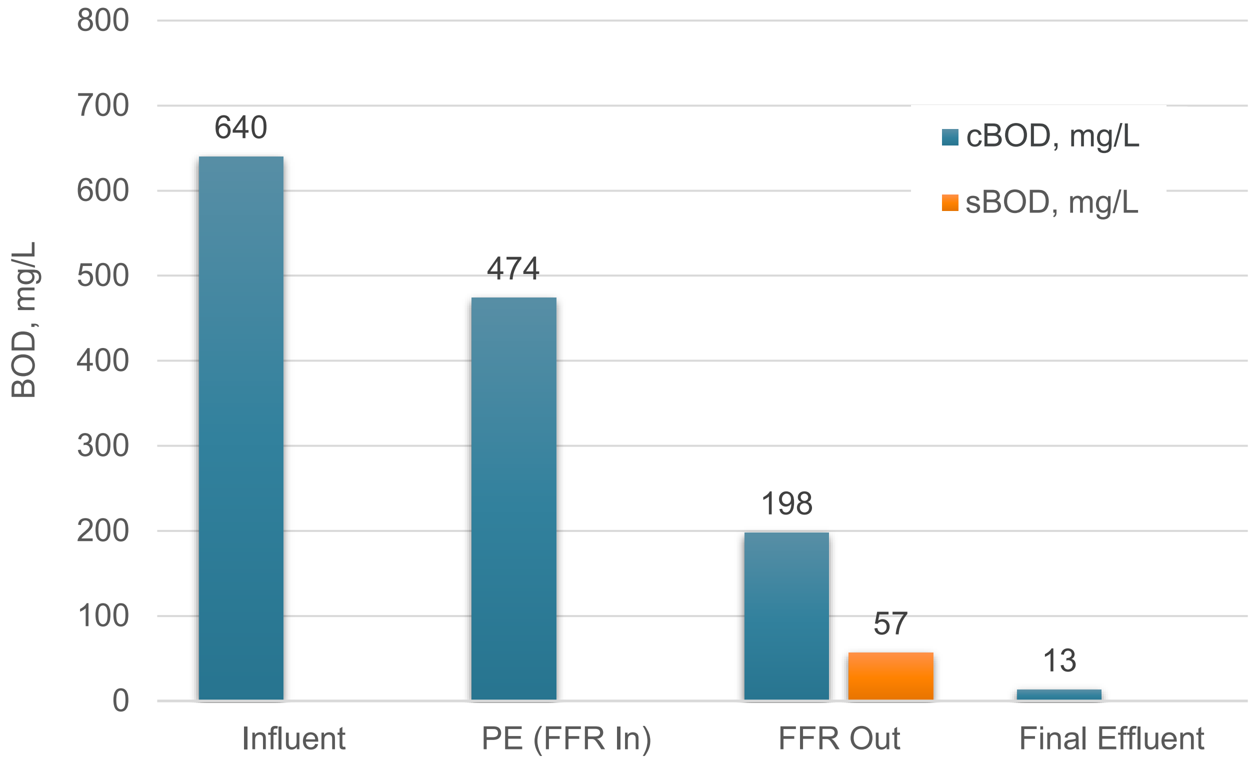

Figure 4-10. Average BOD Concentrations across the Plant

Figure 4-11 presents the nitrogen species concentration across the plant. The species monitored are ammonia and NOx, whereas NOx is the sum of nitrite and nitrate. The basis for these nitrogen parameters is they represent the variables that makeup TIN. Influent ammonia concentrations average 30 mg-N/L, whereas Total Kjeldahl Nitrogen (TKN) concentrations average 56.6 mg-N/L (TKN data not shown in the figure as it is limited to influent sampling).

Ammonia levels remain relatively consistent across the plant – except for an increase in the PE which is attributed to a combination of mechanical dewatering reject streams and the conversion of organic nitrogen to ammonia. The reduction across the FFRs is largely attributed to biological assimilation – indicating that little or no nitrification is occurring across the FFRs or the aeration basins. The lack of ammonia removal is verified and validated by the lack of Nox formation with levels at 2.0 mg N/L or less throughout the plant.

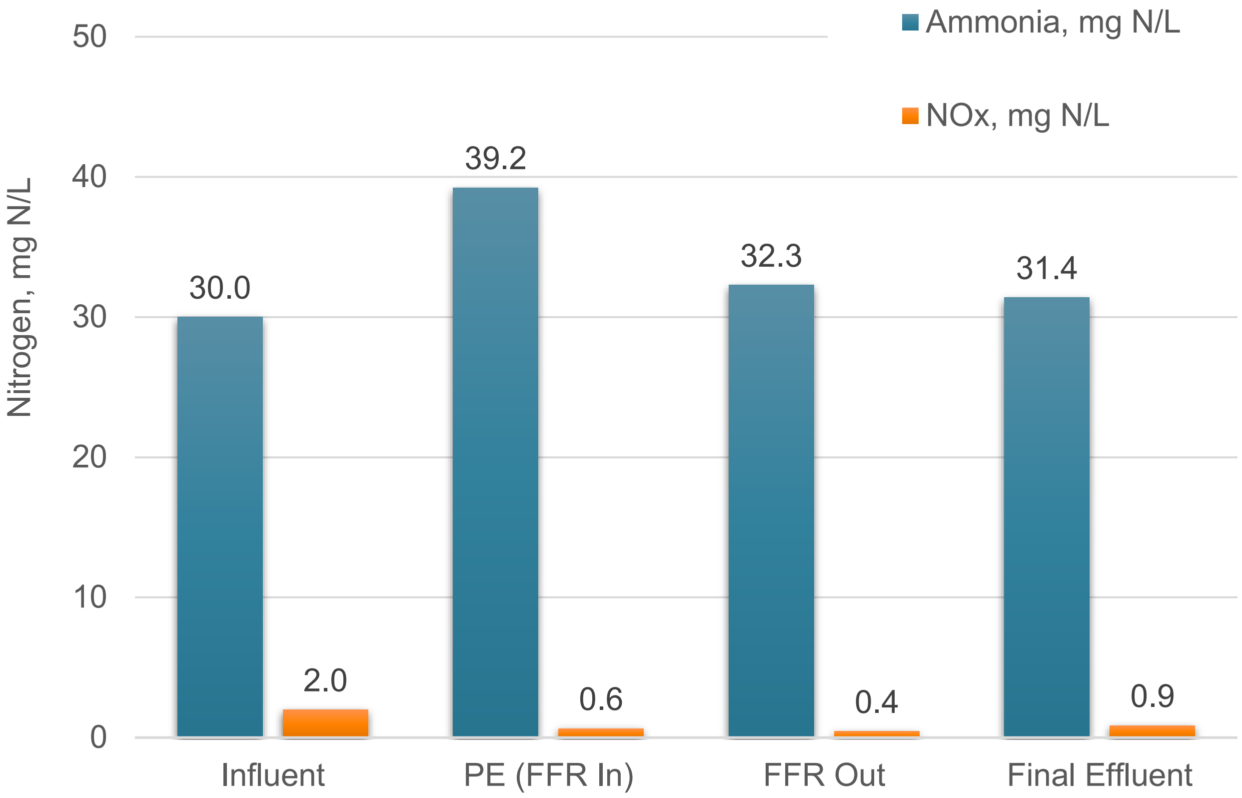

Figure 4-11. Average Nitrogen Concentration across the Plant

4.4.3 Treatment Plant Challenges Unique to the WPCP

While performing this evaluation, the plant experienced a plant upset and it struggled to meet discharge limits. Specifically, the FFRs and aeration basins were impacted as evidenced by white foam formation in the aeration basins and cBOD bleed through in the FFRs. A picture of the formed foam in the aeration basins is presented in Figure 4-12.

During a project meeting at the WPCP, the team collectively identified Quaternary Ammonium Compounds (QACs) as a potential culprit in the plant upset. The WPCP acted swiftly and performed sampling. The results from the QACs sampling confirmed that QACs were the likely culprit. The QAC values were between 5 to 10 mg/L. At such levels, QACs have the potential to inhibit nitrification and start to deteriorate the microbes that perform secondary treatment (Lehman et al., 2023). The City is continuing to study the problem, including additional testing to confirm the 2025 results.

The plant has since recovered. As noted in the modeling calibration section (Section 5), the presence of QACs or other industrial toxin seems to impact the WPCP's ability to remove ammonia. If the QACs and/or other industrial toxins are addressed, the modeling efforts could be viewed as conservative. However, the additional TIN reductions associated with reducing such industrial loads should be tempered as the effluent TIN concentrations would likely not be significantly reduced. The basis for this statement is the sBOD levels are the limiting factor at reducing TIN loads. The primary gains by reducing such industrial loads would be additional plant capacity to maintain TIN effluent concentrations. Regardless, the WPCP should consider reducing such industrial toxins as they do have the potential to "knock out" the biological process once threshold levels are exceeded.

Figure 4-12. White Foam Formation in the Aeration Basins during the 2025 Plant Upset

5 SUMO® Model Calibration

This section presents the SUMO baseline model calibration process and model output compared to measured values. The objective of SUMO baseline model calibration is to adjust model parameters so that the simulated plant performance in the model reasonably matches the historical WPCP plant data. A reasonably calibrated baseline model provides the foundation for nutrient alternatives evaluation.

The baseline SUMO model used for calibration is presented in Figure 5-1.

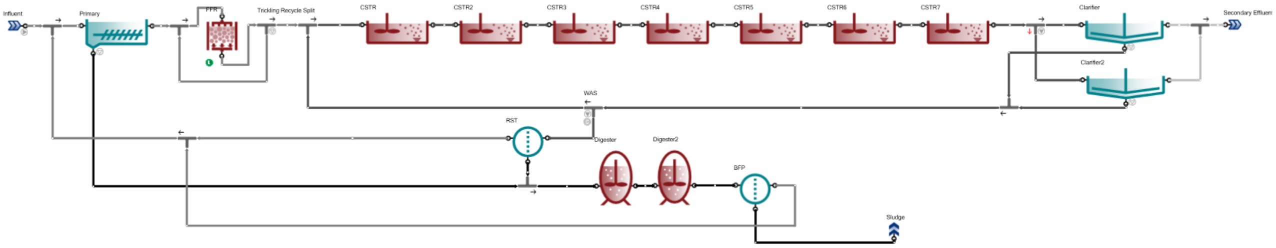

Figure 5-1. SUMO Baseline Model Visual

5.1 Key Assumptions and Model Adjustments

A major challenge encountered during modeling calibration was the lack of detailed influent carbon fractionation and historical plant operation data, which led to several assumptions being made to continue the calibration process.

A list of the key assumptions are as follows:

- Mixed Liquor Suspended Solids (MLSS) concentration: assumed a value of 2,000 mg/L in the aeration basins.
- Dissolved Oxygen (DO): assumed a setpoint of 2.0 mg/L in the aeration basins.
- Mechanical belt filter press: assumed specific solids capture and reject rate based on values that HDR has seen nationwide.

A list of key model adjustments outside of SUMO default values is presented in Table 5-1. The key emphasis was on the growth rates across the FFR and aeration basins. While calibrating the model, the calibration struggled to match the WPCP ammonia levels (i.e., little or no nitrification) as the SUMO model initially removed ammonia (i.e., nitrification). Specifically, the default model showed significant nitrification activity in the aeration basins, whereas the measured data indicated no nitrification activity (Figure 4-11).

To match WPCP lack of nitrification, the maximum Ammonia Oxidizing Bacteria (AOB) growth rate for the microbes that remove ammonia in the model was reduced from the default 0.9 d^{-1} to 0.45 d^{-1} as a strategy to curb ammonia removal. It should be noted that even this reduced value continued to overestimate nitrification in the aeration basins, due to the ongoing nitrifier inhibition likely caused by elevated QAC levels as previously noted.

If QAC treatment is implemented and able to quench QACs, further modeling should be conducted to reflect any updated AOB growth rates associated with such a change.

The other default parameters altered from default were the organic heterotrophic organisms (OHOs) which are the microbes that perform secondary treatment. The max OHO growth rates were increased to match the MLSS levels in the tank. In contrast, the FFR OHO yield values were reduced based on solids leaving the FFRs.

Making such modifications to a plant specific SUMO model is relatively common, albeit in this case the reduction in max AOB growth rates being more profound than typically seen which is attributed to the QACs.

Table 5-1. Major Model Adjustments for San Leandro Baseline Model

Parameter*	Unit	Model Default Value	Adjusted Value
Max AOB Growth Rate	1/d	0.9	0.45
Max OHO Growth Rate	1/d	4.0	8.0
FFR OHO Yield	gCOD/gCOD	0.67	0.4

* AOB = Ammonia Oxidizing Bacteria; OHO = Organic Heterotrophic Organisms, FFR = Fixed-Film Reactor

** COD = Chemical Oxygen Demand

5.2 Baseline Model Calibration Results

A summary of the historical WPCP average values and the SUMO model outputs is provided in Table 5-2. Overall, the model struggled to calibrate within the desired 10 to 20 percent difference for planning level efforts such as this. The relatively large percent difference is attributed to the unique raw influent and the industrial contributions, as well as the model is solids based so it struggles with matching cBOD values. Furthermore, the FFR does the majority of the work across the plant and all treatment plant simulators (including SUMO) struggle to calibrate against FFRs.

Despite the relatively large percent difference(s), the assumed model values were conservatively higher than WPCP data for the key parameter, nitrogen species (ammonia and NOx (not shown)). Furthermore, the FFR effluent values for TSS, cBOD, and sBOD are higher in the SUMO which also supports the conservative nature of the model. It is recommended that the WPCP continue to sample more frequently which will be further discussed in Section 9. Specifically, sampling more frequently for COD and nitrogen species on the primary effluent would enhance confidence on potential nitrogen load reductions across the downstream biological process.

Table 5-2. SUMO Baseline Model Calibration Result

Parameter	Measured Data	Model Output	Percent Difference *
Raw Influent			
cBOD	640 mg/L	640 mg/L	0%
TSS	345 mg/L	345 mg/L	0%
Ammonia	30 mg/L	30 mg/L	0%
Primary Effluent			
cBOD	474 mg/L	428 mg/L	10%
TSS	140 mg/L	146 mg/L	4%
Ammonia	39 mg/L	47 mg/L	20%
FFR Effluent			
cBOD	198 mg/L	254 mg/L	28%
Soluble BOD	57 mg/L	92 mg/L	63%
TSS	213 mg/L	238 mg/L	12%
Ammonia	32 mg/L	37 mg/L	15%
Final Effluent			
TSS	11 mg/L	11 mg/L	<1%
TIN	32 mg/L	38 mg/L	18%
Ammonia	31 mg/L	32 mg/L	<1%

* Percent Difference is calculated as (Measured Data – Model Output) ÷ Measured Data

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6 Nutrient Alternatives Evaluation

The modeling exercise considered flow and load projections at the WPCP as follows:

- Increase influent flow from current (typically 4.3-4.5 mgd during the dry season) to projected influent flows of 4.8 mgd during the dry season (translates to 5.1 mgd annual average).
- The projected influent modeling concentrations match those used for the current influent modeling concentrations (discussed in Section 5.2).
- Overall, the flows and loads increase approximately 10% from current flows and loads. This increase is deemed reasonable given the lack of on-going growth in the area. However, this should be further evaluated if the City decides to move forward with any of the listed alternatives.

This section describes the alternatives that were developed and evaluated for the project. As summarized in Table 6-1, a total of seven alternatives were evaluated. Alternatives 1A, 2A, and 3A represent the mainstream improvements scenarios. Alternatives 1B, 2B, and 3B build upon each “A” alternative by including sidestream treatment. For example, 1B is the same as 1A plus it includes sidestream treatment. And finally, alternative 4 presents the mainstream expansion scenario.

Table 6-1. Overview of Nutrient Alternatives

Alternative	Alternative Number	Description
Nature-based Solution	0*	This is a separate project from this effort. The vision is to divert up to 0.95 mgd of secondary effluent to a nature-based solution. NOTE: this alternative relies on a dedicated new outfall to the Bay.
Mainstream Improvements	1A	Use All Existing Tankage
	2A	FFR Bypass and Parallel Operation of Two Trains with Anoxic Zones
	3A	FFR Bypass and Series Operation of Two Trains with Anoxic Zones and RAS Reaeration
Sidestream Improvements	1B	Sidestream Treatment and Parallel Operation of Two Trains
	2B	Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains with Anoxic Zones
	3B	Sidestream Treatment, FFR Bypass, and Series Operation of Two Trains with Anoxic Zones and RAS Reaeration
Mainstream Expansion	4	Mainstream Tankage Expansion

* The nature-based solution project is separate from this evaluation as it has already been evaluated, and the project appears to be moving forward. It is expecting that this nature-based solution will translate to upwards of a 25% reduction in TIN as 0.95 mgd of the secondary effluent flow is diverted from EBDA’s common outfall. A conservative 10% was assumed in the event that the NbS struggles with capacity and/or performance.

Steady-state SUMO modeling simulations were performed to estimate the TIN reduction performance of each alternative. A key assumption for performing modeling simulations for the various alternatives was to not exceed a MLSS value of 2,500 mg/L in the aeration basins. Such a MLSS value is an industry accepted planning level approach to not overload the downstream secondary clarifiers.

6.1 Nature-based Solution (Alternative #0)

As noted in Table 6-1, a NbS has already been evaluated, and the current plan is to implement in 2027/2028. The NbS will take up to 0.95 mgd of secondary effluent and treat this stream with a nitrifying reactor (anticipate a membrane aerated biofilm reactor (MABR)), followed by an unit open cell wetland system. The treated water will have a stand-alone outfall to the Bay (separate from EBDA).

Figure 6-2 provides a graphical depiction of this alternative, whereby upwards of 0.95 mgd is diverted from secondary effluent to the NbS system. For a scenario where the full 0.95 mgd is diverted translates to upwards of a 25% TIN reduction in San Leandro's load to EBDA's common outfall. Given the uncertainty on capacity and/or performance, the evaluation assumed that approximately half of the 0.95 mgd would be diverted to NbS, which translates to a conservative 10% TIN reduction in San Leandro's load to EBDA's common outfall.

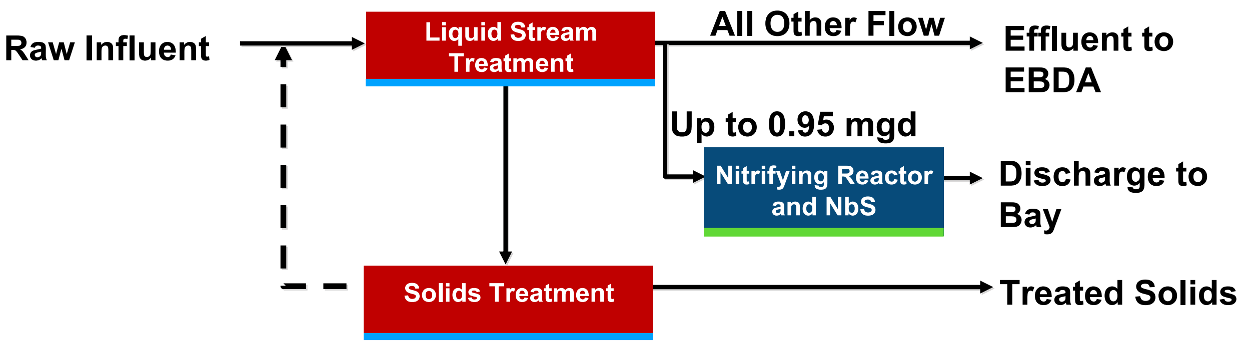

Figure 6-1. PFD for Nature-based Solution (Alternative #0)

6.2 Mainstream Improvements (Alternatives #1A, #2A, and #3A)

As noted in Table 6-1, the mainstream improvements includes three difference sub-alternatives that initially evaluates using both aeration basins (alternative #1), followed by modifying the layouts within each aeration basin coupled with bypassing a portion of FFR influent to the aeration basins (alternatives #2A and #3). The basis for the FFR bypass is to convey sBOD to the aeration basins for biological denitrification.

6.2.1 Alternative #1A: Mainstream Improvements using All Existing Tankage

Figure 6-2 presents this alternative, in which both aeration basins operate in parallel (currently only one basin is in operation), with no additional modifications made to the treatment process. With the proposed modifications, the total aeration basin volume increases from the baseline value of 0.66 MG to 1.32 MG. Besides operating both aeration basins, the solids residence time (SRT) should increase to foster nitrification with the understanding that the MLSS levels should not exceed 2,500 mg/L.

The modeling results suggest that despite having both aeration basins in service, the sludge age can only be increased to 2.1 days until 2,500 mg/L MLSS is reached (i.e., capacity limited). As such, little or no TIN reduction is possible with this alternative as the increase in SRT is insufficient to foster nitrification.

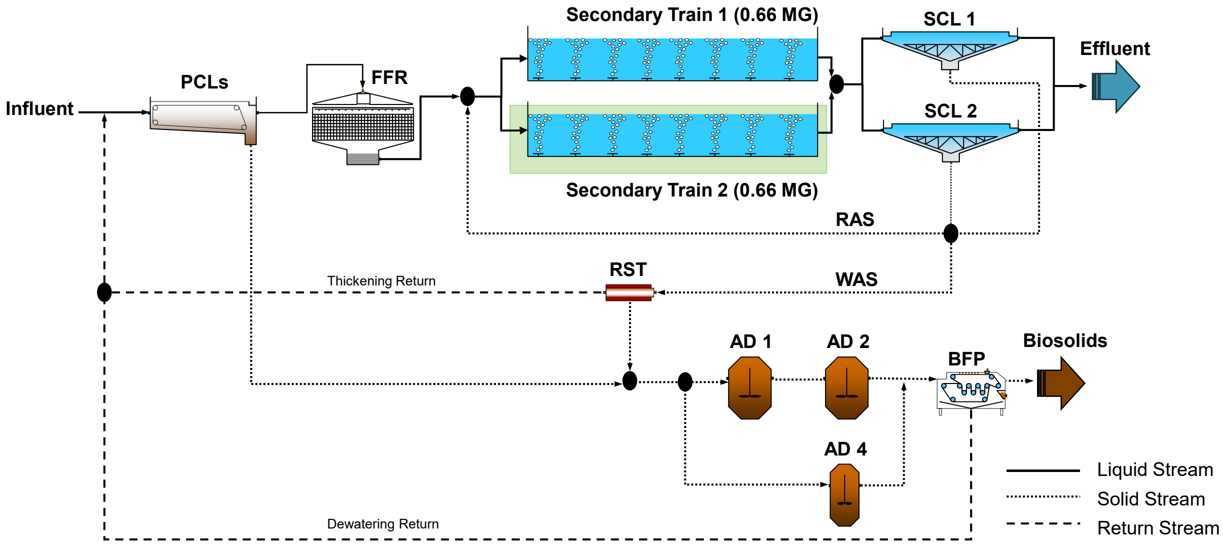

Figure 6-2. PFD for Mainstream Improvements Using All Existing Tankage

A summary of the SUMO modeling outputs for this alternative is provided in Table 6-2. The increase in SRT does translate to some NOx formation, but it is limited to partial nitrification as evidenced by ammonia being the primary form of secondary effluent nitrogen.

Table 6-2. SUMO Model Outputs for Alternative #1A (Mainstream Improvements Using All Existing Tankage)

Parameter	Secondary Effluent Model Outputs
Ammonia	30 mg-N/L
NO_x	7 mg-N/L
TIN	37 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: --% ○ Compared to baseline model: <10%	

6.2.2 Alternative #2A: FFR Bypass and Parallel Operation of Two Trains with Anoxic Zones

A visual illustration of this alternative is presented in Figure 6-3. This alternative builds upon alternative #1, whereby both aeration tanks operate in parallel (similar to alternative #1). The key additional features are converting approximately 0.2 MG within each tank to anoxic zones and bypassing 25% of the primary effluent directly to the anoxic zone. Modification of the anoxic zones and bypassing primary effluent are included to foster biological denitrification.

The efficiency of the nitrification process in the FFR is affected by cBOD loading rate. At higher cBOD loadings, heterotrophs outcompete nitrifiers and stifle potential nitrification within the FFR. Effective nitrification (75–85%) within an FFR is typically achieved when cBOD loading is maintained between 12 and 18 lb cBOD/1,000 ft^3/day[3]. Currently, the average cBOD loading to the FFR is approximately 186 lb/1000 ft^3/d, which represents a moderate to high loading rate appropriate for cBOD removal with little or no potential for nitrification[1]. Therefore, the changes implemented in this alternatives configuration serve two purposes with an emphasis on the latter: (1) to reduce cBOD loading to the FFR and promote nitrification across the FFR (anticipate little or no benefit as it is already heavily loaded), and (2) to redirect a portion of primary effluent carbon to the anoxic zone to support denitrification. The latter is the key driver for this alternative.

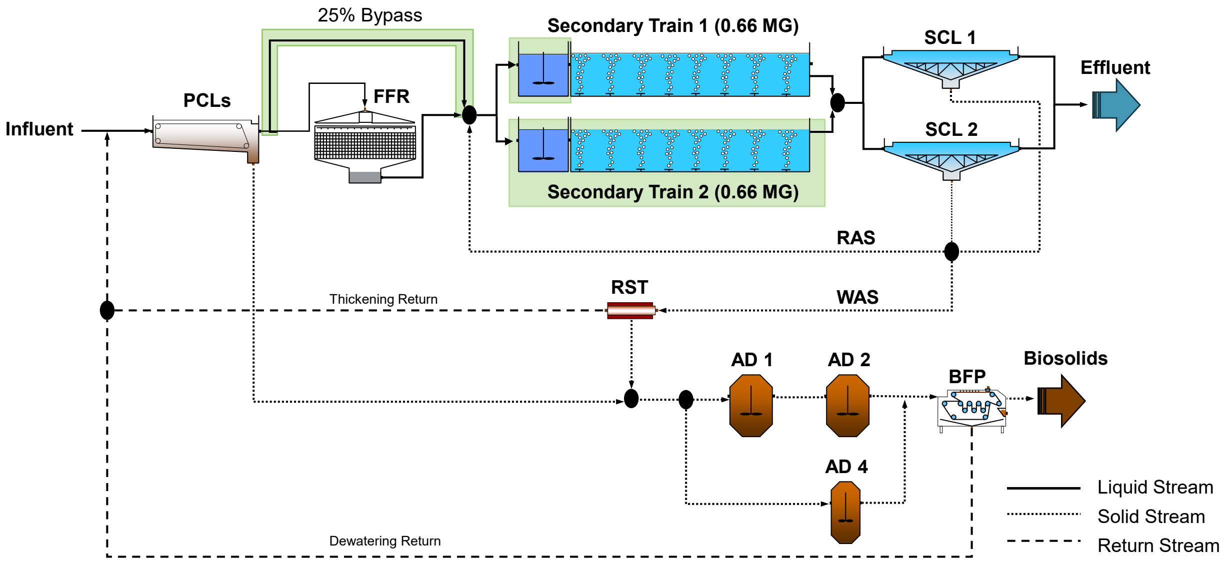

Figure 6-3. PFD for FFR Bypass and Parallel Operation of Two Trains with Anoxic Zones

Similar to alternative #1, this alternative offers little or no opportunity to increase the SRT enough to foster full nitrification. Specifically, the SRT can only be increased to 1.8 days (i.e., too low for full nitrification) until the MLSS capacity of 2,500 mg/L is met. While the ability to foster full nitrification is not possible with the scenario, any formed NOx should be removed in the newly formed anoxic zones.

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[3] U.S. Environmental Protection Agency. (2000). *Wastewater technology fact sheet: Trickling filter nitrification* (EPA 832-F-00-015)

A summary of the SUMO modeling outputs for this alternative is provided in Table 6-3. The increase in SRT does translate to some NOx formation, but it is limited to partial nitrification as evidenced by ammonia being the primary form of nitrogen in the secondary effluent. The sources of NOx are a combination of FFR effluent and any formed NOx in the aeration basins that is returned with the RAS. With this alternative, the effluent TIN loads should be reduced from 0-20%.

Table 6-3. SUMO Model Outputs for Alternative #2 (FFR Bypass and Parallel Operation of Two Trains with Anoxic Zones)

Parameter	Secondary Effluent Model Outputs
Ammonia	30 mg-N/L
NOx	<1 mg-N/L
TIN	31 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: **0-10%** ○ Compared to baseline model: **10-20%**	

6.2.3 Alternative #3A: FFR Bypass and Series Operation of Two Trains with Anoxic Zones and RAS Re-aeration

A visual illustration of this alternative is presented in Figure 6-4. This alternative appears to be similar to alternative #2 except for one key difference, how one of aeration basins is used. In alternative #2, the aeration basins are operated in parallel. In contrast, alternative #3A relies on operating the aeration basin in series. Specifically, the RAS is sent through an aeration basin (listed as aeration tank 2 in Figure 6-4) prior to being introduced with the FFR effluent/FFR bypass and then the aeration basin (listed as aeration tank 1 in Figure 6-4).

The vision behind this treatment configuration is that the concentrated RAS (approximately 3 times the MLSS) will have a longer aeration contact time than non-concentrated MLSS, and as such it provides those microbes with a longer SRT. This additional SRT has the potential to provide sufficient SRT to foster more nitrification than alternatives #2 and #3.

Similar to alternative #2, both aeration tanks would have an anoxic zone up-front that would be fitted with diffusers to operate as a swing zone. This built-in feature provides the means to flip-flop between aeration tanks for which tank serves as the RAS re-aeration tank (listed as aeration tank 2 in Figure 6-4). Furthermore, including the FFR bypass will provide the carbon necessary to biological denitrification.

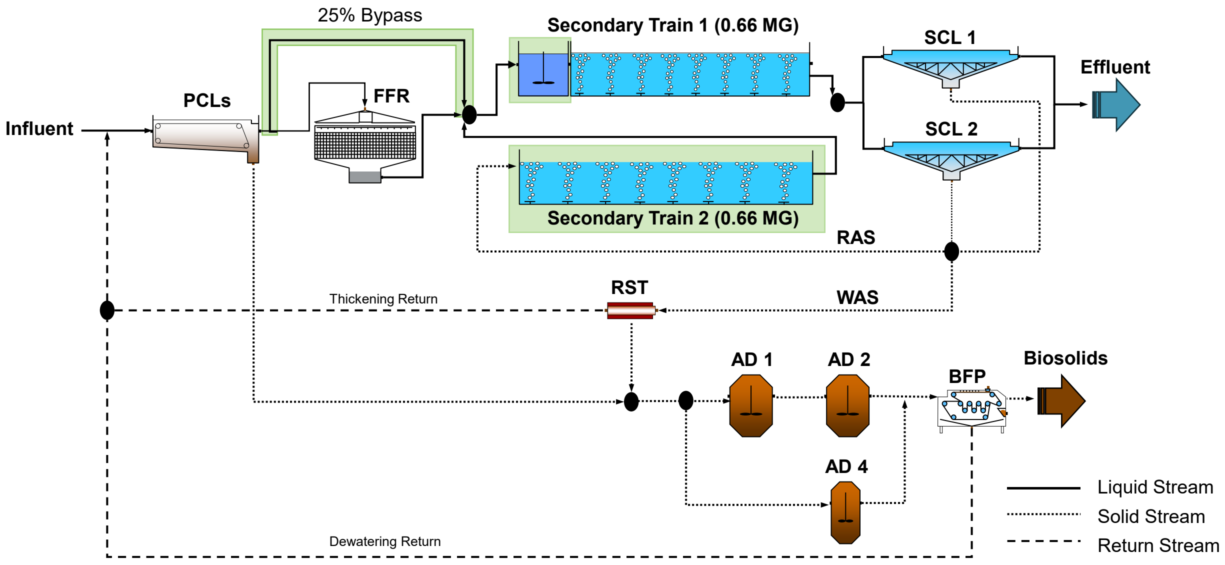


Figure 6-4. PFD for FFR Bypass and Series Operation of Two Trains with Anoxic Zones and RAS Reaeration*

* The aeration tank that is fed RAS (in this case Aeration Tank 2) is known as the RAS Re-Aeration Tank. Note: Aeration Tank 1 can also served as the RAS Re-Aeration Tank, followed by Aeration Tank 2.

The SUMO model results for this configuration are presented in Table 6-4. While this alternative still does not provide full nitrification (i.e., ammonia concentrations less than 1 mg N/L), it is promising compared to alternative #2 as evidenced by secondary effluent model ammonia values of 21 mg N/L (this alternative) versus 30 mg N/L (alternative #2). As for TIN reduction, this alternative did result in bleeding out approximately 2 mg NOx-N/L via the secondary effluent. This residual NOx leaving as secondary clarifier effluent is attributed to nitrification occurring at the end of aeration tanks and not returned with the RAS.

With the proposed modifications, the model predictions indicate a 20–30% reduction in TIN compared to the measured value, and a 30–40% reduction compared to the baseline model.

Table 6-4. SUMO Model Outputs for Alternative #3A (FFR Bypass and Series Operation of Two Trains with Anoxic Zones and RAS Reaeration)

Parameter	Secondary Effluent Model Outputs
Ammonia	21 mg-N/L
NOx	2 mg-N/L
TIN	23 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: 20-30**%** ○ Compared to baseline model: 30-40**%**	

6.3 Sidestream Improvements (Alternatives #1B, #2B, and #3B)

The sidestream refers to the biosolids handling reject streams that are returned to the front of the treatment plant as graphically depicted in Figure 6-5. For example, the existing mechanical dewatering equipment has a reject stream which falls under this sidestream terminology. The sidestream represents a relatively small volume of water (about 1 percent of the influent flow) but it is laden with nutrients as noted in Figure 6-5.

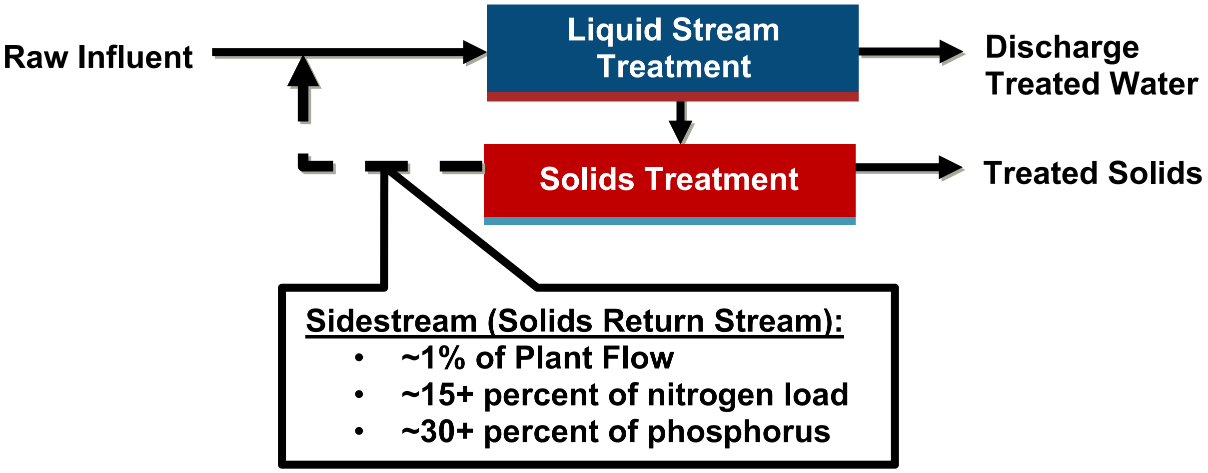


Figure 6-5. Visual Depiction of the Sidestream and its Contribution to Effluent Nutrient Loads

The sidestream that most lends itself to TIN load reduction is the mechanical dewatering reject stream as it contains the highest nutrient loads of any sidestreams. Furthermore, this stream has relatively warm water as it follows anaerobic digestion which favors higher reaction rates and in turn the potential for smaller bioreactors.

This section is broken up into three alternatives (#1B, #2B, and #3B) that include sidestream treatment plus all three alternatives evaluated for the mainstream improvements (i.e., alternatives #1→#3). For example, alternative #1B represents alternative #1A plus sidestream treatment, alternative #2B represents alternative #2 plus sidestream treatment, and alternative #3B represents alternative #3A plus sidestream treatment.

While there are various sidestream treatment technologies, a recent national survey found that such processes remove about 70 percent of the ammonia fed to the process, regardless of biological technology (Dapcic et al., 2023). As such, this effort assumed that the sidestream can remove 70 percent of the ammonia fed to the sidestream reactor. The sidestream technology type can be identified at a later stage.

The evaluation led by Dapcic et al. (2023) was focused on microbial biological sidestream treatment technologies, such as a sequencing batch reactor. Outside of this grouping, the City should consider other strategies for nutrient removal and/or recovery. A few technologies that are gaining traction are algae to treat the sidestream, ammonia recovery using a low-cost ammonia gas stripping membrane (Wang et al., 2023), and Microvi's biocatalyst as it was recently implemented nearby (HDR, 2022). It is recommended that the City consider pilot testing one or more of such technologies as they advance their nutrient management strategy.

6.3.1 Alternative #1B: Sidestream Treatment and Parallel Operation of Two Trains (i.e., Alternative #1A plus Sidestream Treatment)

Figure 6-6 presents alternative #1B which builds upon alternative #1A by adding the sidestream treatment technology. The sidestream reactor is incorporated to remove TIN from the dewatering return stream. Similar to alternative #1, both trains operate in parallel and increase the total active aeration basin volume from the baseline value of 0.66 MG to 1.32 MG. As previously noted, the sidestream treatment technology type can be selected at a later stage.

The modeling results suggest that despite having both aeration basins in service, the sludge age can only be increased to 2.1 days until 2,500 mg/L MLSS is reached (i.e., capacity limited). While the increase in SRT is insufficient to foster nitrification, the sidestream reactor has the potential to “seed” the liquid stream.

The SUMO model results for this configuration are presented in Table 6-5. While this alternative still does not provide full nitrification (i.e., ammonia concentrations less than 1 mg N/L), it is promising compared to any of the mainstream improvements (alternatives #1→#3) as evidenced by the lowest ammonia level (16 mg N/L) of any alternative listed thus far in the TM. This additional ammonia removal is attributed to a combination of the sidestream reactor converting ammonia to NOx plus “seeding” of the sidestream waste activated sludge to the liquid stream. The alternative struggled to denitrify the formed NOx due to a lack of anoxic zones.

Model predictions indicate a 20–30% reduction in TIN compared to the measured value, and a 30–40% reduction compared to the baseline model (Table 6-5).

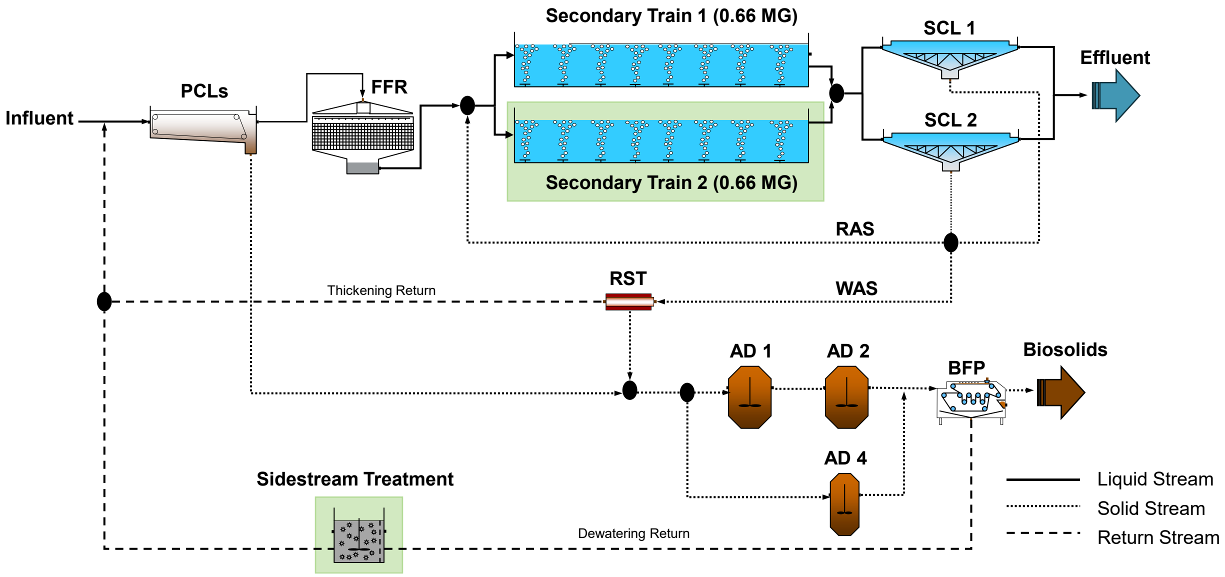


Figure 6-6. PFD for Sidestream Treatment and Parallel Operation of Two Trains

Table 6-5. SUMO Model Outputs for Alternative #1B (Sidestream Treatment and Parallel Operation of Two Trains)

Parameter	Secondary Effluent Model Outputs
Ammonia	16 mg-N/L
NOx	8 mg-N/L
TIN	25 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: 20-30% ○ Compared to baseline model: 30-40%	

6.3.2 Alternative #2B: Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains with Anoxic Zones (i.e., Alternative #2A plus Sidestream Treatment)

Figure 6-7 presents alternative #2B which builds upon alternative #2A by adding the sidestream treatment technology. The sidestream reactor is incorporated to remove TIN from the dewatering return stream. Similar to alternative #2, both trains operate in parallel and increase the total active aeration basin volume from the baseline value of 0.66 MG to 1.32 MG, as well as adding the FFR bypass and the anoxic zones. As previously noted, the sidestream treatment technology type can be selected at a later stage.

The modeling results suggest that despite having both aeration basins in service, the sludge age can only be increased to 1.7 days until 2,500 mg/L MLSS is reached (i.e., capacity limited). While the increase in SRT is insufficient to foster nitrification, the sidestream reactor has the potential to “seed” the liquid stream.

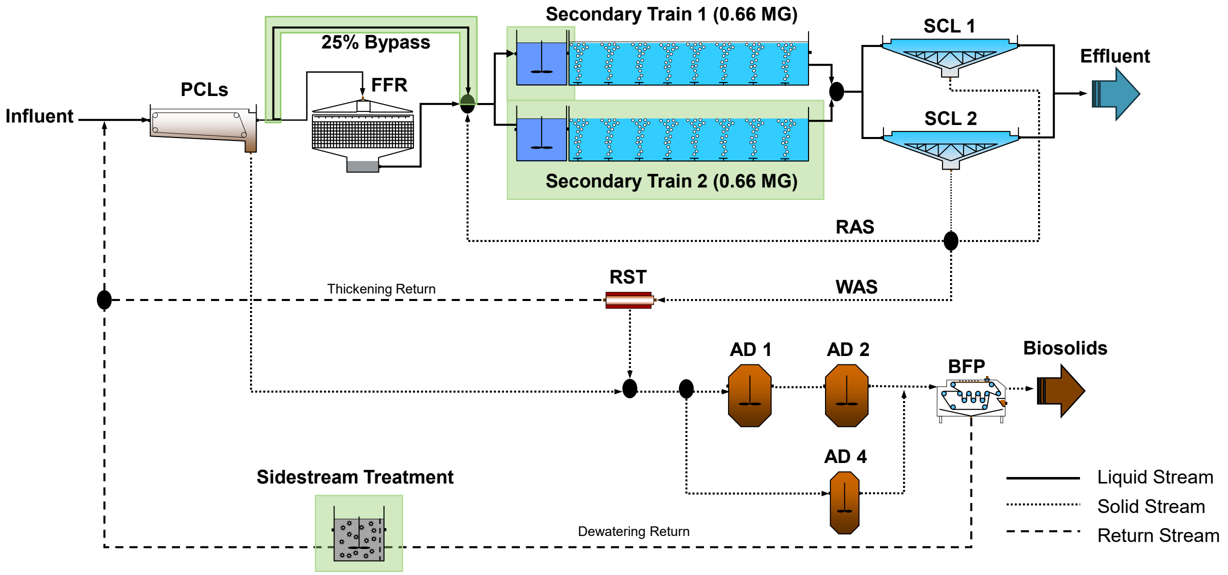


Figure 6-7. PFD for Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains with Anoxic Zones

The SUMO model results for this configuration are presented in Table 6-6. While this alternative still does not provide full nitrification (i.e., ammonia concentrations less than 1 mg N/L), it is comparable to alternative #1B in terms of ammonia reduction performance. In contrast, this alternative offers a means to biologically denitrify as evidenced by NOx levels at less than 1 mg N/L. The ability to denitrify is attributed to the anoxic zones and FFR bypass features.

Model predictions indicate a 40–50% reduction in TIN compared to the measured value, and a 50–60% reduction compared to the baseline model (Table 6-6).

Table 6-6. SUMO Model Outputs for Alternative #2B (Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains with Anoxic Zones)

Parameter	Secondary Effluent Model Outputs
Ammonia	17 mg-N/L
NOx	<1 mg-N/L
TIN	17 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: 40-50**%** ○ Compared to baseline model: 50-60**%**	

6.3.3 Alternative #3B: Sidestream Treatment, FFR Bypass, and Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration (i.e., Alternative #3A plus Sidestream Treatment)

Figure 6-8 presents alternative #3B which builds upon alternative #3A by adding the sidestream treatment technology. The sidestream reactor is incorporated to remove TIN from the dewatering return stream. Similar to alternative #3, the trains operate in series which fosters RAS Re-Aeration, as well as adding the FFR bypass and the anoxic zones. Note: the anoxic zones can operate as swing zones and provide air (if needed). Furthermore, the design would have the ability to flip flop which aeration train functions as the initial reactor and secondary reactors.

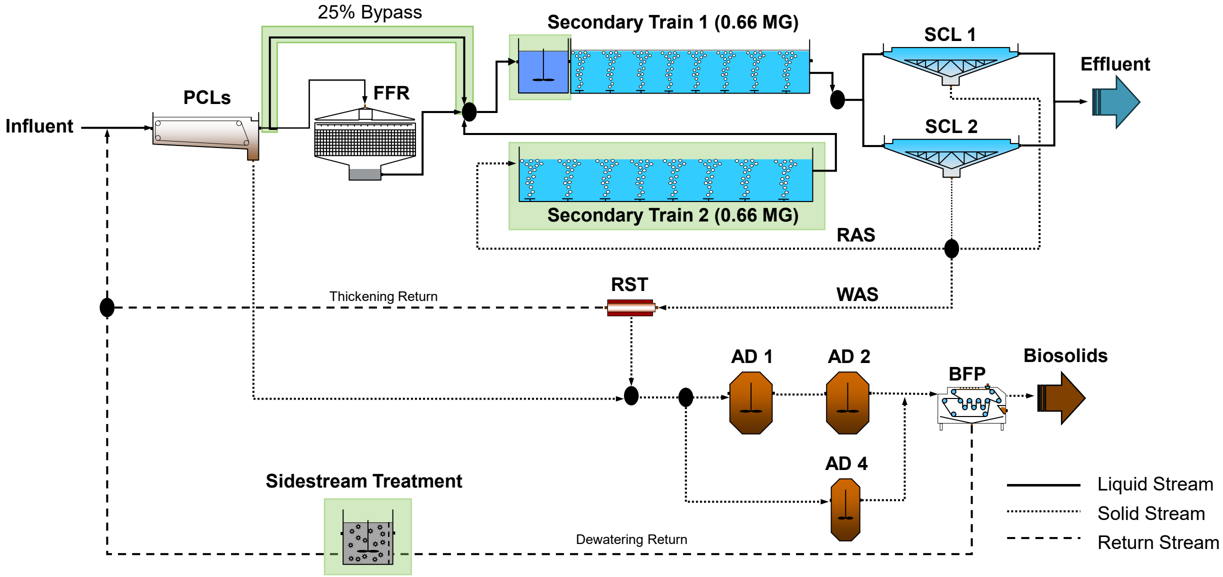


Figure 6-8. PFD for Sidestream Treatment, FFR Bypass, and Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration

The SUMO model results for this configuration are presented in Table 6-7. While this alternative still does not provide full nitrification (i.e., ammonia concentrations less than 1 mg N/L), it is achieving slightly improved effluent ammonia levels compared to alternative #2B. This additional ammonia reduction is attributed to the additional SRT associated with the RAS Re-Aeration feature. Similar to alternative #2B, any formed NOx is readily removed which is attributed to the anoxic zone and FFR bypass features.

Model predictions indicate a 40–50% reduction in TIN compared to the measured value, and a 50–60% reduction compared to the baseline model (Table 6-6).

Table 6-7. SUMO Model Outputs for Alternative #3B (Sidestream Treatment, FFR Bypass, and Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration)

Parameter	Secondary Effluent Model Outputs
Ammonia	13 mg-N/L
NOx	<1 mg-N/L
TIN	14 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: 50-60**%** ○ Compared to baseline model: 60+**%**	

6.4 Mainstream Expansions (Alternative #4)

Figure 6-9 presents the mainstream expansion scenario in which the two treatment trains are expanded from the original volume of 0.66 MG each to 2.05 MG each. An internal mixed liquor recycling (IMLR) is incorporated, assuming 300% IMLR rate. The other mainstream improvements mimic alternative #2, whereby 25% of the primary effluent is bypassed to the anoxic zone to supply carbon to support denitrification and anoxic zones are included up-front in each secondary train. After the expansion, the total volume of the secondary basins will increase to 4.1 MG, consisting of 0.85 MG of anoxic volume and 3.25 MG of aerobic volume.

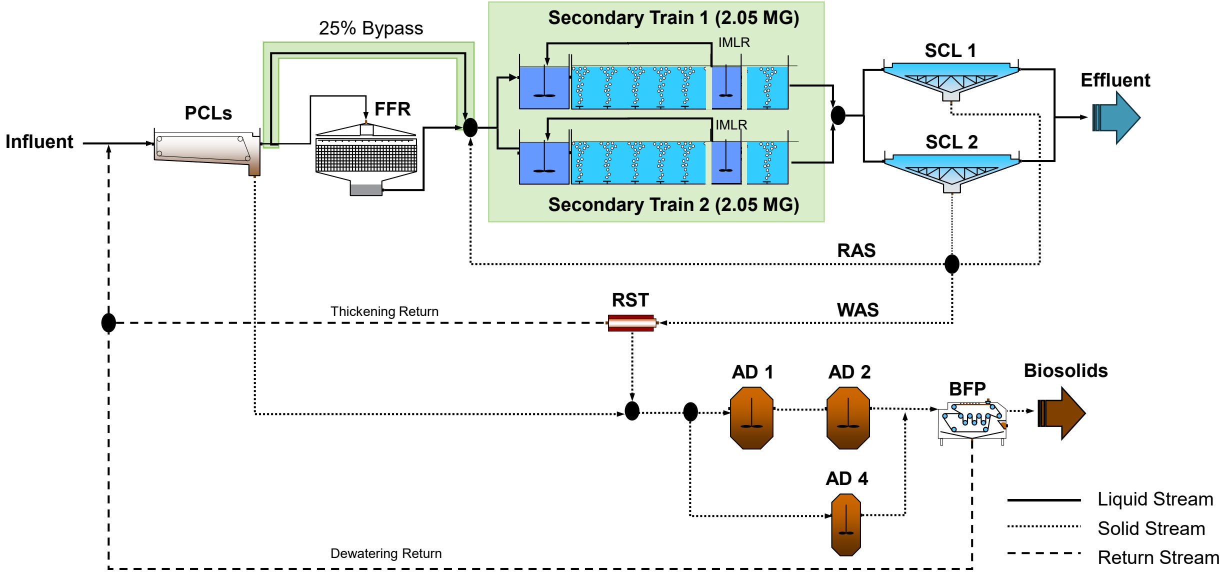


Figure 6-9. PFD for Mainstream Expansion

The SUMO model results for the mainstream expansion option are presented in Table 6-8. With the proposed modifications, the MLSS concentration is expected to increase from 2,000 mg/L to 2,500 mg/L, resulting in an aerobic SRT of 7.5 days and total SRT of 9.4 days. While the SRT increase is considerable, full nitrification is still not achieved.

Model predictions indicate a 50–60% reduction in TIN compared to the measured value, and over a 60% reduction compared to the baseline model.

Table 6-8. SUMO Model Outputs for Alternative #4 (Mainstream Expansion)

Parameter	Secondary Effluent Model Outputs
Ammonia	12 mg-N/L
NOx	3 mg-N/L
TIN	15 mg-N/L
Effluent TIN Improvement: ○ Compared to measured value: 50-60% ○ Compared to baseline model: 760+%	

6.5 Summary

Table 6-9 summarizes the model outcomes for all scenarios evaluated for both with and without NbS. Assuming that the NbS project moves forward and removes approximately 10% of the TIN load from EBDA, SUMO modeling results suggest that alternatives #3A, 1B, 2B, and 3B have the potential to reduce TIN loads by 40% or greater without major tankage expansion. The 40% or greater is relevant as the Third Permit has a TIN load reduction goal of 40% for EBDA. Alternative #3A builds on the other mainstream improvements (alternatives #1A and #2A), whereas Alternatives #1B, #2B, and #3B all include involve sidestream treatment, FFR bypass, and aeration basin modifications, and Alternative #3B includes an additional RAS re-aeration step.

The construction options for the FFR bypass and aeration basin modifications, along with associated cost, are discussed in Section 7.

Table 6-9. Summary of SUMO Model Outcomes

Alternatives	Alternative No.	Description	Projected TIN Reduction (w/out NbS)	Projected TIN Reduction (w/NbS)
Nature-based Solution (NbS)	0	Diverting upwards of 0.95 mgd of secondary effluent to an NbS with a separate outfall from EBDA	--	10%
Mainstream Improvements	1A	Use all Existing Tankage	0-5%	10-15%
	2A	FFR Bypass and Parallel Operation of Two Trains with Anoxic Zones	10-20%	20-30%
	3A	FFR Bypass and Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration	30-40%	40-50%
Mainstream Improvements PLUS Sidestream Treatment	1B	Sidestream Treatment and Parallel Operation of Two Trains	30-40%	35-45%
	2B	Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains with Anoxic Zones	50-60%	55-65%
	3B	Sidestream Treatment, FFR Bypass, and Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration	55-65%	60-70%
Mainstream Expansion	4	Mainstream Tankage Expansion	55-65%	60-70%

7 Construction Options and Cost

This section summarizes the construction elements and costs for the various alternatives. Given that the alternatives build upon concepts from other alternatives, the section is broken up into individual costing elements and summarized at the end of this section.

7.1 Ancillary Equipment Costs

For items discussed in Sections 7.2 and 7.3, there will be a host of ancillary equipment that should be moved to a different location and/or replaced/rehabilitated due to it being at the end of its useful life. Most of these assets are within the secondary process. For example, there are multiple pipes/valves that are not currently used but they should be removed for safety purposes. Furthermore, several assets will need to be moved, such as the blower motor control centers to make space on the aeration basin decks.

Given the uncertainty with such costs, a conservative $6M was assumed as a placeholder for such items.

7.2 FFR Bypass (2 Options)

The ability to bypass the FFR considered two different options as laid out in the subsections that follow.

7.2.1 FFR Bypass Option 1 – Repurpose FFR Recirculation Pipe

Figure 7-1 presents the yard piping plan illustrating how the existing FFR recirculation operates. Primary effluent is lifted by the FFR lift station and conveyed to the FFR via the 30’’ FFI pipe (blue line). Effluent from the FFR is then conveyed to the FFR effluent junction box via the 30’’ FFE pipe (orange line), after which it flows into the aeration basins. A portion of FFR effluent is recirculated from the junction box back to the FFR lift station through the 24’’ FFE pipe (purple line). According to the City, the FFR recirculation function is used only occasionally, typically when the plant receives a heavy load and double treatment through FFR is required.

FFR Bypass Option 1 proposes repurposing the FFR recirculation pipe (purple line) to convey the flow in reverse direction, enabling the FFR bypass function. This can be accomplished by installing a new pipe connecting the FFI pipe to the FFE recirculation pipe at the FFR lift station (Figure 7-2). A control valve and flow meter will be required to regulate the bypass flow. This modification is relatively simple, as the existing FFR lift station has space reserved for future upgrades. However, implementing this option would eliminate the FFR recirculation capability.

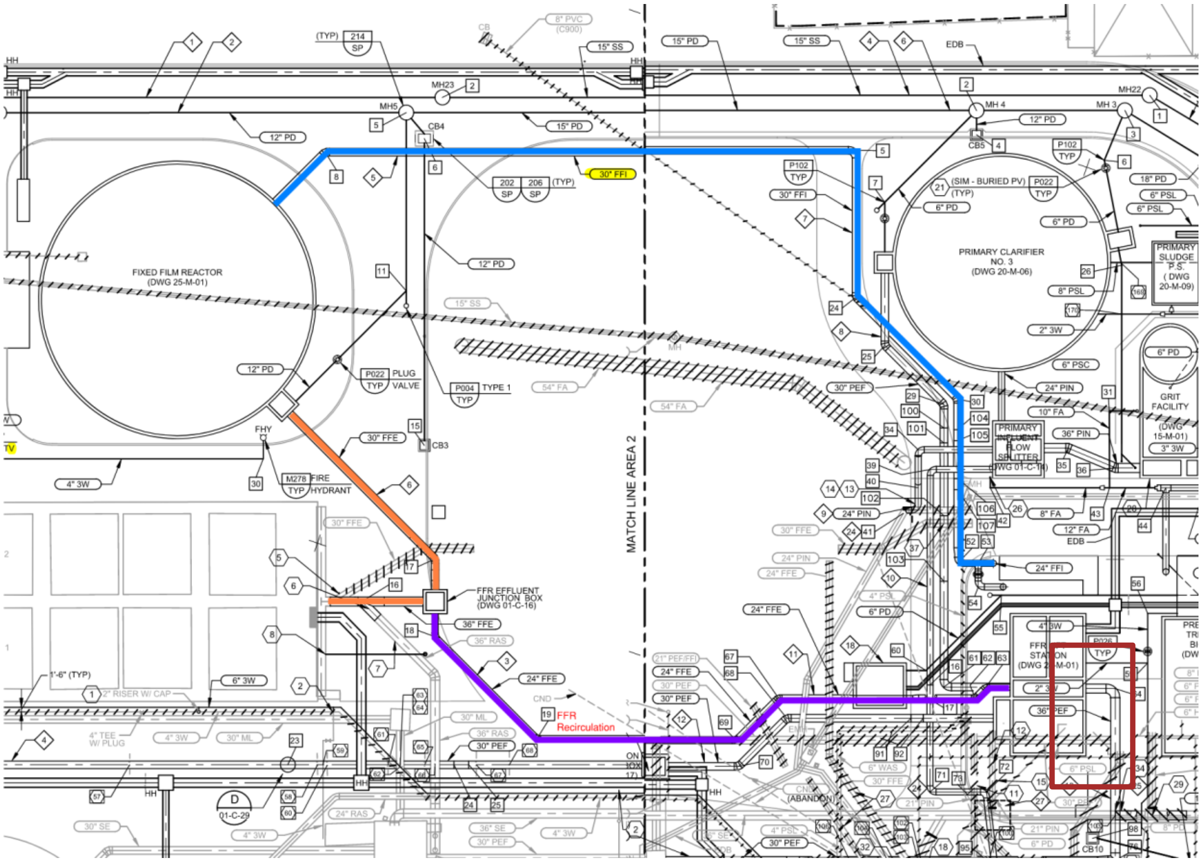
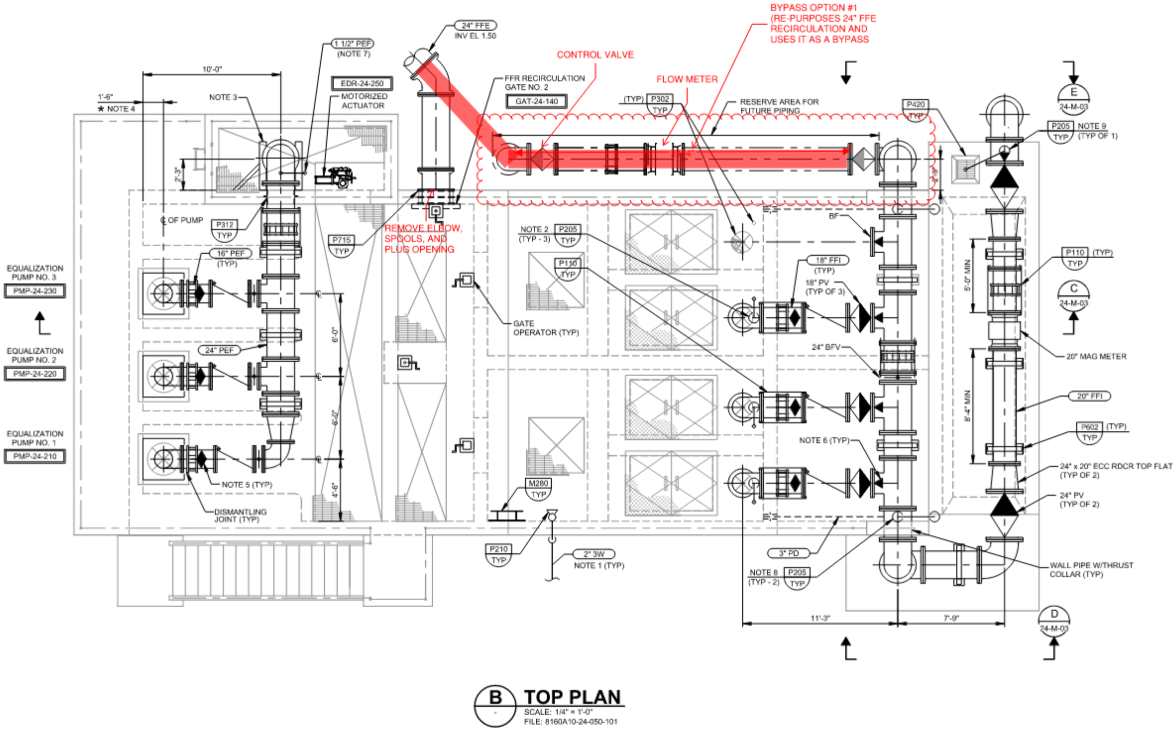


Figure 7-1. Existing FFR Recirculating Loop



FFR BYPASS - OPTION 1
RE-PURPOSE FFR RECYCLE PIPING

Figure 7-2. FFR Bypass Option 1 – Repurpose FFR Recycle Piping

Table 7-1 presents the estimated cost for FFR bypass Option 1, including the direct cost and the cost with markups. A detailed cost breakdown, including what is covered in the markup, is provided in Appendix B.

Table 7-1. Estimated Cost for FFR Bypass Option 1 – Repurpose FFR Recirculation Pipe

Direct Cost	Cost with Markups
$170,000	$370,000
Note: Estimated cost is based on a midpoint of construction date of 2027.	

7.2.2 FFR Bypass Option 2 – Tie-in Upstream of FFR and Expand FFR Effluent Junction Box

Figure 7-3 presents FFR Bypass Option 2, which proposes installing a bypass pipe that ties in upstream of the FFR and extends to the FFR effluent junction box. An FFR bypass vault with control valve and flow meter would be needed for flow control. The junction box would need to be expanded, with a slide gate installed between the structures to facilitate construction. Compared to Option 1, this option would retain the ability to recirculate the FFR effluent.

Table 7-2 presents the estimated cost for FFR bypass Option 2. A detailed cost breakdown is provided in Appendix B.

Table 7-2. Estimated Cost for FFR Bypass Option 2 – Tie-In Upstream of FFR and Expand FFR Effluent Junction Box

Direct Cost	Cost with Markups
$340,000	$740,000
Notes: (1) Estimated cost is based on a midpoint of construction date of 2027. (2) Retain the ability to recirculate FFE	

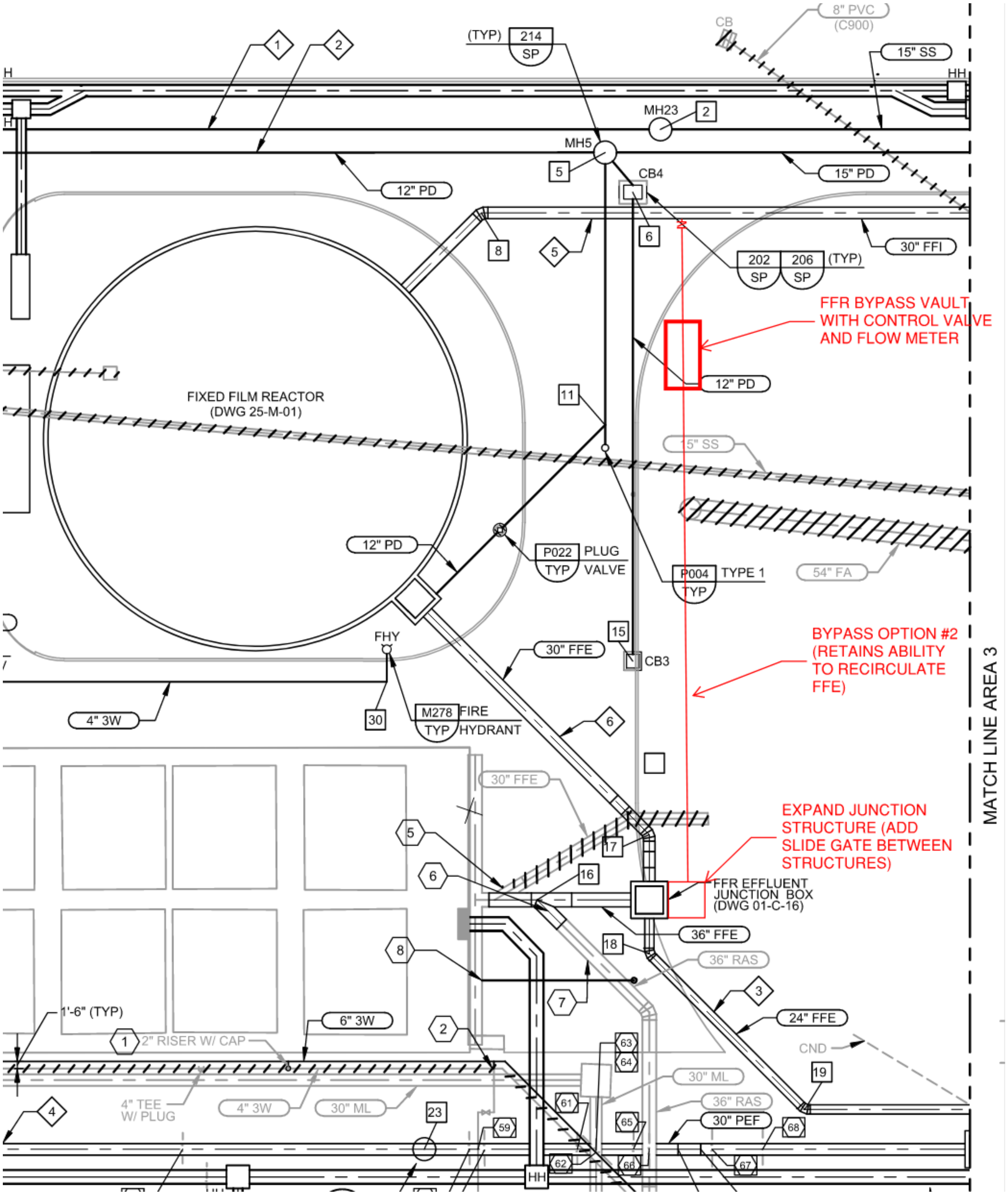


Figure 7-3. FFR Bypass Option 2 – Tie-in Upstream of FFR and Expand FFR Effluent Junction Box

7.3 Aeration Tank Modifications

The aeration tank modifications consider options that allow the aeration tanks to operate in parallel or series mode as laid out in the subsections that follow.

7.3.1 Parallel Operation of Two Trains with Anoxic Zones

The WPCP was originally constructed in 1938, and modifications to the aeration basins are needed to improve current conditions and to accommodate nutrient removal process. For example, the mixed liquor at the end of the aeration tank is collected using a 36'' center pipe instead of a mixed liquor channel, and the 24'' overflow pipe is rusted and needs replacement. Figure 7-4 presents the proposed basin modifications intended to improve basin conditions and incorporate anoxic zones for nutrient removal. Major modifications include the following:

- Remove the existing 24'' overflow pipe at each basin.
- Remove the first aeration turbine and install Fiber Reinforced Plastic (FRP) baffle walls to create the anoxic zone.
- Add submersible mixer at each anoxic zone.
- Extend the aeration tank structure and add a new mixed liquor channel with a gated walkway. The section cut of the new mixed liquor channel is shown in Figure 7-5.

The estimated cost for the proposed modifications is summarized in Table 7-3.

Table 7-3. Estimated Cost for Aeration Tank Modifications – Parallel Operation of Two Trains with Anoxic Zones

Direct Cost	Cost with Markups
$1,600,000	$3,400,000
Note: the cost only includes aeration tank modifications and does not include FFR bypass	

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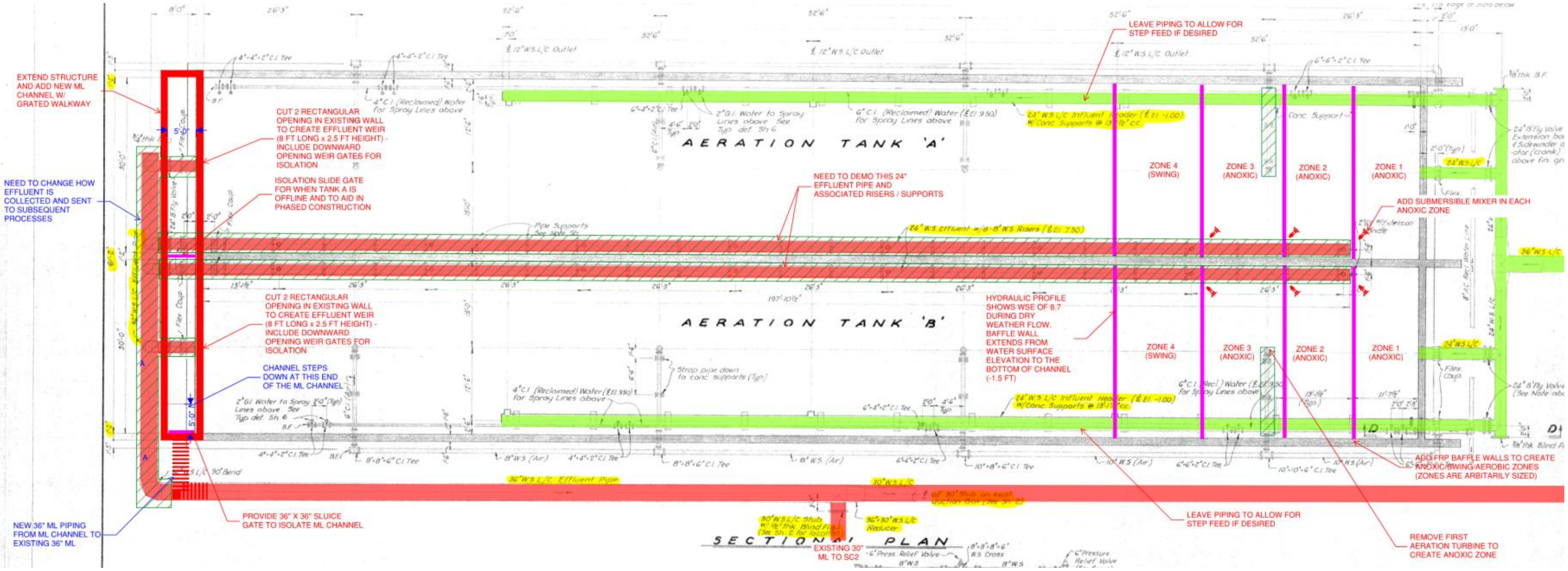


EXTEND STRUCTURE AND ADD NEW ML CHANNEL W/ GRATED WALKWAY

NEED TO CHANGE HOW EFFLUENT IS COLLECTED AND SENT TO SUBSEQUENT PROCESSES

CUT 2 RECTANGULAR OPENING IN EXISTING WALL TO CREATE EFFLUENT WEIR (8 FT LONG x 2.5 FT HEIGHT) - INCLUDE DOWNWARD OPENING WEIR GATES FOR ISOLATION

ISOLATION SLIDE GATE FOR WHEN TANK A IS OFFLINE AND TO AID IN PHASED CONSTRUCTION

NEED TO DEMO THIS 24" EFFLUENT PIPE AND ASSOCIATED RISERS / SUPPORTS

LEAVE PIPING TO ALLOW FOR STEP FEED IF DESIRED

ADD SUBMERSIBLE MIXER IN EACH ANOXIC ZONE

CUT 2 RECTANGULAR OPENING IN EXISTING WALL TO CREATE EFFLUENT WEIR (8 FT LONG x 2.5 FT HEIGHT) - INCLUDE DOWNWARD OPENING WEIR GATES FOR ISOLATION

CHANNEL STEPS DOWN AT THIS END OF THE ML CHANNEL

HYDRAULIC PROFILE SHOWS WSE OF 8.7 DURING DRY WEATHER FLOW. BAFFLE WALL EXTENDS FROM WATER SURFACE ELEVATION TO THE BOTTOM OF CHANNEL (-1.5 FT)

ADD FRP BAFFLE WALLS TO CREATE ANOXIC/SWING/AEROBIC ZONES (ZONES ARE ARBITARILY SIZED)

PROVIDE 36" X 36" SLUICE GATE TO ISOLATE ML CHANNEL

NEW 36" ML PIPING FROM ML CHANNEL TO EXISTING 36" ML

EXISTING 30" ML TO SC2

LEAVE PIPING TO ALLOW FOR STEP FEED IF DESIRED

REMOVE FIRST AERATION TURBINE TO CREATE ANOXIC ZONE

Figure 7-4. Proposed Basin Modifications for Parallel Operation of Two Trains with Anoxic Zones

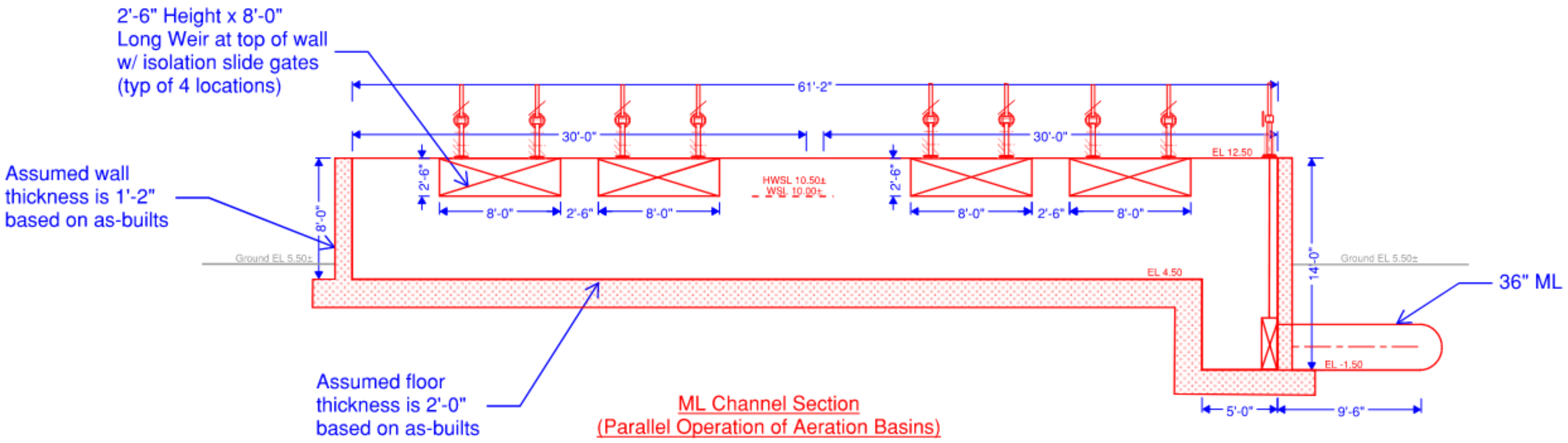


Figure 7-5. Parallel Operation of Two Trains with Anoxic Zones – Mixed Liquor Channel Section Cut

7.3.2 Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration

Figure 7-6 is the PFD recapitulating the configuration of the RAS re-aeration option. The main goal of this option includes:

(1) Separate the RAS piping and direct RAS flow to only one basin. Currently, RAS combines with FFR effluent after the junction box before entering the aeration basins.

(2) Construct a mixed liquor channel and install a submersible pump to pump RAS from the end of one basin to the head of the other.

(3) Maintain operational flexibility to alternate which basin is in the lead.

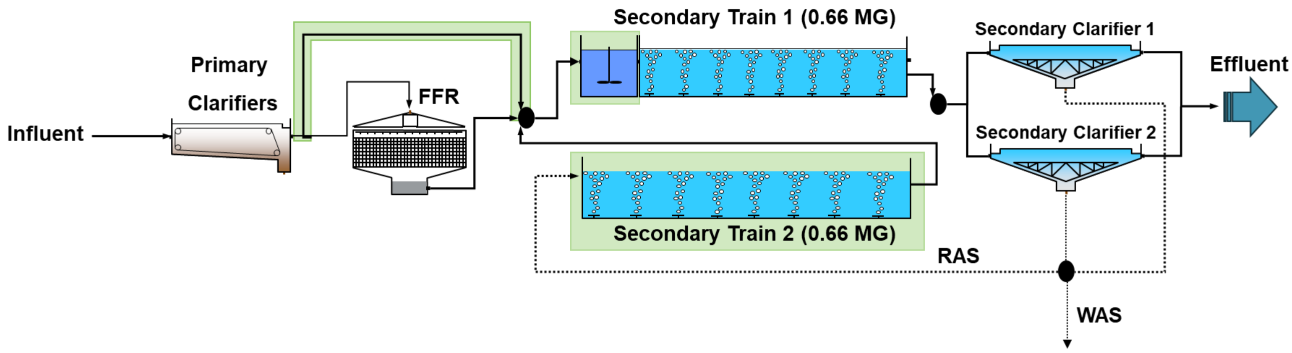


Figure 7-6. PFD for RAS Re-Aeration

The basic basin modifications are similar to those required for the parallel operation option. For example, the 24'' overflow pipe at each basin needs to be removed, and baffle walls and submersible mixers installed to create the anoxic zone at each basin (Figure 7-7). Compared to the parallel operation configuration, the additional basin and piping modifications include the following:

(1) Install new RAS piping that penetrates through the aeration basins, as shown in Figure 7-8. This configuration allows RAS flow to be separated from the FFR effluent. Isolation valves are required at each basin to control RAS flow direction.

(2) Extend the aeration tank structure and add a new mixed liquor channel, which includes a gated walkway and a wet well for submersible pumps. The section cut of the new mixed liquor channel is shown in Figure 7-9.

(3) Install new submersible pumps in the wet well, along with new piping to send treated RAS to the other basin.

The estimated cost for the proposed modifications is summarized in Table 7-4.

Table 7-4. Estimated Cost for Series Operation of Two Trains with Anoxic Zones and RAS Re-Aeration

Direct Cost	Cost with Markups
$2,500,000	$5,400,000
Note: the cost only includes aeration tank and RAS pipe modifications and does not include FFR bypass	

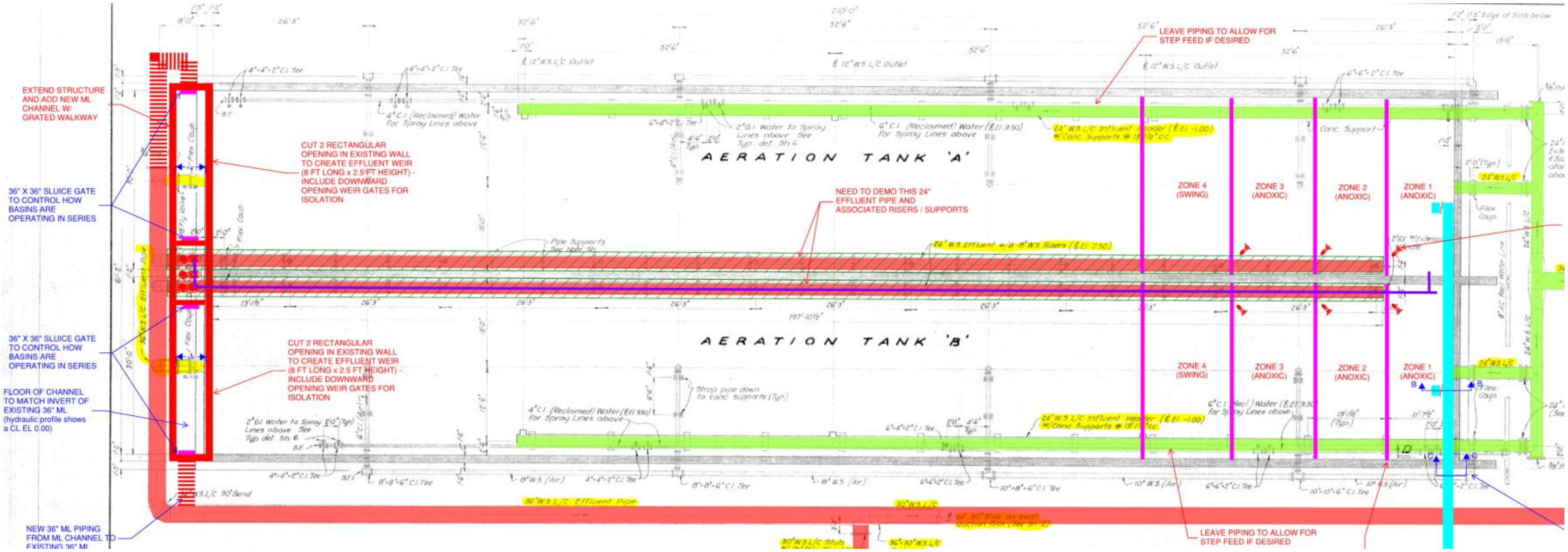
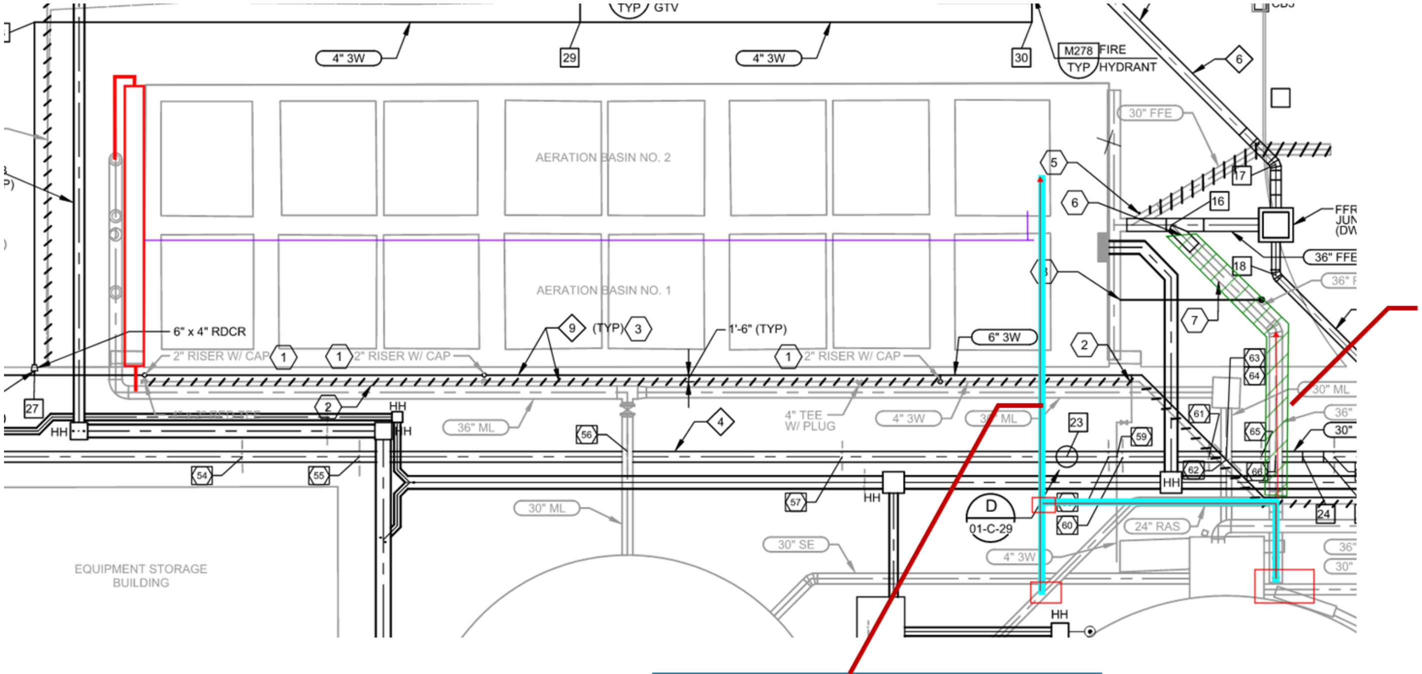


Figure 7-7. Proposed Basin Modifications for Series Operation of Two Trains



Existing RAS Pipe combines with FFR effluent after the junction box

New RAS Pipe penetrates through the walls

Figure 7-8. Proposed RAS Pipe Modifications

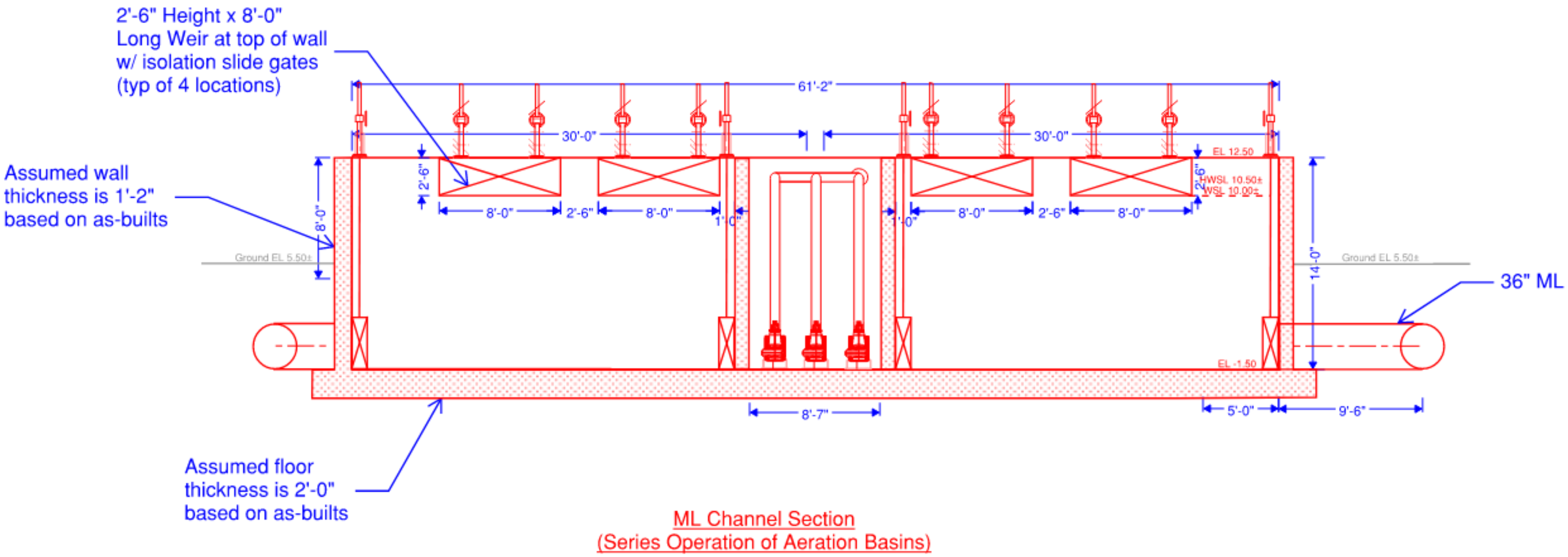


Figure 7-9. Series Operation of Two Trains – Mixed Liquor Channel Section Cut

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7.4 Sidestream Treatment

Sidestream treatment has been previously evaluated as part of the first Nutrient Watershed Permit, R2-2014-0014 (Nutrient-Watershed-Permit-R2-2014-0014.pdf). Sidestream treatment was an integral part of the evaluation that was submitted to the Regional Water Quality Control Board in 2018 (bacwa.org/wp-content/uploads/2018/06/BACWA_Final_Nutrient_Reduction_Report.pdf).

The 2018 cost estimates were predicated on using the San Francisco Bay Engineering News Record (ENR) Construction Cost Index (CCI) value of 12,014.72 (January 2018). To escalate forward, the construction costs were based on the San Francisco Bay ENR CCI value of 15,595.35 (May 2023). To escalate the costs forward to 2023 dollars, the 2018 report values were multiplied by the ratio of the San Francisco Bay ENR CCI 2023 and 2018 values as follows:

$$2025\ Construction\ Cost = 2018\ Construction\ Cost\ X\ \frac{San\ Francisco\ Bay\ ENR\ CCI\ Index\ 2025\ (15{,}559.78)}{San\ Francisco\ Bay\ ENR\ CCI\ Index\ 2018\ (12{,}014.72)}$$

Note: the ratio of ENR CCI Indices for 2025 to 2018 is 1.3 (i.e., 15,559.78 ÷ 12,014.72).

For San Leandro, the cost for sidestream treatment in 2018 dollars was $9.8M. The escalated construction cost based on the equation above translates to a construction cost of $13.2M. Note: this is a stand-alone cost and does not assume a building or modification of the existing flow equalization tank with the sidestream treatment equipment on top of this tank.

Given the uncertainty on sidestream location and whether it includes a building and/or modification of the flow equalization tank, it is recommended that a construction cost value of $15M-$20M be assumed for this planning level exercise.

As previously noted in Section 6, this cost estimate is based on a biological treatment reactor (e.g., sequencing batch reactor). It is in the City’s interest to consider sidestream treatment strategies beyond such technologies, such as algae treatment and/or ammonia recovery.

8 Cost and TIN Load Reduction Summary

A summary of the cost elements for each alternative and the corresponding TIN load reduction range is presented in Table 8-1. Note: the cost estimate includes ancillary elements outside of TIN reduction which should be replaced/repurposed as part of any such improvements. For example, the aeration basins have various elements that should be replaced due to location and/or safety concerns (e.g., need to move blower motor control center, step-feed mechanical facilities, various piping in the aeration basins, etc.). It is recommended that the City consider including such improvements for any alternatives that are carried forward.

Of the mainstream improvements (alternatives #1A, #2A, and #3A), the RAS Re-Aeration alternative #3A offers the most cost-effective means for TIN load reduction (approximately $12M for reducing TIN loads at 20-40%). The addition of sidestream treatment coupled with RAS Re-Aeration (alternative #3B) should reliably meet the 40+ percent desired TIN load, but at an additional $15-$20M beyond alternative #3A.

This $15M-$20M cost estimate for sidestream treatment should serve as a placeholder for now. As previously noted in Section 6, it is in the City’s interest to consider sidestream treatment strategies that includes traditional biological technologies, innovative biological technologies (e.g., deammonification, Microvi, etc.), algae treatment, and/or ammonia recovery. Such technologies might reduce the construction cost estimates. To better understand the potential for such sidestream technologies, it is recommended that the City consider pilot-testing an innovative treatment technology, algae treatment, and/or ammonia recovery technology (e.g., Falk et al., 2023; Wang et al., 2023).

As for a mainstream expansion (alternative #4), this alternative requires considerably more infrastructure than the other alternatives. Specifically, the required tankage increases from 0.66 MG per train to approximately 2 MG per train. Such an increase in tankage would require considerably footprint and it comes at a cost as noted in Table 8-1. As such, it should only be viewed as a long-term alternative for future TIN loads beyond the third nutrient watershed permit.

Table 8-1. Summary of the Cost Elements and Corresponding TIN Load Reductions Developed for the Various Alternatives

Alternative	Alternative Number	Description	Cost Estimate*	Projected TIN Reduction (w/out NbS)	Projected TIN Reduction (w/NbS)
Nature-based Solution (NbS)	0	Diverting upwards of 0.95 mgd of secondary effluent to an NbS	**$13M (50% is funded via grants)**	--	10%
Mainstream Improvements	1A	Use All Existing Tankage	--	0-5%	10-15%
	2A	FFR Bypass and Parallel Operation of Two Trains with Anoxic Zones	FFR Bypass: $370-$740k Aeration Basins: $3.4M Ancillary Equipment*: $6M **Total = $10M**	10-20%	20-30%
	3A	FFR Bypass and Series Operation of Two Trains with Anoxic Zones and RAS Reaeration	FFR Bypass: $370-$740k Aeration Basins: $5.4M Ancillary Equipment*: $6M **Total = $12M**	30-40%	40-50%
Sidestream Improvements PLUS Mainstream Improvements	1B	Sidestream Treatment and Parallel Operation of Two Trains	Sidestream: $15M-$20M Aeration Basins: $3.4M Ancillary Equipment*: $6M **Total = $25M-$30M**	30-40%	35-45%
	2B	Sidestream Treatment, FFR Bypass, and Parallel Operation of Two Trains with Anoxic Zones	Sidestream: $15M-$20M FFR Bypass: $370-$740k Aeration Basins: $3.4M Ancillary Equipment*: $6M **Total = $25M-$30M**	50-60%	55-65%
	3B	Sidestream Treatment, FFR Bypass, and Series Operation of Two Trains with Anoxic Zones and RAS Reaeration	Sidestream: $15M-$20M FFR Bypass: $370-$740k Aeration Basins: $5.4M Ancillary Equipment*: $6M **Total = $27M-$32M**	55-65%	60-70%
Mainstream Expansion	4	Mainstream Tankage Expansion	**>$40M**	55-65%	60-70%

* The cost estimate includes assets which should be replaced/repurposed as part of any such improvements.

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9 Supplemental Sampling in August 2025

Given the relatively wide range of TIN load reductions per alternative, HDR recommended supplemental sampling to bolster the SUMO model and to better understand the carbon speciation. The supplemental sampling covered two consecutive weeks (including weekends) compared to routine sampling which occurs weekly (mid-week). The mid-week sampling is in place as that is when industrial loads have historically been the highest.

A summary of the recommended sampling values and the corresponding locations is provided in Table 9-1. Overall, the supplemental sampling provided the necessary information to refine the SUMO model. Regardless, the TIN load reduction ranges per alternative was maintained from pre-supplemental sampling due to uncertainty associated with industrial loads.

A summary of the key takeaways by parameter while comparing the supplemental versus the historical values are as follows:

- **TSS:** except for the primary effluent, the values track well between the supplemental sampling and the historical plant data. The supplemental sampling primary effluent values were approximately 30 mg/L lower than the historical values. It is worth continuing to further monitor the primary effluent TSS values as this impacts downstream capacity in the biological treatment.
- **VSS:** little or no historical data available. Overall, the key variable is the ratio of VSS:TSS (0.91), which is slightly higher than the industry benchmark range of 0.75-0.85. A theme that is prevalent throughout is this is attributed to the relatively high industrial contributions to the WPCP.
- **COD:** there was little or no available COD data available. The intent behind this request was to better understand the carbon fractionation across the WPCP. The breakdown of relevant ratios is as follows:
    - *Raw Influent COD:cBOD:* the sampled value of 2.5 is slightly higher than the industry benchmark range of 1.9 – 2.2. This relatively higher ratio is reflective of poorly biodegradable substances. Having a higher value was expected given the relatively high industrial contribution.
    - *Raw Influent filtered COD (fCOD):COD:* the sampled value of 0.47 is within the industry benchmark of 0.3 to 0.5 (albeit on the upper end). This was expected considering the relatively high industrial contributions.
    - *Filtered COD (fCOD):* while relatively high, it is by and large readily biodegradable as evidenced by an over 70% reduction from the headworks through the FFRs (1-165 mg/L ÷ 619 mg/L = 74%) and nearly 90% reduction across the WPCP (1- 67 mg/L ÷ 619 mg/L = 89%).
    - *Filtered Flocculated COD (ffCOD):* serves as an indicator of how readily biodegradable the filtered COD is. A ratio of 0.75 (ffCOD:fCOD) supports the notion of readily biodegradable raw influent. This notion is supported by the relatively large reduction across the FFRs (>80% compared to the raw influent ffCOD).

- **cBOD:** The supplemental sampling values are considerably less than the historical data (495 versus 640 mg/L). This discrepancy is attributed to the industrial load contribution. As previously noted, industrial loads have historically been highest midweek and should have been captured over the two weeks of intensive sampling.
- **sBOD:** the discrepancy between supplemental sampling and historical values are within 25 mg/L and thus likely within the noise. Regardless of the dataset, the values on average are less than 60 mg/L, which suggests that the FFR is removing more or less all of any readily biodegradable sBOD.
- **Raw influent ammonia and NOx**: values are both similar to historical datasets. The key item to note across the WPCP is how much higher the ammonia values are for primary effluent samples. This discrepancy is likely due to a larger than normal contribution from the sidestream during supplemental sampling.
- **Alkalinity:** data suggests considerable contributions from the sidestream as the FFR effluent and effluent values are nearly 50% greater than the raw influent. This alkalinity contribution is critical as the raw influent levels suggest that the WPCP would be short of alkalinity to reliably nitrify the entire influent ammonia load.

Table 9-1. Summary of Supplemental Sampling Values*

Parameter	Influent (Historical Average)	Primary Effluent (Historical Average)	FFR Effluent (Historical Average)	Final Effluent (Historical Average)	BFP Filtrate (Historical Average)
TSS	359 (345)	114 (146)	234 (238)	9.1 (11)	--
VSS	325	101	191	--	--
COD	1,217	832	628	91	--
Filtered COD (fCOD)	619	584	165	67	--
Filtered Flocculated COD (ffCOD)	466	488	82	--	--
cBOD	495 (640)	412 (474)	156 (198)	14 (13)	--
sBOD	--	--	33.4 (57)	--	--
TKN	54.7	--	--	--	--
NHx	30.8 (30.0)	48.6 (39.2)	40 (32.3)	39 (31.4)	614
NOx	1.7 (2.0)	0.3 (0.6)	1.0 (0.4)	2.7 (0.9)	--
Alkalinity	189	--	298	266	--

* The historical average values represent the original dataset provided by the WPCP that was used to calibrate the SUMO model (evaluated in Section 4.4).

10 Summary of Findings and Recommendations

This study serves as a first step in establishing a nutrient roadmap for the WPCP. A visual depiction of this nutrient roadmap is provided in Figure 10-1. The nutrient roadmap references the on-going nature-based solutions effort (in light-blue color), but it does not include it in the analysis as that is a separate on-going effort. Given that, the progression of plant optimization/modifications associated with this TM focuses initially on reconfiguring the existing mainstream tankage (i.e., alternatives #1A and #2), followed by adding RAS Re-Aeration (i.e., alternative #3), and lastly the addition of sidestream treatment (i.e., alternative #6). The timeline for implemented such steps is largely dependent on funding availability and City Staff availability to implement.

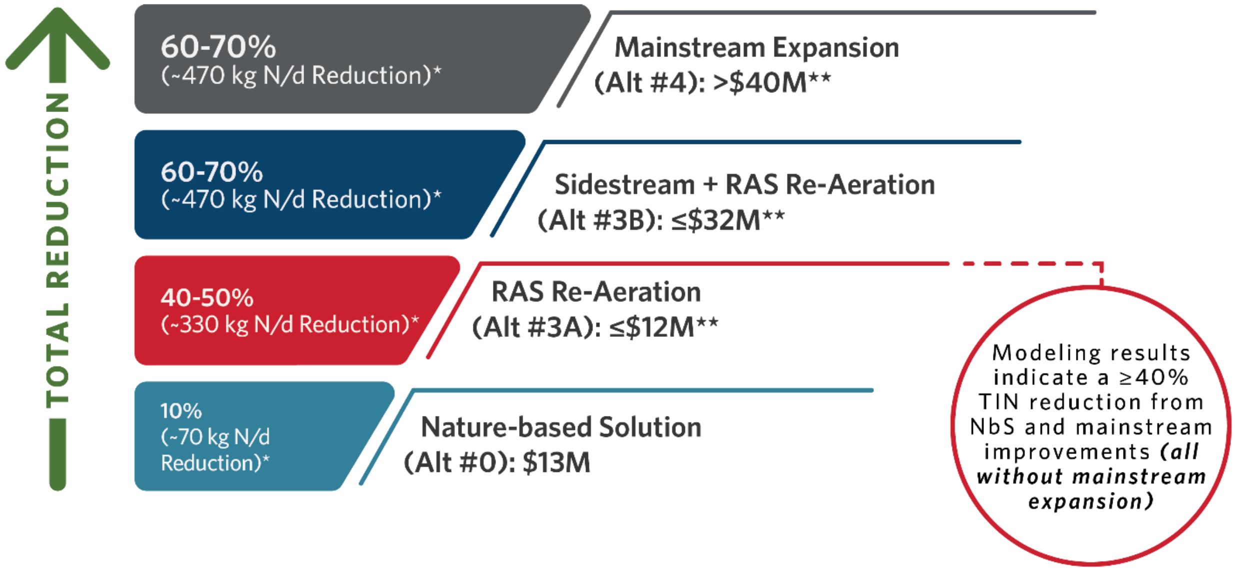

Figure 10-1. Nutrient Roadmap for Reducing TIN Loads and the Corresponding Costs

* The TIN reduction values (both percent and load) include NbS reductions

** The costs excludes other ancillary elements outside of TIN reduction which should be replaced/repurposed as part of any such improvements (details in Section 7).

The costs for each incremental step is as follows:

1) Nature-based Solution (Alternative #0; $13M (50% grant funded))
2) Reconfigure Existing Mainstream Tankage (Alternatives #1A or #2A; up to $10M)
3) Introduce RAS Re-Aeration (Alternative #3A: up to $12M)
4) Sidestream Treatment (up to $20M). The cost increases if Alternatives #1A, #2A, or #3A is included with sidestream treatment (up to $32M)

As noted throughout this TM, the sidestream cost estimate should serve as a placeholder as the technology selection is unclear, as well as the sidestream treatment location. The options to date for location are above the flow equalization tank or a new sidestream treatment building.

Furthermore, the technology is predicated on a biological reactor, such as a sequencing batch reactor.

It is recommended that the WPCP consider doing a more detailed evaluation of sidestream treatment that might include a desktop study and/or a pilot to further evaluate. A piloting exercise treatment could consider a baseline biological reactor compared against algae treatment, an ammonia recovery technology, and others (e.g., Microvi as it was effectively implemented at nearby Oro Loma/Castrol Valley Sanitary District).

Despite successful supplemental sampling to better understand the COD speciation and other parameters, the component that is unclear are QACs. The uncertainty is attributed to it being by and large outside of the WPCP's control. It is recommended that the WPCP continue sampling for QACs and develop a strategy to address process upsets associated with QACs by having the appropriate chemicals on hand.

A summary of the overall recommendations and next steps are as follows:

1) Gain consensus from the City on the nutrient roadmap incremental progressions as noted in Figure 10-1.
2) Further advance the roadmap by developing a timeline of key milestones.
3) Develop a funding strategy to implement the various incremental progressions.
4) Identify additional assets that should be replaced as part of implementing any of the listed alternatives and assign costs for such replacements. For example, there are various mechanical elements throughout the aeration basins that are well beyond their useful life. Such assets should be replaced while performing any modifications to the aeration basins.
5) Garner support from the City to pilot a sidestream treatment technology(s). Potential objectives for such piloting is as follows:
    a. Treatability as San Leandro does have a relatively high industrial load
    b. Technology evaluation (baseline technology versus emerging technologies)
    c. Refining cost estimates based on actual pilot performance data (i.e., reaction kinetics)
    d. Refine siting of any potential sidestream technology(s)
    e. Others
6) QACs: perform a more detailed sewershed assessment to better understand the potential industrial contributors. As part of this effort, consider including QACs as part of the WPCP's pre-treatment program.
7) Others

The aforementioned recommended next steps could be included as part of a Facility Plan for implementation at the WPCP.

11 References

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Appendix A. Meeting Minutes and Presentations

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Appendix B. Detailed Equipment Breakdown for the Opinion of Probable Construction Cost Estimates

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