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Technical Memorandum

Prepared for: Sewer Authority Mid-Coastside

Project Title: WWTP Capacity and Process Study

Project No.: 156642

Technical Memorandum

Subject: Capacity Assessment and Alternatives Evaluation

Date: August 10, 2021

To: Kishen Prathivadi, Sewer Authority Mid-Coastside

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Limitations:

This document was prepared solely for Sewer Authority Mid-Coastside in accordance with professional standards at the time the services were performed and in accordance with the contract between Sewer Authority Mid-Coastside and Brown and Caldwell dated March 22, 2021. This document is governed by the specific scope of work authorized by Sewer Authority Mid-Coastside; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by City of Santa Rosa and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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List of Abbreviations

AA	annual average
ADW	average dry weather
ADWF	average dry weather flow
BC	Brown and Caldwell
BOD	biochemical oxygen demand
CEPT	chemically enhanced primary treatment
EPDM	ethylene propylene diene monomer
$FeCl_3$	ferric chloride
gpd/sqft =	gallons per day per square foot
H_2S	hydrogen sulfide
lb/d	pounds per day
mgd	million gallons per day
mg/L	milligrams per liter
mL/g	milliliters per gram
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MM	maximum month
O&M	Operations and Maintenance
OPCC	opinion of probable construction costs
PD	peak day
PDWWF	peak day wet weather flow
psig	pound-force per square inch
RAS	return activated sludge
SAM	Sewer Authority Mid-Coastside
scfm	standard cubic feet per minute
SLR	solids loading rate
SOR	surface overflow rate
SVI	sludge volume index
TM	technical memorandum
TSS	total suspended solids
VSS	volatile suspended solids
WAS	waste activated sludge
WWTP	Wastewater Treatment Plant

Executive Summary

The Sewer Authority Mid-Coastside (SAM) hired Brown and Caldwell (BC) in March 2021 to complete a wastewater treatment plant (WWTP) capacity assessment and operations evaluation. This request was in response to high influent biochemical oxygen demand (BOD) loading events that occurred in October 2020 that may have contributed to process upsets at the SAM WWTP.

BC initiated the work by conducting an on-site kickoff meeting on March 30, 2021, to discuss project objectives. Immediately after the kickoff meeting, BC conducted a visual assessment of the secondary treatment facilities. Over the next three weeks, BC reviewed the historical flow and loading data and past treatment performance as a basis for determining existing treatment capacity of the primary and secondary treatment processes. BC presented this information to SAM staff on May 17, 2021 and conducted a more detailed operations assessment to further confirm process capacity. BC concluded that using industry-standard assumptions for estimating process capacity along with the information obtained during the operations assessment, that the WWTP did not have adequate capacity to treat current flow and loading with only Aeration Basin 3, and that additional modifications should be constructed to increase the capacity at the WWTP.

Furthermore, improvements at the WWTP need to be coupled with source control in the collection system to reduce BOD spikes entering the WWTP to provide higher probabilities of maintaining compliance. Biological processes tend to perform better with stable influent loadings or loadings that change slowly. Significant peak events that arrive suddenly may result in elevated effluent pollutant concentrations which may result in permit violations. It cannot be deduced from this work that the very high influent BOD spike on its own caused the subsequent process upset. It is recommended to investigate the source of high BOD spikes in the collection system through a source control program to dampen the high BOD spikes entering the WWTP and provide higher probabilities of maintaining permit compliance.

BC finalized the existing facilities capacity analysis and identified future alternatives to increase secondary treatment capacity. BC presented the capacity information and proposed future treatment alternatives to SAM operation staff on June 17, 2021. Future alternatives presented and discussed in this workshop were:

1. Alternative 1 – Outfit Aeration Basin 4 with fine-bubble diffusers to match Aeration Basin 3. Operate both Aeration Basins 3 and 4 in parallel and have existing Aeration Basins 1 and 2 serve as a backup when Aeration Basins 3 or 4 are taken out of service for inspection.
2. Alternative 2 – Retrofit Aeration Basins 1 and 2 with fine-bubble diffusers instead of outfitting Aeration Basin 4. Operate all three basins in parallel.
3. Alternative 3 – Modify Aeration Basin 2 to operate in series prior to flow entering Aeration Basin 3.
4. Equalization – Modify Aeration Basin 1 to be able to operate as equalization by enabling gravity flow into the basin and pumping flow out.

During the June 17, 2021, workshop, the decision was made to continue to investigate all four treatment alternatives. BC developed construction cost estimates and associated treatment capacities for these alternatives. Additionally, system resiliency was assessed for each alternative to factor in the probability of system upsets, system redundancy, and operational complexity. The results were presented to SAM operations staff on July 21, 2021. Following discussion with operations staff, Alternative 1 was selected as the recommended alternative as it provides the most redundancy and does so at the lowest estimated cost with the lowest of risk potential plant violations. The draft report with this recommendation was presented to the SAM board on July 26, 2021

Section 1: Introduction and Objectives

The Sewer Authority Mid-Coastside's (SAM) wastewater treatment plant (WWTP) observed very high biochemical oxygen demand (BOD) concentrations and loading entering the WWTP in Fall 2020. This high loading period triggered a process upset that resulted in elevated BOD and total suspended solids (TSS) concentrations in the effluent. In response, SAM staff hired Brown and Caldwell (BC) to determine the capacity of the secondary treatment process and to provide recommendations for how to increase secondary treatment capacity. The previous design documents and operations and maintenance (O&M) manual did not document how the secondary process was intended to operate, so SAM also requested that BC provide updated O&M guidance.

The purpose of this technical memorandum (TM) is to present BC findings related to the existing secondary treatment capacity and to recommend a path forward for increasing secondary treatment capacity. BC provided operational guidance as part of this project, which is documented in a separate TM.

Section 2: Historical Data Review

2.1 Description of Composite Sampling Locations

A raw influent flow meter is located at the WWTP that measures flow using water level at the influent flume. A flow-weighted composite sample collects raw influent samples. A primary effluent composite sampler is used to collect time-weighted samples. A final effluent flow-weighted composite sample is used for effluent monitoring.

2.2 Flow and Loading Assumptions

An evaluation of data from 2018-2020 was performed to determine the flow and loading basis to use for the capacity assessment. The WWTP was designed in the 1990s, and influent wastewater characteristics have changed significantly since that timeframe, especially due to changes experienced from the drought that occurred in California from 2010-2015. Tables 2-1 and 2-2 summarize the raw influent flow and loading from 2018-2020, as well as the associated peaking factors used in the analysis.

Data from 2020 is shown for reference but is omitted from the analysis because it was skewed by a very high BOD spike in Fall 2020 that is not representative of typical wastewater characteristics and was not what the WWTP was designed to treat.

Table 2-1. Summary of Flow and Loading Statistics from 2018-2020

	Infuent Flow, mgd				Influent BOD Load, lb/d				Influent TSS Load, lb/d			
	ADWF	AA	MM	PD	ADWF	AA	MM	PD	ADWF	AA	MM	PD
2018	1.3	1.4	1.9	5.3	3778	3590	4,788	5,771	3,203	3,297	3,739	5,626
2019	1.3	1.7	3.1	5.7	3636	3851	4,645	5,451	3,277	3,597	4,806	5,670
2020	1.2	1.3	1.7	3.0	4561	5058	12,593	19,871	3,216	3,510	4,311	5,725

AA = annual average
ADWF = average dry weather flow
MM = maximum month
PD = peak day
mgd = million gallons per day
lb/d = pounds per day

Table 2-2. Summary of Peaking Factors Selected									
Peaking Factors									
2018	1.1	1.5	4.2	1.0	1.3	1.5	1.0	1.2	1.8
2019	1.3	2.4	4.3	1.1	1.3	1.5	1.1	1.5	1.7
2020	1.1	1.4	2.4	1.1	2.8	4.4	1.1	1.3	1.8
	Peaking Factor Selected	2.4	4.3		1.3	1.5		1.5	1.7

Figures 2-1 and 2-2 display time series plots of the influent flow, and BOD and TSS loading, respectively. These are shown to provide graphical representations of the data over time.

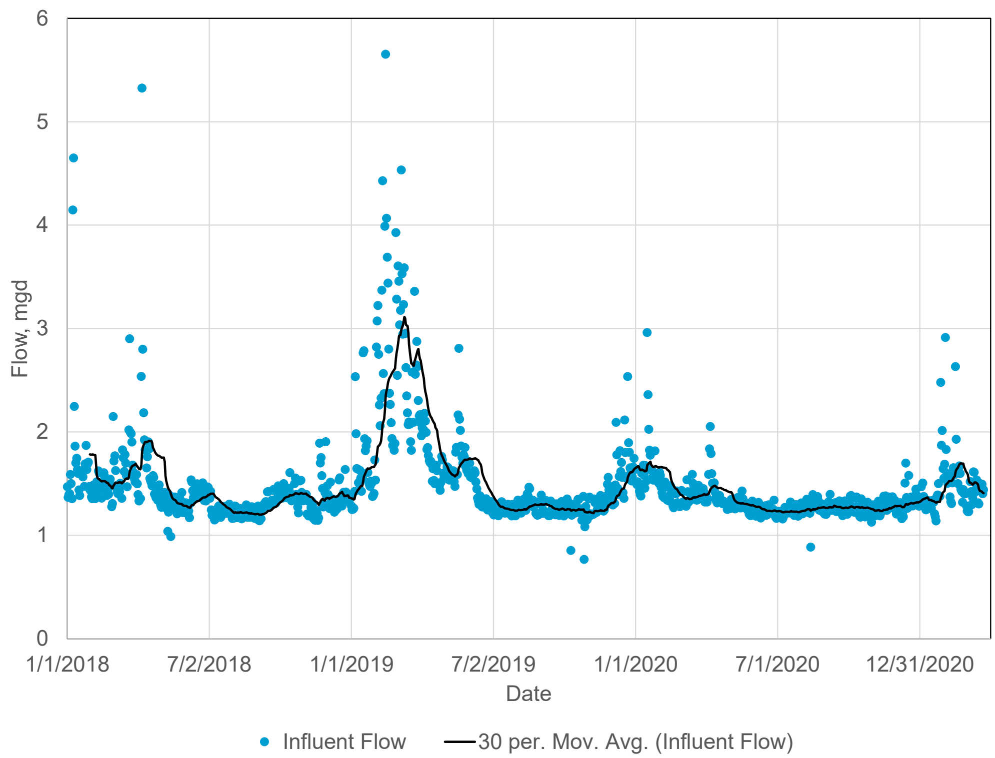


Figure 2-1. Influent flow rate

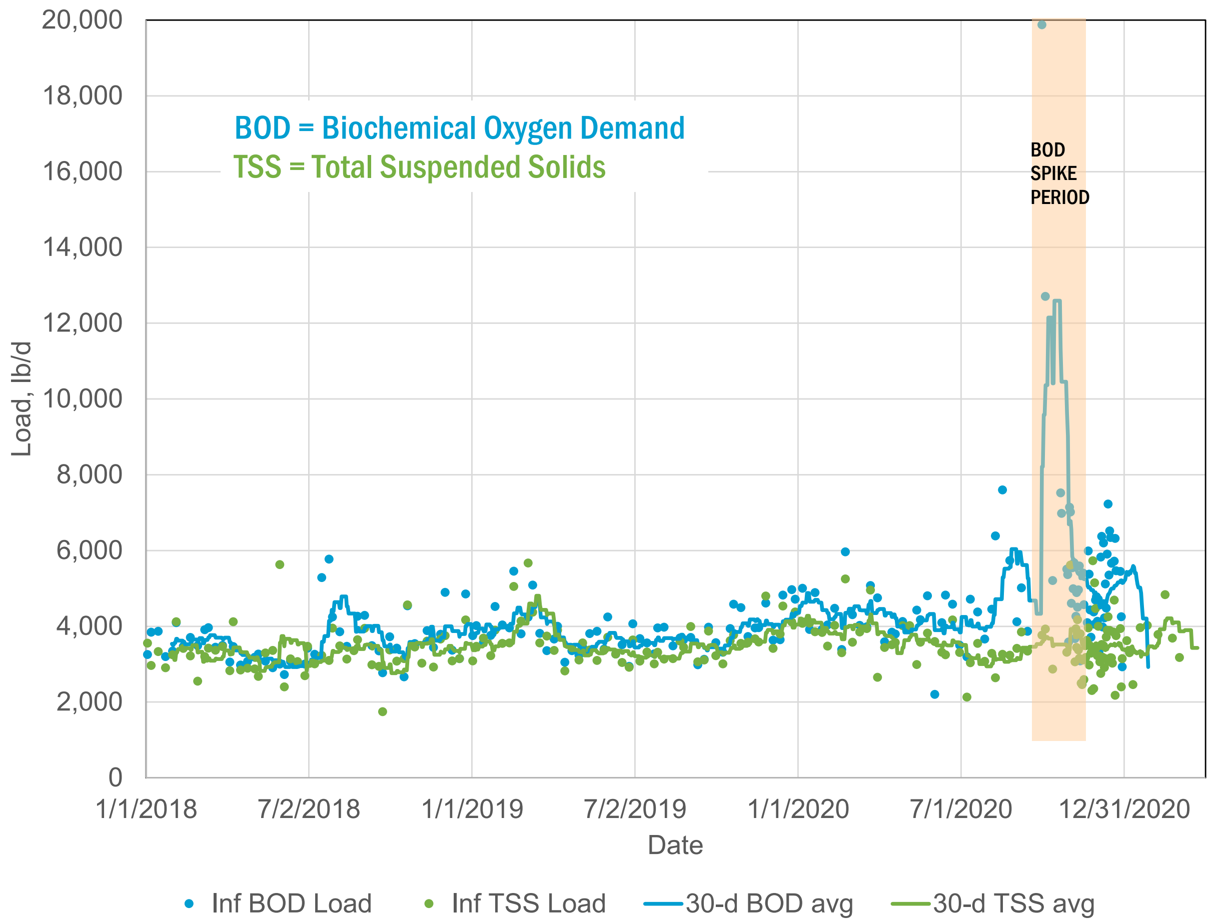


Figure 2-2. Raw influent BOD and TSS loading

2.3 Primary Clarifier Performance

There are a total of four rectangular primary clarifiers at the WWTP. Primary Clarifiers 1 and 2 were constructed originally in the 1950s. Primary Clarifiers 3 and 4 are old Aeration Tanks 1 and 2 that were reconfigured to primary clarifiers in 1999.Primary Clarifier 4 does not have equipment in it and is, therefore, not functional. Preliminary effluent from aerated grit tanks is sent to a channel, from which effluent is distributed to all primary clarifiers via slide gates. Table 2-3 shows a summary of primary clarifier dimensions.

Table 2-3. Summary of Primary Clarifier Dimensions (only equipped primary clarifiers are shown)

Parameter	Primary Clarifiers 1 and 2	Primary Clarifier 3
Length, feet (ft)	65	75
Width, ft	20	20
Depth, ft	11	11
Surface area, square ft	1,300	1,500

The primary clarifiers at SAM have performed well over the period of data reviewed (January 2018–March 2021). Ferric chloride has been added upstream of the aerated grit tanks over that entire period, with annual average doses ranging from 10.6 to 14.4 milligrams per liter (mg/L) as ferric chloride ($FeCl_3$). The FeCl3 is not flow paced. The primary purpose of dosing ferric chloride at this location is sulfide control in the digesters. This is a typical dosing scheme used at municipal wastewater treatment plants because the ferric chloride binds with sulfides and other compounds and then settles in the primary clarifiers before getting pumped into the digesters. The bound sulfide will not be converted to hydrogen sulfide (H_2S) in the digesters.

SAM staff started dosing polymer in the primary influent channel to try and achieve chemically enhanced primary treatment (CEPT) reactions. CEPT is typically characterized as dosing a coagulant (in this case ferric chloride) at least 3 to 5 minutes upstream of dosing a flocculant (i.e., polymer). The goal of CEPT dosing is to achieve higher TSS and BOD removal by creating larger particles and/or flocs that are more likely to settle in the primary clarifiers.

Table 2-4 shows a summary of primary clarifier performance over several time periods, with and without polymer addition. In general, the SAM WWTP achieves good TSS and BOD removal. Typical municipal WWTP primary clarifiers achieve 60 percent to 65 percent TSS removal, while SAM achieves 70 percent TSS removal on average. The data suggest that the addition of polymer did not improve primary clarifier performance.

Figure 2-3 shows time series plots of TSS and BOD removal as a means to visually display the primary clarifier performance over the period summarized in Table 2-4.

Table 2-4. Summary of Primary Clarifier Performance

Date and Condition	SOR, gpd/sqft	TSS Removal, percent	BOD Removal, percent	Ferric as $FeCl_3$, mg/L	Polymer, mg/L
2018 (no polymer)	650	70%	40%	10.6	0
2019 (no polymer)	736	71%	41%	11.8	0
Jan. 1, 2020 to Nov. 30, 2020 (no polymer)	408	70%	38%	14.4	0
Dec. 1, 2020 to March 24, 2021 (with polymer addition)	406	66%	36%	13.6	2.2

gpd/sqft = gallons per day per square foot

SOR = surface overflow rate

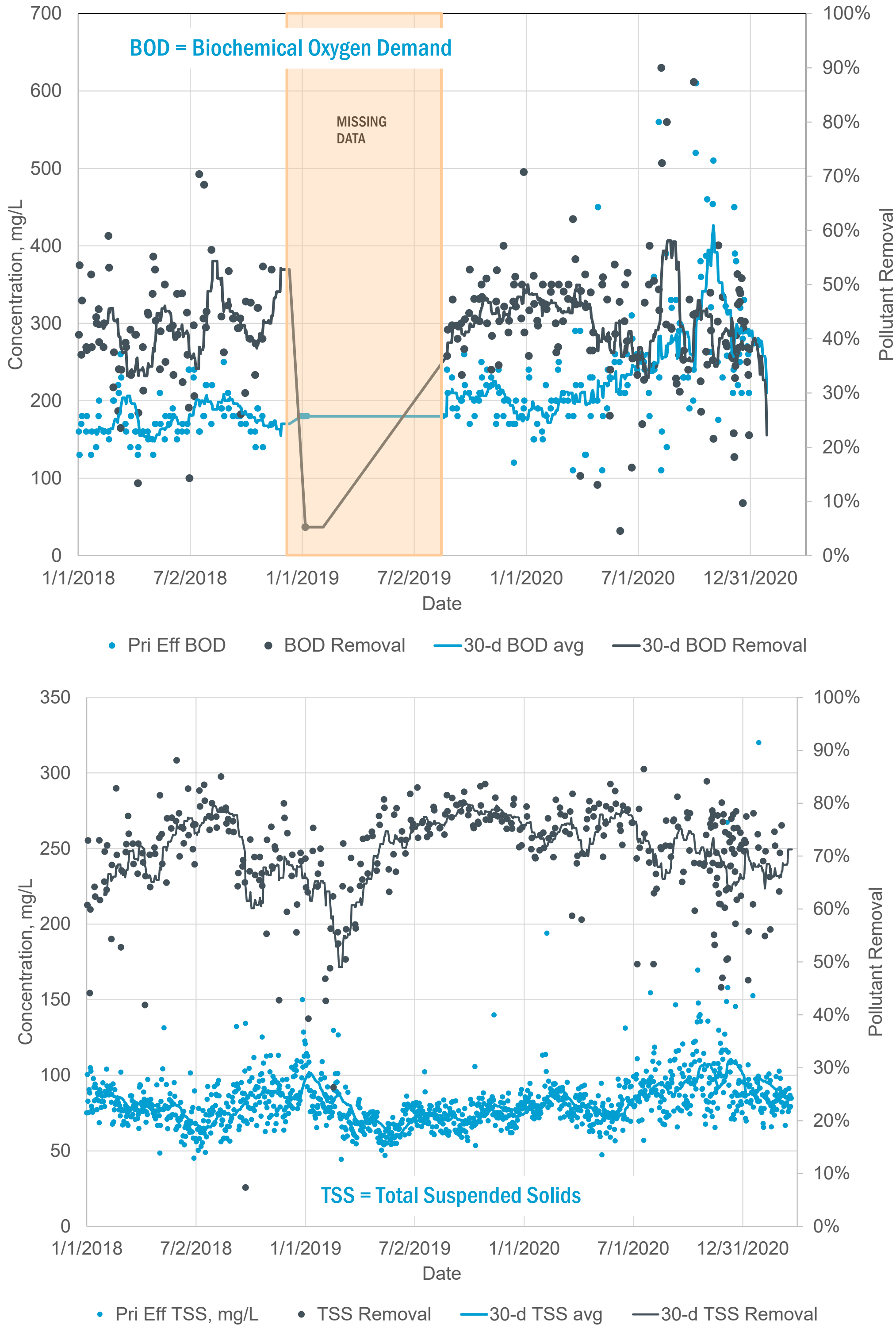


Figure 2-3. Primary clarifier BOD removal (top) and TSS removal (bottom)

2.3.1.1 Primary Clarifier Recommendations

If SAM wants to continue with CEPT, it is recommended to have a chemical vendor conduct jar tests to determine the most appropriate polymer chemical selection, along with the optimal chemical doses. It is also recommended that the chemical feed systems be improved to improve mixing where it is being added. Finally, it recommended to include flow pacing to the influent flow rate; the facility currently uses constant chemical flow rates for ferric chloride and polymer.

2.4 Secondary System Performance

There are a total of four rectangular aeration basins at the WWTP. Aeration Basins 1 and 2 were constructed originally in the 1950s, while Aeration Basins 3 and 4 were constructed in 1999. Primary effluent flow from primary clarifiers is sent to a common channel, which then mixes with return activated sludge (RAS) and is fed to all basins. SAM staff have been using Aeration Basin 3 as the primary form of secondary treatment. Table 2-5 shows a summary of aeration basin dimensions.

Table 2-5. Summary of Aeration Basin Data

Parameter	Reference: As-built Drawing Notes (Drawing No. G-2)	
	Aeration Basins 1 and 2	Aeration Basins 3 and 4
Length, ft	88.5	88.5
Width, ft	24	30
Depth, ft	16.3	16.3
Volume, cubic feet million gallons	34,620 (0.259)	43,280 (0.323)

There are four 125-horsepower centrifugal blowers (3 duty plus 1 standby) at the WWTP at a capacity of 2,275 standard cubic feet per minute (scfm) at 8.5 pounds of force per square inch gauge (psig). The total capacity of the blowers is 6,825 scfm at 8.5 psig with three of the four blowers online. Aeration Basins 1 and 2 have coarse-bubble diffusers, while Aeration Basin 3 has 9-inch Environmental Dynamics International (EDI) disc membrane diffusers (920 diffusers each tank), which were last replaced in May 2021. These diffusers have ethylene propylene diene monomer (EPDM) fine-bubble membranes, which are more efficient at transferring oxygen into the wastewater than the coarse-bubble diffusers. Aeration Basin 4 is not equipped with diffusers.

The solids residence time at SAM is typically around 2 days on average when accounting for only the inventory in the aeration basins. This has resulted in a typical mixed liquor suspended solids (MLSS) concentration around 1,500 mg/L. Figure 2-4 presents a time series plot of MLSS and waste activated sludge (WAS) TSS concentrations.

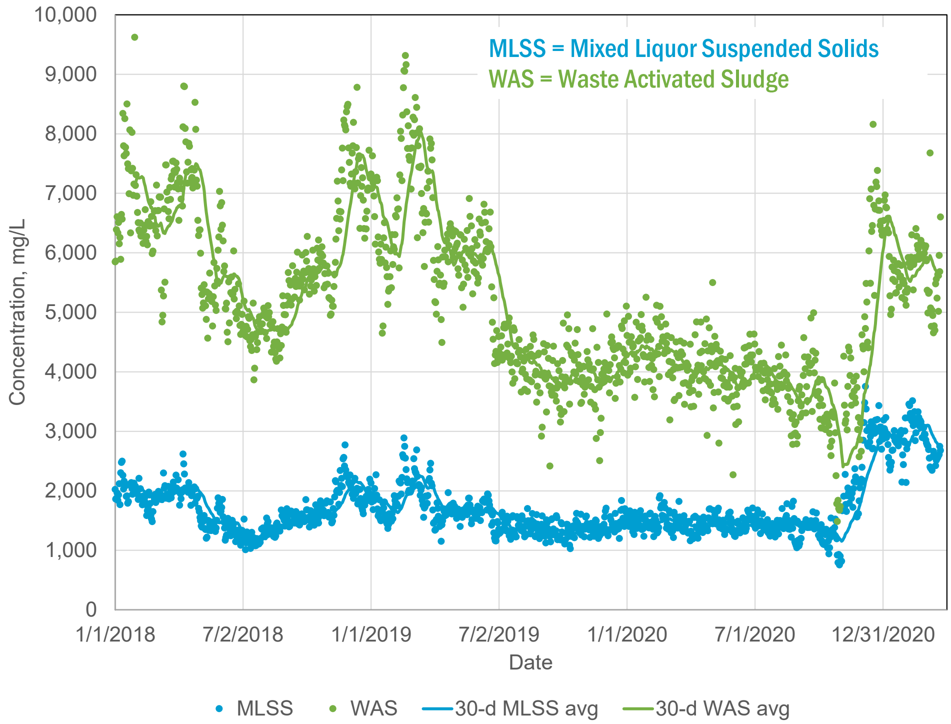


Figure 2-4. Aeration basin historical MLSS and WAS profile

The sludge volume index (SVI) data at SAM is shown on Figure 2-5 with RAS chlorination dosing. In general, the RAS chlorination dose has been very high at times and may have contributed to very high SVI values in late Fall 2020. If the RAS chlorination dose is too high, bacteria responsible for treatment may be impacted, which would limit their ability to treat the incoming wastewater. BC has provided operational guidance on RAS chlorination, which is documented separately in the Operations Assistance TM (Attachment E). The SVI statistics are summarized in Table 2-6. For the planning purposes of this TM, the design value 90th percentile SVI of 200 milliliters per gram (mL/g) was assumed. The high SVI associated with the upset was not used in this analysis.

After the period of data that this analysis was based on, there have been significantly high SVI excursions well past SVI values of 1,000 mL/g. The analysis here was not updated to accommodate such a high SVI but it should be mentioned for context.

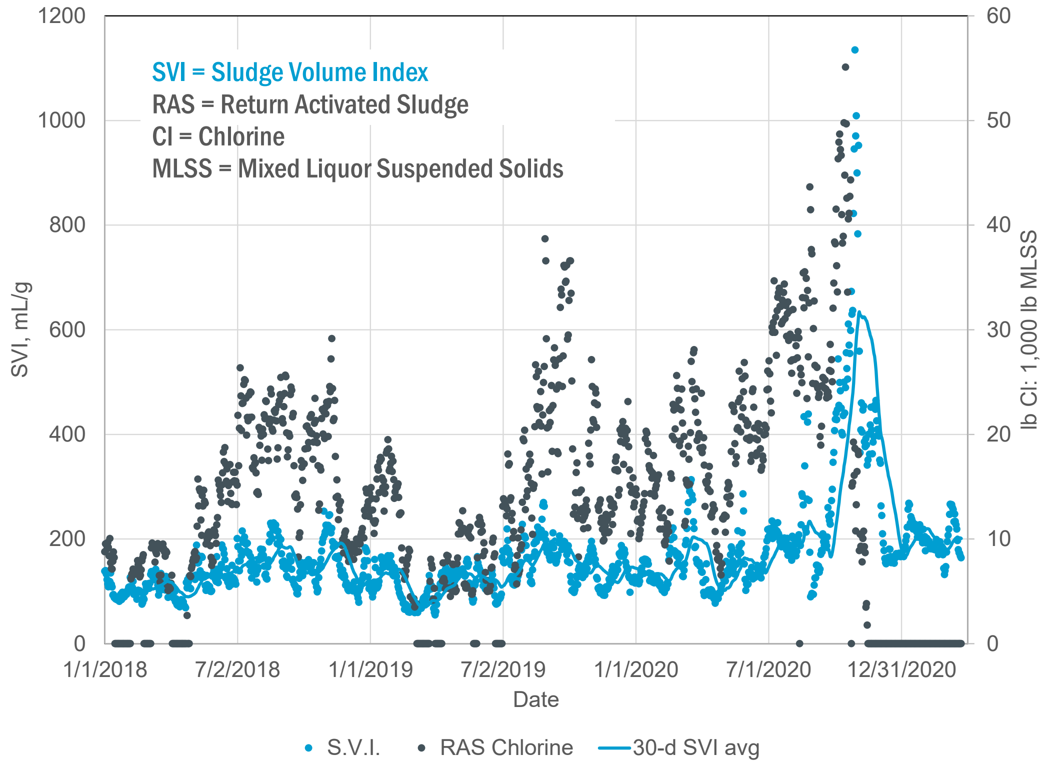


Figure 2-5. Historical RAS chlorination impact on SVI

Table 2-6. Summary of SVI Statistics		
Timeframe	Average SVI, mL/g	90th Percentile SVI, mL/g
2018	135	192
2019	134	187
2020	229	438
January 2021 – March 2021	204	248
January 2018 – July 2020 (prior to upset and used for planning purposes)	**139**	**197**

There are a total of two circular secondary clarifiers at the WWTP. These tanks were constructed in 1999 at the time of the regional facility expansion. Table 2-7 shows a summary of secondary clarifier dimensions. Figure 2-6 presents a time series plot of SOR and solids loading rate (SLR).

Table 2-7. Secondary Clarifier Information

	Secondary Clarifiers 1 and 2
Diameter, ft	85
Side Water Depth, ft	14
Total Effective Area, ft^2, each	5,670
Design Peak Hour Overflow Rate, gpd/ft^2	1,401
RAS Pumping Capacity (1 pump offline), gallons per minute	3,600

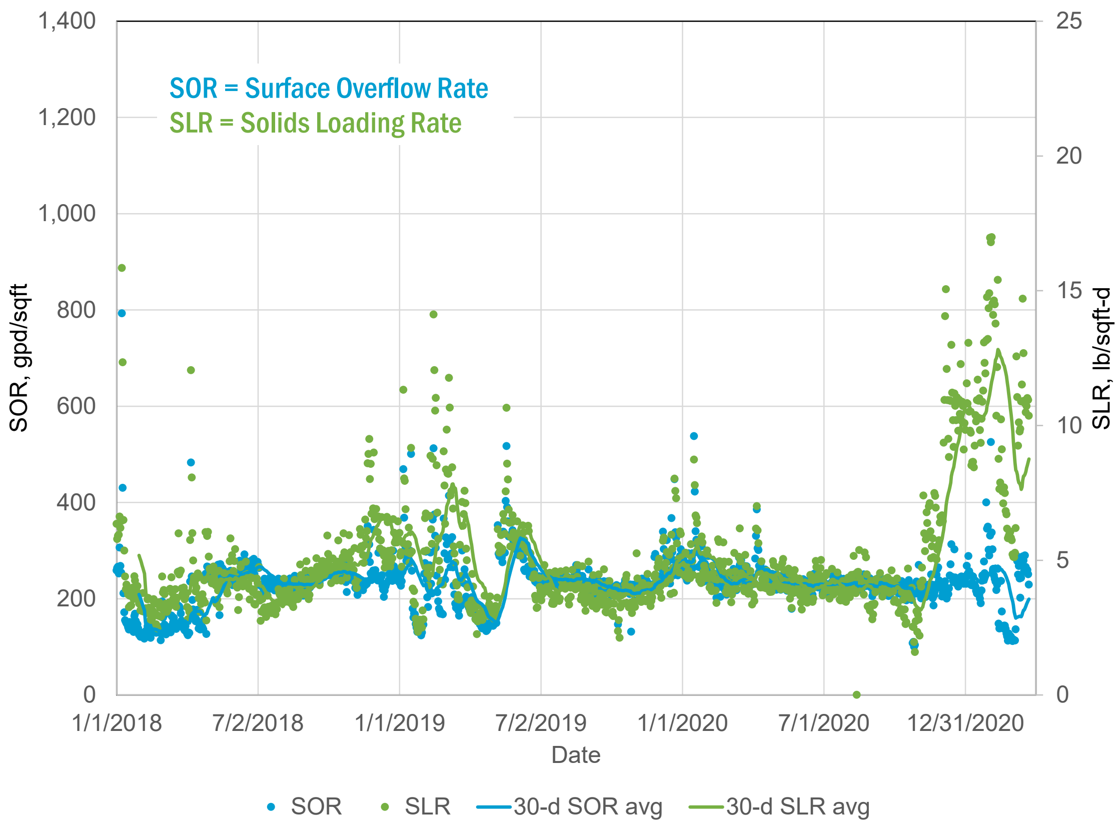


Figure 2-6. Secondary clarifier historical performance based on SOR and SLR

2.5 BOD Spike and Process Upset

An influent BOD spike occurred on August 8, 2020, with BOD topping 1,000 mg/L. A second BOD spike occurred around October 1, 2020, with BOD increasing to 1,900 mg/L. The influent BOD spikes were not concurrent with influent TSS spikes, which would indicate that most of the BOD spike was soluble. However, primary effluent BOD data suggested that much of the BOD in the raw influent was removed through the primary clarification process, suggesting that the BOD was not soluble, as primary clarifiers do not remove soluble BOD. The raw influent and primary effluent data are not consistent during this period.

SAM staff provided direction that the capacity and alternatives analysis should not be based on this very high BOD spike and should instead be based on typical influent flow and loading values before the spike. Subsequent investigations into the collection system will work to prevent such BOD spikes in the future.

Attachment D provides a series of water quality plots to document the BOD spikes that occurred in 2020.

Section 3: Process Model Development

This section documents the development of the plantwide process model using BioWin Version 6.2. A screenshot of the BioWin model is provided in Figure 3-1.

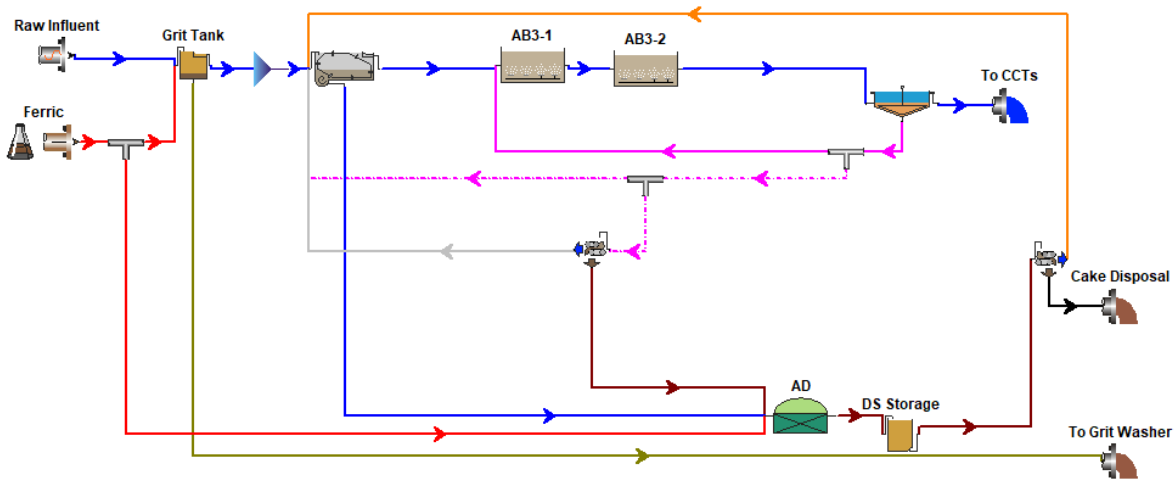


Figure 3-1. SAM WWTP plantwide BioWin Model schematics

The aeration tanks were modeled as two zones to represent the two aeration drop legs along the length of the rectangular each tank. The model was calibrated first using actual plant data, and then validated using two validation periods. Once the model was validated, it was used to estimate capacity of the current system (see Section 4) and then was used to simulate future optimization scenarios (see Section 5).

A Level 2 calibration was performed based on historical data (Melcer et al., 2003). Model calibration and validation were performed to develop a model that could predict performance of the aeration basins relatively well, and then be used for capacity and plant performance evaluations.

3.1.1 Calibration and Validation Results

A detailed summary of the calibration and validation effort are tabulated in Attachment B. The following provides a summary of the conclusions and findings from the steady-state and dynamic model validations:

- Overall, the model predicts most parameters within 10 percent of historical data, which is suitable for a Level 2 calibration.
- The model provided a good match for MLSS and mixed liquor volatile suspended solids (MLVSS) inventory (within 10 percent for calibration and both validation periods).
- The model provided a good match for SRT (<5 percent for calibration and <15 percent for both validation periods) based on TSS:VSS ratio of 0.85.
- The model underpredicts aeration demand by <20 percent. However, SAM staff indicated that air is regularly wasted and/or blown off, so airflow values measured at SAM are not indicative of process air requirements.

Section 4: Capacity Assessment

BC assessed the WWTP's secondary treatment capacity to understand the maximum loading that can be treated. In addition, at the request of SAM staff, BC evaluated ways to operate the primary clarifiers at various flow rates.

4.1 Primary Clarifier Operating Guidance

SAM staff requested that BC provide guidance on how to operate the primary clarifiers at various influent flow conditions. A comprehensive evaluation of the existing primary clarifier capacity was not evaluated, but instead a focus on providing operational guidance was provided. Figure 4-1 shows the SOR values for various conditions plotted against influent flow rates. Operating only one of the small primary clarifiers is not a feasible option. In general, it is recommended to operate the two smaller primary clarifiers during dry weather conditions. Although the hydraulic design capacity (per original design drawings) shows that the two smaller clarifiers are sufficient to treat flows up to 9 mgd, it is recommended to switch to three primary clarifiers online when peak hourly flows are anticipated to exceed 5 mgd. This will optimize treatment performance by minimizing the SOR during peak flow events. Table 4-1 summarizes the primary clarifier operating recommendations.

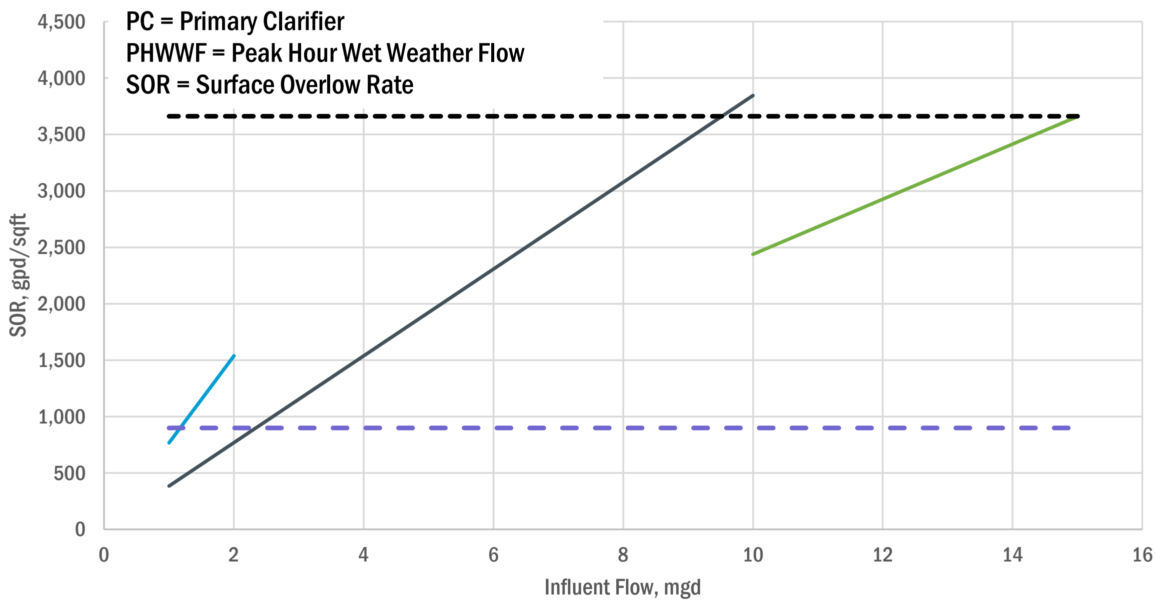


Figure 4-1. SOR Versus Influent Flow at Various Conditions

Table 4-1. Summary of Recommended Primary Clarifier Operating Conditions	
Flow Condition	**Primary Clarifier Condition**
Influent flows up 5 mgd hourly flows	Operate both small clarifiers
Influent flows exceeding 5 mgd hourly flow	Operate all 3 clarifiers

4.2 Secondary System

A secondary system capacity assessment was conducted to determine the capacity of the secondary system. Capacity of the secondary system could be limited by several factors, including:

- **Solids loading rate to the secondary clarifiers** –governed by a combination of MLSS concentrations, influent flow rate, and RAS flow rate.
- **Blower aeration capacity** –governed by how much air the blowers can output under certain conditions
- **Diffuser flux capacity** –governed by a how much air can be conveyed through each diffuser without exceeding design limitations

The approach to evaluating the secondary system was to estimate the capacity for each of the three items described above, understanding that the actual secondary treatment capacity is limited by whichever item had the lowest treatment capacity.

The secondary treatment capacity was evaluated using current wastewater conditions and influent concentrations, which are significantly higher than when the original facility was designed. This is due to significant levels of water conservation, which have decreased flows significantly. The facility is designed for an ADWF of 3.69 mgd, but currently treats approximately 1.3 mgd, which is 35 percent of the design value. Due to the variability observed over the last 20 years and the chance for additional changes in the future, the secondary treatment capacity is shown in terms of BOD loading. The BOD loading is driven mostly by population changes in SAM's collection system but may also be changed if significant industrial/commercial sources move into the area. The loading will go up if the population goes up, regardless of whether the flow per capita goes up or down. This method of quantifying capacity provides better information compared to evaluating capacity as a flow basis.

4.2.1 Solids Loading Rate Capacity

The solids loading rate capacity is governed by MLSS concentration, influent flow rate, settleability (i.e., SVI measurement), and RAS flow rate. The MLSS concentration was estimated using the BioWin model based on the primary effluent loadings and the aeration basin operating assumptions.

The solids loading rate capacity is determined by putting various combinations of these parameters into a state point analysis tool. The state point analysis tool evaluates various solids flux conditions and compares them to the solids flux curve, which is developed based on clarifier geometry and settleability assumptions. Information on each of these parameters is described in the following subsections.

4.2.1.1 Flow Assumptions

The SAM WWTP is rated for a peak design flow of 9 mgd and a peak hourly wet weather flow of 15 mgd. Over the historical period evaluated, the maximum peak day was 5.6 mgd. The peak day flow was used for estimating capacity, because the clarifiers appear well designed and are relatively deep, which yields some sludge storage capacity to address peak hourly flow rates. It may be unlikely that SAM observes a peak day flow of 9 mgd in the near future, but the capacity is rated based on this previously rated peak day capacity to avoid any attempt to re-rate the hydraulics at the SAM WWTP.

4.2.1.2 Settleability Assumptions

An SVI value of 200 mL/g was used (the 90th percentile over the period before the process upset was 197 mL/g), per Section 2.4.

4.2.2 Capacity Results

The BioWin modeling and subsequent airflow calculations suggested that there is sufficient aeration capacity for both the blower system and for diffuser flux, and that the solids loading rate was always the limiting factor when evaluating capacity at SAM. As such, the capacity results are shown in terms of solids loading rate. Capacities are based on recent BOD loading data from January 2018 through July 2020. The BOD loading associated with the BOD spikes (described in Section 2.5) are not included in this analysis.

Table 4-2 summarizes the capacity findings. Figure 4-2 presents the results for the capacity analysis graphically. The capacity is shown two ways:

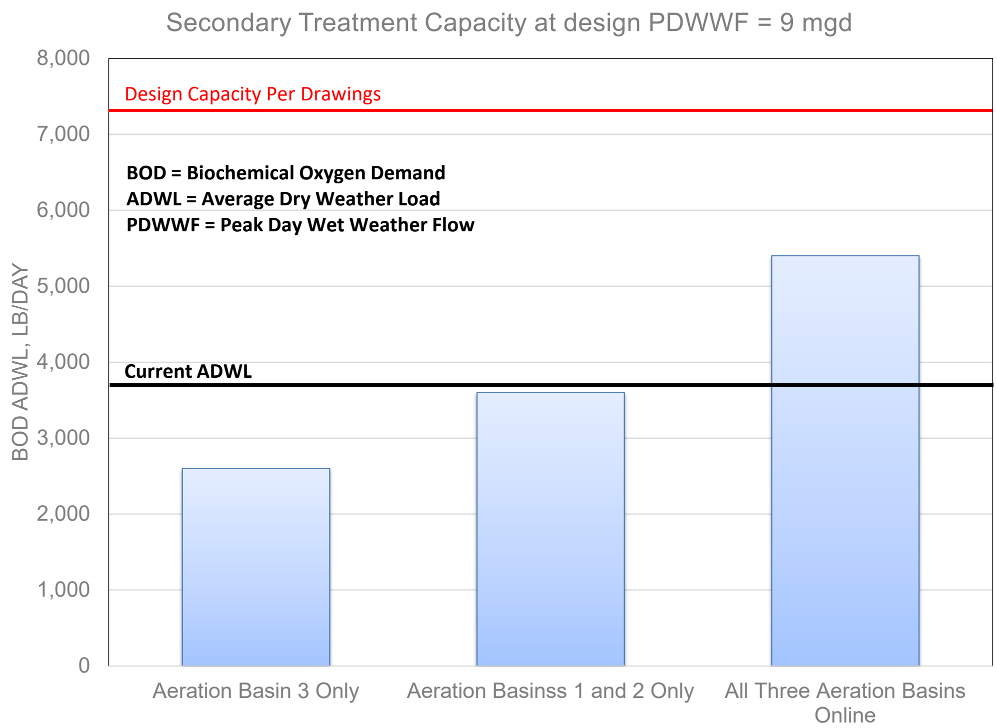
- To treat a peak day flow of 9 mgd (to match rated design capacity)
- To treat a peak day flow of 6 mgd (rounded up from recent maximum peak day flow of 5.6 mgd)

The rated capacity is based on the rated design capacity of 9 mgd; however, SAM may not observe a peak day flow of 9 mgd in the short term. To provide context as to what the capacity may be in the short term, the same capacity calculations were performed at a peak day flow of 6 mgd, which is close to the recent maximum of 5.6 mgd.

Table 4-2. Summary of Existing Capacity

Condition	Units	Aeration Basin 3 Only	Aeration Basins 1 and 2 Only	All Three Aeration Basins Online
PDWWF of 9 mgd	ADW BOD load, lb/d	2,600	3,600	5,400
PDWWF of 6 mgd	ADW BOD load, lb/d	3,400	4,600	7,300

Note: The current ADW BOD load is approximately 3,700 lb/d
ADW = average dry weather
PDWWF = peak day wet weather flow



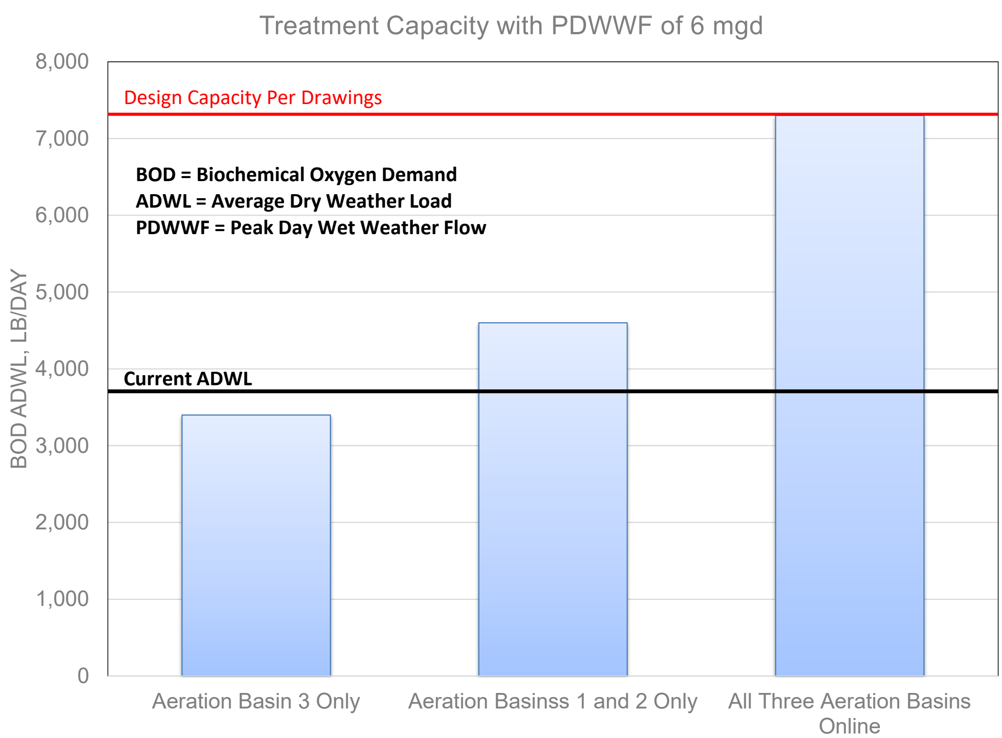


Figure 4-2. Capacity estimate based on design PDWWF of 9 mgd (top) and 6 mgd (bottom)

Section 5: Plant Optimization and Operational Improvements

BC evaluated several alternatives to upgrade the existing secondary process to provide more treatment capacity. Details of the scope of what is included in each alternative is provided in each subsection. A summary of the process capacities is provided in Section 5.6.

The process capacity was determined for each alternative using the following assumptions:

- Design PDWWF of 9 mgd
- A 90th percentile SVI of 200 mL/g
- Average BOD concentration of 340 mg/L
- Alternatives did not evaluate the ability to treat extreme BOD spikes, as it is anticipated that the pre-treatment analysis will return the BOD loading to normal conditions (i.e., January 2018 to June 2020)

5.1 Cost Estimating Assumptions

Conceptual-level opinion of probable construction costs (OPCC) prepared for this TM represent order-of-magnitude estimates as defined by the Association for the Advancement of Cost Engineering International criteria for a Class 5 estimate (–50 percent to +100 percent accuracy). The OPCCs are based on a recommended project's scopes of work and material quantity and represent costs that would be incurred if the project were bid in 2021 under current market conditions. The estimates provided include costs for demolition, mechanical equipment and piping, and structural and electrical improvements. The OPCC includes contractor overhead, profit, mobilization, bonds, insurance, and contingency markups.

All of the costs presented in this TM are construction cost estimates to be compared to a contractor's bid. To derive total project costs (i.e., capital costs), SAM staff would need to apply the appropriate factors for items such as administration, planning/environmental, design, and construction management. Typically, these costs may add an additional 30 percent to 45 percent markup on top of construction costs presented in this TM, but the amount of markup is specific to each agency.

Annual operating costs were not included as part of the alternatives evaluations because the costs would be similar between the alternatives and would not impact process selection.

Attachment A contains detailed descriptions of each cost estimate as well as detailed markups and assumptions.

5.2 Alternative 1

Alternative 1 consisted of installing new equipment in Aeration Basin 4 such that it matches the equipment in Aeration Basin 3. This included the following scope:

- Install fine-bubble diffusers in Aeration Basin 4 to match Aeration Basin 3
- Replace weir gates in Aeration Basins 1 and 2 so that Aeration Basins 1 and 2 can be used in parallel with either Aeration Basin 3 or 4 during maintenance events
- Install aeration piping with valving for two drop legs in Aeration Basin 4
- Install spray header with spray nozzles in Aeration Basin 4
- Install new dissolved oxygen instruments in Aeration Basin 4

Figure 5-1 presents a schematic of Alternative 1. Aeration Basins 3 and 4 are assumed to be used for the main form of treatment, with Aeration Basins 1 and 2 used only as needed during maintenance events. This alternative provides the highest level of redundancy, because all four tanks would be equipped. The Aeration

Basins 1 and 2 would still have coarse-bubble diffusers, providing less efficient treatment and recommended only for limited use.

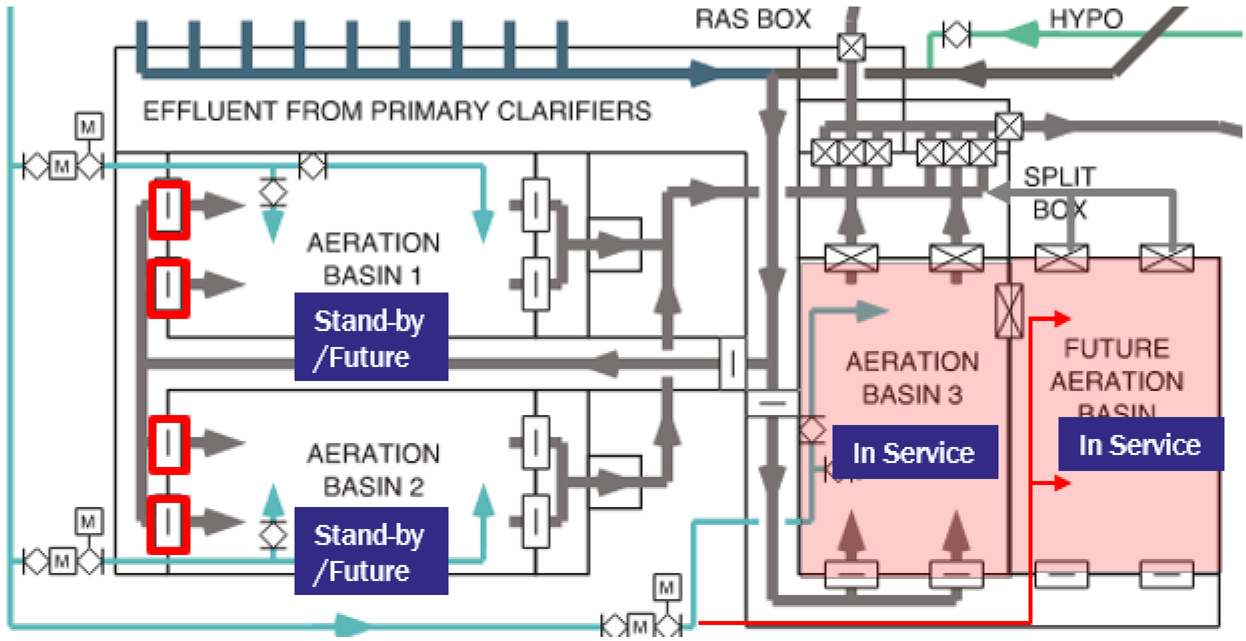


Figure 5-1. Schematic of Alternative 1

5.2.1 Hydraulic Considerations

The flow routing will be the same as the current operation. The only hydraulic modifications are to replace the gates at the inlet of Aeration Basins 1 and 2 with weir gates sized to provide the appropriate flow split between Aeration Basins 1 and 2 and Aeration Basins 3 and 4. Hydraulic modeling during pre-design should be performed to determine the weir length and weir height to be used to obtain a volume-proportional flow split (i.e., more flow should go to Aeration Basins 3 and 4 than to Aeration Basins 1 and 2 because Aeration Basins 3 and 4 have a higher volume than Aeration Basins 1 and 2).

Attachment C contains schematics depicting the hydraulic upgrades required.

5.2.2 Cost Breakdown

The OPCC for Alternative 1 was $565,000, which represents a range of $283,000 to $1,130,000. Figure 5-2 presents an approximate cost breakdown. Refer to the detailed cost estimate in Attachment A for further details.

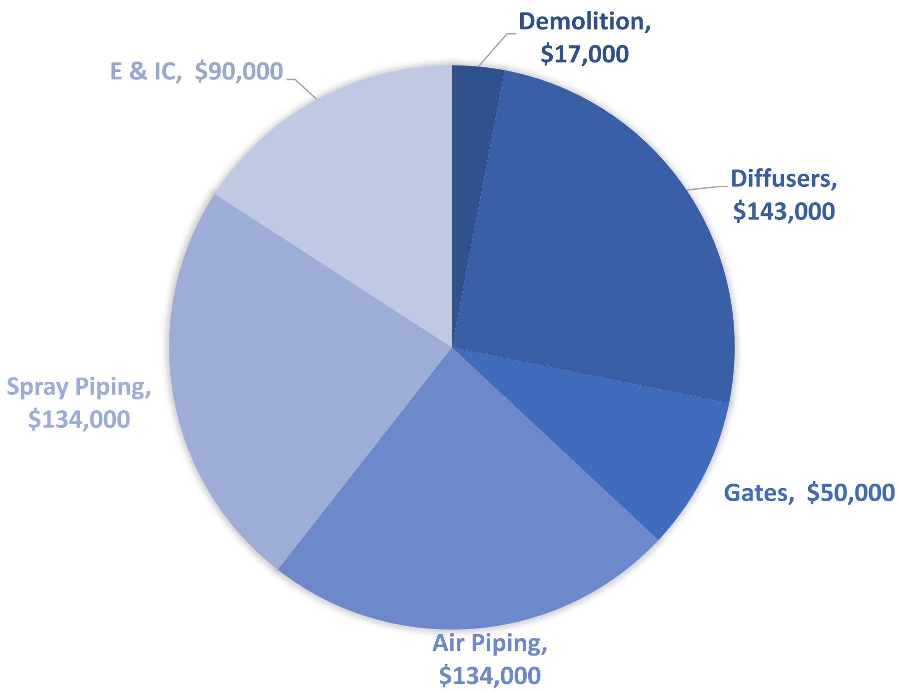


Figure 5-2. Alternative 1 cost breakdown

Note that this cost breakdown has costs rounded for clarity and the sum may not exactly match the cost estimate.

5.3 Alternative 2

Alternative 2 consisted of retrofitting Aeration Basins 1 and 2 with fine-bubble diffusers to operate continuously in parallel with Aeration Basin 3. Aeration Basin 4 is not used in this Alternative. This included the following scope:

- Remove the existing coarse-bubble diffuser system in Aeration Basins 1 and 2
- Install new fine-bubble diffusers in Aeration Basins 1 and 2 using the same diffuser density as Aeration Basin 3
- Replace weir gates to Aeration Basins 1 and 2 (similar to Alternative 1)
- Construct new baffle walls in Aeration Basins 1 and 2 to address perceived short-circuiting issues

Figure 5-3 presents a schematic of Alternative 2. This alternative assumes that Aeration Basins 1, 2, and 3 would operate in parallel to perform secondary treatment. Replacing the weir gates provides more redundancy than SAM currently has because any combination of basins could operate in parallel. However, this alternative does not have the same level of redundancy and resiliency as Alternative 1.

The baffle walls may or may not be needed. It is recommended to perform testing to determine if short-circuiting is occurring or not prior to installing any baffling for this alternative. In addition, the cost estimate assumed concrete baffle walls, which was assumed to provide a conservative cost estimate. If baffle walls are installed, the design engineer should consider other materials that may be less costly.

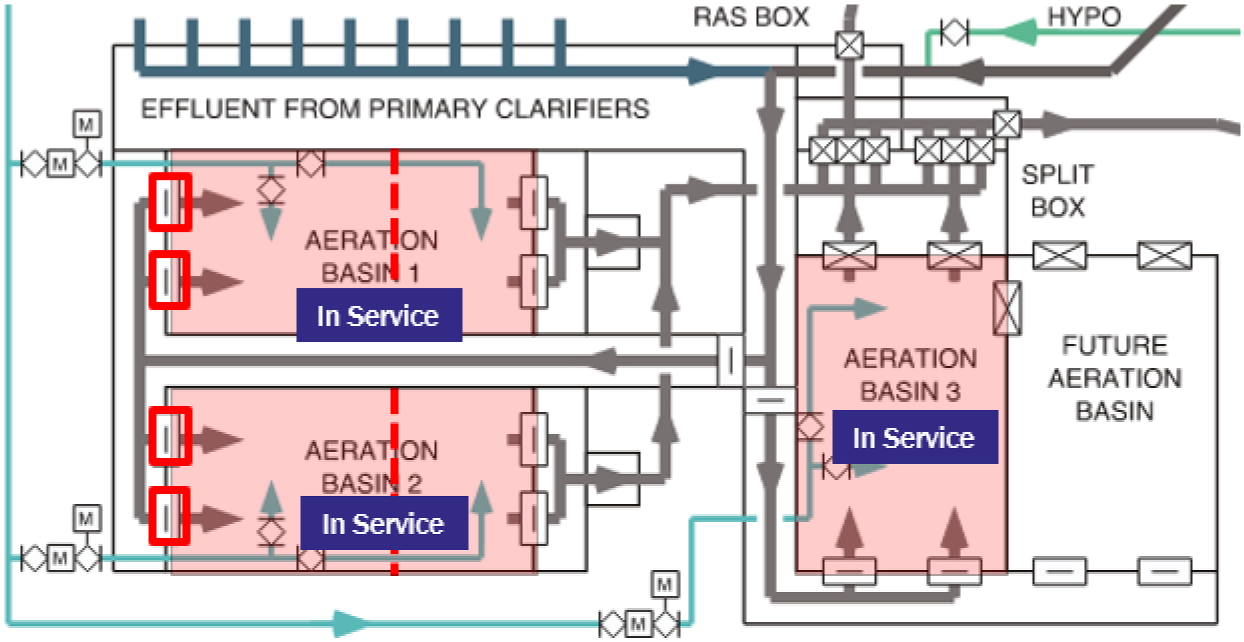


Figure 5-3. Schematic of Alternative 2

5.3.1 Hydraulic Considerations

The flow routing will be the same as the current operation. The only hydraulic modifications are to replace the gates at the inlet of Aeration Basins 1 and 2 with weir gates. Hydraulic modeling during pre-design should be performed to determine the weir length and weir height to be used to obtain a volume-proportional flow split. These considerations are the same as Alternative 1.

Attachment C contains schematics depicting the hydraulic upgrades required.

5.3.2 Cost Breakdown

The OPCC for Alternative 2 was $658,000, which represents a range of $329,000 to $1,316,000. Figure 5-4 presents an approximate cost breakdown. Refer to the detailed cost estimate in Attachment A for further details.

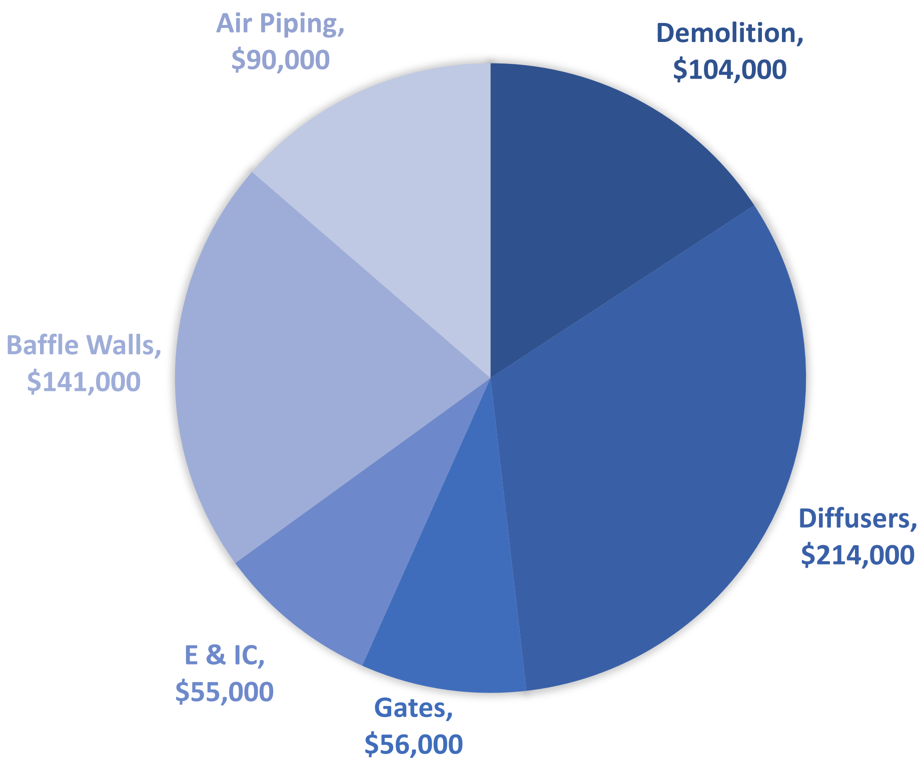


Figure 5-4. Alternative 1 Cost Breakdown

Note that this cost breakdown has costs rounded for clarity and the sum may not exactly match the cost estimate.

5.4 Alternative 3

Alternatives 1 and 2 presented options to upgrade the infrastructure at the SAM WWTP while following the same treatment philosophy currently employed. Alternative 3 represents a significant change from the secondary treatment philosophy and implements an anaerobic selector within the aeration basins. The purpose of the anaerobic selector is to reduce the readily biodegradable BOD before it reaches the aerobic zones, which would significantly improve settleability (i.e., decrease the design SVI). This has a great benefit to capacity because the existing capacity limitations at the WWTP are related to poor settleability (i.e., high SVI), which limits the solids loading rate that clarifiers can treat. This alternative provides the most treatment capacity per available basin volume.

One drawback of implementing an anerobic selector at SAM would be the high probability of struvite precipitation in the anaerobic digesters and associated downstream equipment. Struvite would have a high probability of precipitating because the sludge being sent to the digester would have significantly higher concentrations of phosphorus, which is a key element in struvite. The new treatment process would have an anaerobic zone that would encourage biological phosphorus removal, which would encourage biomass to grow that may have four to six times more phosphorus than the biomass currently present in the WWTP's aeration basins.

Alternative 3 requires significant modifications to implement. It would require Aeration Basin 2 to flow in series with Aeration Basin 3, whereas they currently operate in parallel. Aeration Basin 2 would require approximately 60 percent of the volume to be unaerated and instead mixed with mechanical mixers. The remaining 40 percent of the volume would be replaced with fine-bubble diffusers at high density. Aeration Basin 4 would be configured to match Aeration Basin 3.

This alternative includes the following scope:

- Perform the scope of work for Alternative 1 as described above
- Remove the existing coarse-bubble diffusers in Aeration Basins 1 and 2
- Install new fine-bubble diffusers in the last 40 percent of volume in Aeration Basin 2
- Replace weir gates in Aeration Basins 1 and 2
- Construct a new baffle walls in Aeration Basin 2
- Install two submersible mixers in Aeration Basin 2
- Install coarse-bubble diffusers in the Aeration Basin 1 channel
- Infill openings in the concrete divider wall in the Aeration Basin 1 channel
- Install stainless steel stop plates in the basin channels

Figure 5-5 presents a schematic of Alternative 3. This alternative assumes that Aeration Basin 2 flows in series into Aeration Basin 3. This alternative does not have a high level of redundancy for the anaerobic selector. If Aeration Basin 2 had to come offline, SAM could operate with Aeration Basins 3 and 4 in parallel in a fully aerobic mode of operation. This alternative has the highest capacity per online basin volume, and if all basins are retrofitted would have the highest capacity rating. In addition, due to achieving significantly better settleability (i.e., lower SVI), the facility would have better process resiliency from upset periods.

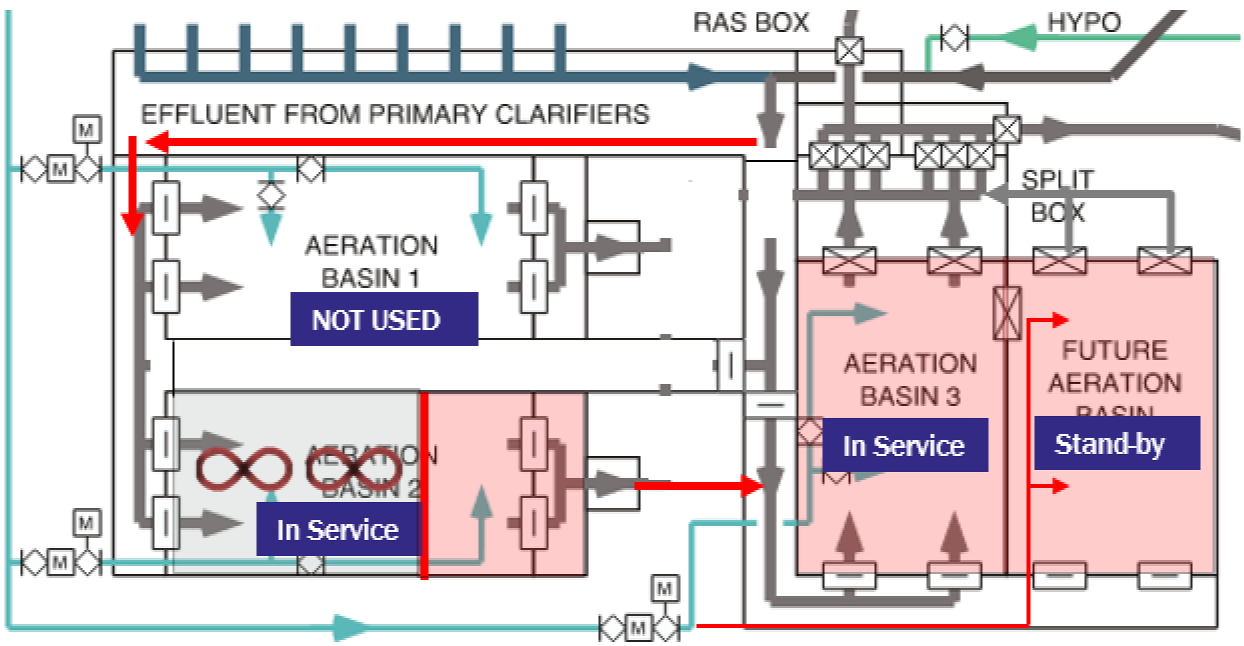


Figure 5-5. Schematic of Alternative 3

5.4.1 Hydraulic Considerations

Alternative 3 requires the most hydraulic upgrades. It requires reversing flow in the primary effluent channel such that primary effluent and RAS flow into the front of Aeration Basin 2, with flow from Aeration Basin 2 flowing into the Aeration Basin 3 influent channel and through Aeration Basin 3 and/or Aeration Basin 4. Flow from Aeration Basins 3 and 4 would still go to the secondary clarifiers.

Attachment C contains schematics depicting the hydraulic upgrades required.

5.4.2 Cost Breakdown

The OPCC for Alternative 3 was $1,051,000, which represents a range of $526,000 to $2,106,000. Figure 5-6 presents an approximate cost breakdown. Refer to the detailed cost estimate in Attachment A for further details.

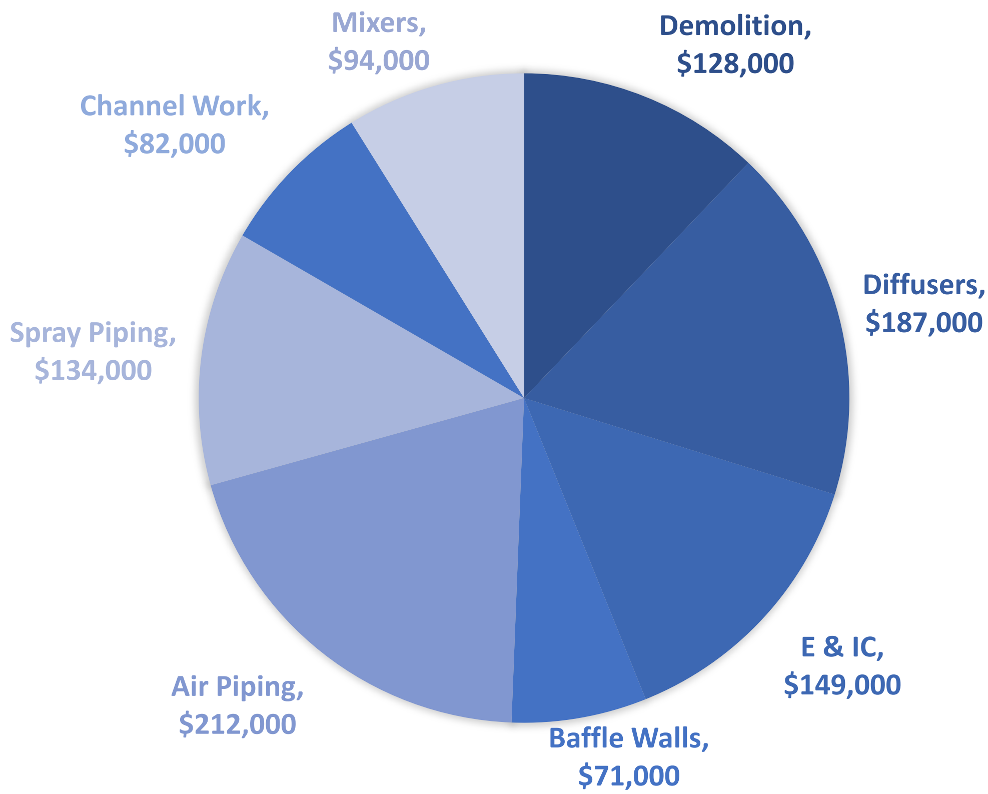


Figure 5-6. Alternative 1 Cost Breakdown

Note that this cost breakdown has costs rounded for clarity and the sum may not exactly match the cost estimate.

5.5 Equalization Opportunity

Operations staff asked BC to evaluate what it would take to repurpose Aeration Basin 1 as an equalization basin. Although physical modifications were identified and costed out to do this, this mode of operation is not recommended at this time. Using Aeration Basin 1 for equalization does not increase capacity. The driver for using Aeration Basin 1 as an equalization basin would be operational flexibility. Since this work focused on identifying ways to increase capacity, and given re-purposing Aeration Basin 1 as an equalization basin does not increase capacity, repurposing Aeration Basin 1 is not recommended at this time.

The scope of this work includes:

- Installing an 8-inch influent pipe with a magnetic flow meter in Aeration Basin 1
- Installing a submersible pump with a variable-frequency drive in Aeration Basin 1

The OPCC for these upgrades was $244,000, with a range of $122,000 to $488,000.

5.6 Capacity Comparison of Alternatives

The capacity of each alternative was evaluated based on the assumptions listed at the beginning of Section 5. Figure 5-7 presents capacities identified for each alternative. All three alternatives provided capacity at a BOD loading that is at least 20 percent greater than the current average dry weather BOD loading of 3,700 lb/d.

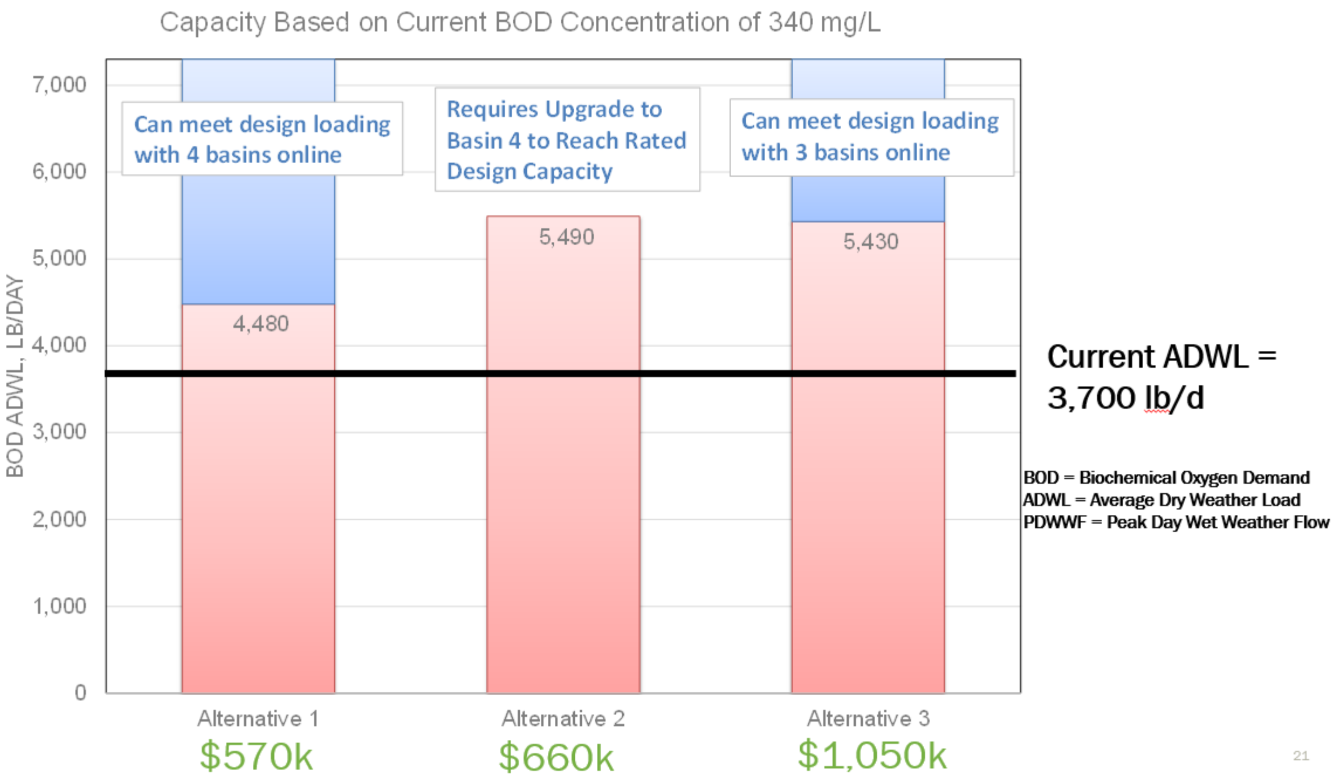


Figure 5-7. Capacity of each alternative with planned mode of operation (red) and with all equipped basins operating (blue)

The OPCC estimates are shown as green text under each alternative.

5.7 Alternative Analysis Summary

Table 5-1 compares each alternative based on several criteria, including operational flexibility, cost, risk of violations, cost certainty, and redundancy. For comparison purposes, each alternative is compared to the current plant configuration.

Table 5-1. Alternatives Analysis Summary

Condition	Current Configuration	Alternative 1	Alternative 2	Alternative 3
Treatment Capacity to meet current loading	No	Yes	Yes	Yes
Redundancy	No	Yes	No	No
Cost	N/A	Low	Medium	High
Risk of construction cost increase	N/A	Low	High	High

Table 5-1. Alternatives Analysis Summary				
Condition	Current Configuration	Alternative 1	Alternative 2	Alternative 3
Probability risk of violation	High	Low	Medium	Low
Construction Risk	N/A	Low	High	High
Operational complexity and risk	Low	Low	Low	High
Maintenance risk	High	Low	High	High

Note: The current configuration is assumed to be either Aeration Basin 3 in service or Aeration Basins 1 and 2 in service

There are also some process improvements which are recommended which are common to all alternatives. These include flow pacing ferric and polymer at the WWTP. This is important because over dosing ferric may result in a phosphorus deficiency and underdosing may result in higher BOD loading to the activated sludge system. A planning level cost for making the physical upgrades to flow pace chemicals is $70,000.

All costs presented in this section can be refined during pre-design. Selection of materials and type of bidding process impact costs and assumptions were made to develop planning level costs for the purposes of making decisions. It is likely that costs can be optimized during pre-design.

Recommendations

Alternative 1 provides the most redundancy and does so at the lowest estimated cost. It provides a simple construction and implementation schedule because the construction is in an empty basin, and the construction period would have minimal impacts on the existing treatment process. It would provide four available aeration basins to SAM staff, thus providing more flexibility in treatment.

It is recommended to implement Alternative 1. If loading significantly increases due to population growth or new industrial contributions, then Aeration Basins 1 and 2 can be retrofitted with fine-bubble diffusers to provide additional, high-efficiency treatment. Until Aeration Basins 1 and 2 are needed for normal treatment, they can be used as emergency/standby aeration basins to be used during maintenance events when Aeration Basins 3 or 4 are not available.

It is recommended to adjust chemicals onsite to be flow paced, specifically the ferric chloride and polymer, which are used for CEPT. The data review suggests that the polymer did not help increase settling in the primary clarifiers, but optimizing the dose and flow-pacing the chemical may result in better treatment. Costs for flow pacing chemicals are estimated to be $70,000.

Section 6: References

H. Melcer, P.L. Dold, R.M. Jones, C.M. Bye, T. I., H.D. Stensel, A.W. Wilson, P. Sun, S. Bury. Methods for Wastewater Characterization in Activated Sludge Modelling Water Environment Research Foundation, IWA Publishing and Water Environment Federation, Alexandria, VA, USA and London, UK (2003)

Attachment A: Cost Estimate

Memorandum

Date:	July 21, 2021
To:	Mike Harrison, Sacramento
From:	Steve Payne, Atlanta
Reviewed by:	Bill Agster, Atlanta
Project No.:	156642.300.302
Subject:	WWTP Capacity Study Planning Level Basis of Estimate of Probable Construction Cost

The Basis of Estimate Report and supporting estimate reports for the subject project are attached. Please call me if you have questions or need additional information.

Enclosures (3):

1. Basis of Estimate Report
2. Summary Estimate
3. Detailed Estimate

Basis of Estimate Report

Project Title

Introduction

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the Sewer Authority Mid-Coastside's WWTP Capacity Study, Half Moon Bay, California.

Estimated Project Costs

Based on the typical accuracy of a Class 5 estimate, the expected ranges of costs are:

	Upper Range	Estimated Cost	Lower Range
	+ 100 %		- 50 %
Alt 1	$1,130,000	$565,000	$283,000
Alt 2	$1,316,000	$658,000	$329,000
Alt 3	$2,106,000	$1,051,000	$526,000
Alt 4	$488,000	$244,000	$122,000

Summary

This Basis of Estimate contains the following information:

- Scope of work
- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Allowances for known but undefined work
- Contractor and other estimate markups

Scope of Work

The project consists of four alternatives, the scopes of which are described below:

Alternative 1

- Install fine bubble diffusers in Basin 4
- Replace weir gates in Basins 1 and 2
- Install aeration piping with valving for two drop legs in Basin 4

- Install spray header with spray nozzles in Basin 4
- Install two DO probes in Basin 4

Alternative 2

- Remove the existing coarse bubble diffusers in Basin 1 and 2
- Install new fine bubble diffusers in Basins 1 and 2
- Replace weir gates in Basins 1 and 2
- Construct new baffle walls in Basins 1 and 2

Alternative 3

- Perform the scope of work for Alternate 1 as described above
- Remove the existing coarse bubble diffusers in Basin 1 and 2
- Install new fine bubble diffusers in Basin 2
- Replace weir gates in Basins 1 and 2
- Construct a new baffle walls in Basin 2
- Install two submersible mixers in Basin 2
- Install coarse bubble diffusers in the Basin 1 Channel
- Infill openings in the concrete divider wall in the Basin 1 Channel
- Install stainless steel stop plates in the basin channels

Alternative 4

- Install an 8" influent pipe with magnetic flow meter in Basin 1
- Install a submersible pump with VFD in Basin 1. The 8" pump discharge pipe will include a magnetic flow meter.

Background of this Estimate

No previous estimates have been prepared for this project by BC's Estimating and Scheduling Group (ESG).

The attached estimate of probable construction cost is based on documents dated June 2021, received by the Estimating and Scheduling Group (ESG). These documents are described as planning level based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

Class 5: 0 to 2 Percent Conceptual Design Completion

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 5 estimate. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete. Class 5 estimates are used to prepare planning level cost scopes or evaluation of alternative schemes, long range capital outlay planning and can also form the base work for the Class 4 Planning Level or Design Technical Feasibility Estimate.

Expected accuracy for Class 5 estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of Sage Construction and Real Estate 300 estimating software engine (formerly Timberline) using RS Means database, historical project data, the latest vendor and material cost information, and other costs specific to the project location.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel) and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and worker's compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Local sales tax has been applied to material and equipment rentals. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data.

The contractor's cost for builder's risk, general liability and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost and are added after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Contractor's credentials, applicable to the type of project.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.
4. Bidders will account for General Provisions and Special Provisions of the contract documents and will perform all work except electrical which will be performed by a specialty subcontractor.

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. The fine bubble diffuser system in Basin 4 is based on 1,564 diffuser heads.
2. The fine bubble diffuser systems for Basins 1 and 2 are based on 660 diffuser heads per basin.
3. The coarse bubble diffuser system in the Basin 1 Channel is based on 28 diffuser heads.
4. All piping is based on 316 stainless steel, schedule 10.
5. Contractor will be pressure wash the basins prior to beginning demolition and/or installation activities.
6. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
7. Contractor has complete access for lay-down areas and mobile equipment.
8. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
9. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
10. Major equipment costs are based on vendor supplied price quotes obtained by the project design team and/or estimators and on historical pricing of like equipment.
11. Process equipment vendor training using vendors' standard Operations and Maintenance (O&M) material is included in the purchase price of major equipment items where so stated in that quotation.
12. Bulk material quantities are based on manual quantity take-offs.
13. There is enough electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project except for the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.
5. Impacts from COVID-19 including additional labor and management hours required to meet social distancing, personal protection, and cleaning routines, additional costs of protective equipment, supply chain impacts, and material shortages.

Allowances for Known but Undefined Work

The following allowances were made in the development of this estimate.

1. $24,000 each for the submersible mixers.
2. $50,000 for the submersible pump and VFD.
3. $45 per coarse bubble diffuser head.

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups

Item	Rate (%)
Net Cost Markups	
Labor (employer payroll burden)	15
Materials and process equipment	10
Equipment (construction-related)	10
Subcontractor	10
Other – Process Equipment	8
Sales Tax (State and local for materials, process equipment and construction equipment rentals, etc.)	8.75
Sales Tax (Excise-Gross Receipts-Contract Value)	0
Material Shipping and Handling	2
Gross Cost Markups	
Contractor General Conditions	15
Start-up, Training and O&M	2
Construction Contingency	30
Builders Risk, Liability and Auto Insurance	2
Performance and Payment Bonds	1.5

Labor Markup

The labor rates used in the estimate were derived from RS Means latest national average wage rate tables and city cost indexes. These include base rate paid to the laborer plus fringes. A labor burden factor is applied to these such that the final rates include all employer paid taxes. These taxes are FICA (which covers social security plus Medicare), Workers Comp (which varies based on state, employer experience and history) and unemployment insurance. The result is fully loaded labor rates. In addition to the fully loaded labor rate, an overhead and profit markup is applied at the back end of the estimate. This covers payroll and accounting, estimator's wages, home office rent, advertising and owner profit.

Materials and Process Equipment Markup

This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup

This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all the equipment needed for the job, but to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is like the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup

This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Sales Tax (Materials, Process Equipment and Construction Equipment)

This is the tax that the contractor must pay according to state and local tax laws. The percentage is applied to both the material and equipment the GC purchases as well as the cost for rental equipment. The percentage is based on the local rates in place at the time the estimate was prepared.

Contractor Startup, Training, and O&M Manuals

This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup and O&M manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and troubleshoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings and coordination with the plant personnel in other areas of the plant operation.

Builders Risk, Liability, and Vehicle Insurance

This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and the contractor's insurability at the time the project is bid.

Material Shipping and Handling

This can range from 2 to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paperwork, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the amount of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies, e.g., oil, gaskets and bolts that may be missing from the equipment or materials shipped.

Escalation to Midpoint for Labor, Materials and Subcontractors

In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material and equipment costs beyond values at the time the estimate is prepared. For this project, the anticipated rate of escalation is four percent per annum.

The estimated construction time for this project has not been determined. Four percent escalation has been included in the estimate

Undesigned/Undeveloped Contingency

The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that cannot be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage and area factors, construction contingency can range from 10 to 50 percent.

Performance and Payment Bonds

Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

Estimate Summary Report

7/20/2021 8:12 PM

BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 1

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATIVE 1
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

Brown AND Caldwell

Estimate Summary Report

7/20/2021 8:12 PM

BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 1

Phase	Description	Gross Total Cost with Markups
01 TOTALS		
01 Alternative 1		
01 Demolition		16,340
04 Process Mechanical		461,135
05 Electrical and Instrumentation		87,884
01 Alternative 1		565,360
01 TOTALS		565,360

WWTP CAPACITY STUDY - ALTERNATIVE 1

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATIVE 1
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01 TOTALS										
01 Alternative 1										
01 Demolition										
02999 Demo Weir Gates										
02-22-04. 50	Site demolition, 48" weir gate	BC-0056	4.00 ea	1,016.51	-	-	-	-	1,016.51	4,066
	Demo Weir Gates		**0.00**							**4,066**
02999 Pressure Wash Basin 4										
04-01-30. 20	Cleaning masonry, high pressure wash, average soil, biological staining, water only, excludes scaffolding	0420	2,700.00 sf	1.54	0.26	-	-	-	1.80	4,873
	Pressure Wash Basin 4		**0.00**							**4,873**
	01 Demolition									**8,939**
04 Process Mechanical										
22112 4" Spray Piping A53 Threaded Field Run w/ 60 Nozzles										
22-11-13. 44	Pipe, steel, black, threaded, 4" diameter, schedule 40, Spec. A-53, includes coupling and clevis hanger assembly sized for covering, 10' OC	0650	248.00 lf	41.63	-	28.00	-	-	69.63	17,267
22-11-13. 45	Elbow, 90 Deg., steel, cast iron, black, straight, threaded, standard weight, 4"	0180	4.00 ea	249.76	-	221.00	-	-	470.76	1,883
22-11-13. 45	Tee, steel, cast iron, black, straight, threaded, standard weight, 4"	0620	61.00 ea	374.64	-	335.00	-	-	709.64	43,288
22-11-19. 34	Sleeve, pipe, steel with water stop, 12" long, 6" diam. for 4" carrier pipe, includes link seal	0200	1.00 ea	169.42	-	142.00	-	-	311.42	311
22-20-02. 95	High impact, flat spray nozzle,2 gpm@40 psi,35 deg spray angle,ball jt	BC-0001	60.00 ea	103.02		28.39	-	-	131.41	7,885
40-05-05. 00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000 000	248.00 lf	2.72	-	-	-	-	2.72	675
09-91-06. 41	Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	260.00 sqft	0.96	-	0.89	-	-	1.84	480
	4" Spray Piping A53 Threaded Field Run w/ 60 Nozzles		**248.00 lf**	**167.13**		**122.34**			**289.47**	**71,789**
40360 16" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23. 20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 16 Inch (400mm)	A201005160 0S	33.00 lf	-	-	85.23	-	-	85.23	2,813

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 16" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 10S 16 Inch (400mm)	A202112160000	4.00 ea	-	-	356.78	-	-	356.78	1,427
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Tee-Sch 10S 16 Inch (400mm)	A202114160000	1.00 ea	-	-	1,322.76	-	-	1,322.76	1,323
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S 16 Inch (400mm)	A202421176200	13.00 ea	-	-	471.75	-	-	471.75	6,133
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange Blind-Cls 150 16 Inch (400mm)	A202424006200	1.00 ea	-	-	588.85	-	-	588.85	589
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 16 Inch (400mm)	L203102160000	24.00 ea	-	-	24.39	-	-	24.39	585
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 16 Inch (400mm)	L2040021600P2	33.00 lf	42.63	-	-	-	-	42.63	1,407
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 16 Inch (400mm)	L205102160000	2.00 ea	309.52	60.42	1.16	-	-	371.10	742
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 16 Inch (400mm)	A203400006200	8.00 ea	97.16	-	248.14	-	-	345.30	2,762
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 16 Inch (400mm)	A206043000000	1.00 ea	48.58	-	49.56	-	-	98.14	98
40-05-05.00	Field Testing-Hydrotest-Non-Specific 16 Inch (400mm)	L209048000000	33.00 lf	23.32	-	-	-	-	23.32	769
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	12.00 mh	82.48	44.17	-	-	-	126.65	1,520
	16" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**33.00 lf**	**139.72**	**19.72**	**451.71**	-		**611.15**	**20,168**
40360 14" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 14 Inch (350mm)	A1910051600S	20.00 lf	-	-	66.19	-	-	66.19	1,324
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell45-Sch 10S 14 Inch (350mm)	A192111160000	2.00 ea	-	-	184.67	-	-	184.67	369
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Reducer 1 Dia-Sch 10S 14 Inch (350mm)	A192116160000	1.00 ea	-	-	288.55	-	-	288.55	289
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Tee-Sch 10S 14 Inch (350mm)	A192114160000	1.00 ea	-	-	892.10	-	-	892.10	892
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S 14 Inch (350mm)	A192421176200	14.00 ea	-	-	330.06	-	-	330.06	4,621
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 14 Inch (350mm)	L193102160000	22.00 ea	-	-	21.71	-	-	21.71	478

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 14" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 14 Inch (350mm)	A196434206200	1.00 ea	-	-	1,502.24	-	-	1,502.24	1,502
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 14 Inch (350mm)	L194062006200	1.00 ea	320.04	-	-	-	-	320.04	320
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 14 Inch (350mm)	L1940021600P2	20.00 lf	37.16	-	-	-	-	37.16	743
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 14 Inch (350mm)	L195102160000	1.00 ea	275.51	53.78	1.02	-	-	330.31	330
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 14 Inch (350mm)	A193400006200	9.00 ea	97.16	-	186.95	-	-	284.11	2,557
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 14 Inch (350mm)	A196043000000	1.00 ea	29.15	-	38.55	-	-	67.70	68
40-05-05.00	Field Testing-Hydrotest-Non-Specific 14 Inch (350mm)	L199048000000	20.00 lf	18.07	-	-	-	-	18.07	361
40-05-57.23	Valves-Accessories-Motor Operator-14 Inch (350mm)	A196046000000	1.00 ea	-	-	13,562.83	-	-	13,562.83	13,563
27-20-52.00	FE - Flow Meter - Install, Calibrate, Test, Loop Check	BC-0010	1.00 ea	635.01	-	250.00	-	-	885.01	885
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	10.00 mh	82.48	44.17	-	-	-	126.65	1,267
	14" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**20.00 lf**	**203.18**	**24.78**	**1,250.46**	-		**1,478.42**	**29,568**
40360 8" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 8 Inch (200mm)	A1610051600S	80.00 lf	-	-	26.65	-	-	26.65	2,132
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 10S 8 Inch (200mm)	A162112160000	3.00 ea	-	-	55.70	-	-	55.70	167
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 8 Inch (200mm)	A162421176200	5.00 ea	-	-	99.12	-	-	99.12	496
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L163102160000	11.00 ea	-	-	12.20	-	-	12.20	134
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 8 Inch (200mm)	A166434206200	2.00 ea	-	-	595.95	-	-	595.95	1,192
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 8 Inch (200mm)	L164062006200	2.00 ea	180.72	-	-	-	-	180.72	361
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L1640021600P2	80.00 lf	17.49	-	-	-	-	17.49	1,399

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 8" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L165102160000	4.00 ea	154.76	30.21	0.47	-	-	185.44	742
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	5.00 ea	48.58	-	57.60	-	-	106.18	531
40-05-07.00	Pipe Support 8 Inch (200mm)	A166044000000	4.00 ea	97.16	-	27.54	-	-	124.69	499
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	8.00 ea	29.15	-	27.54	-	-	56.68	453
40-05-05.00	Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	80.00 lf	7.48	-	-	-	-	7.48	598
22-20-03.00	Pipe coupling, sleeve-type, Dresser style, 8"	BC-0216	2.00 ea	325.29	-	1,500.00	-	-	1,825.29	3,651
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	16.00 mh	82.48	44.17	-	-	-	126.65	2,026
	8" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**80.00 lf**	**72.66**	**10.34**	**96.76**			**179.77**	**14,381**
40360 8" AA Manifold Piping SS316 Butt Welded - Install Only										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L1640021600P2	60.00 lf	17.49	-	-	-	-	17.49	1,049
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L165102160000	3.00 ea	154.76	30.21	0.47	-	-	185.44	556
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	8.00 ea	48.58	-	57.60	-	-	106.18	849
40-05-07.00	Pipe Support 8 Inch (200mm)	A166044000000	4.00 ea	97.16	-	27.54	-	-	124.69	499
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	8.00 ea	29.15	-	27.54	-	-	56.68	453
40-05-05.00	Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	60.00 lf	7.48	-	-	-	-	7.48	449
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	8.00 mh	82.48	44.17	-	-	-	126.65	1,013
	8" AA Manifold Piping SS316 Butt Welded - Install Only		**60.00 lf**	**60.55**	**7.40**	**13.21**			**81.16**	**4,869**
40360 4" Purge Piping SS316 Butt Welded - Install Only										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	46.00 lf	15.30	-	-	-	-	15.30	704

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 4" Purge Piping SS316 Butt Welded - Install Only										
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	106.18	20.73	0.19	-	-	127.10	508
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00 ea	97.16	-	16.52	-	-	113.68	909
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00 ea	19.43	-	22.03	-	-	41.46	663
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	46.00 lf	2.72	-	-	-	-	2.72	125
	4" Purge Piping SS316 Butt Welded - Install Only		**46.00 lf**	**50.91**	**1.80**	**10.55**			**63.27**	**2,910**
46999 Fine Bubble Diffusers - 924 ea.										
46-06-00.00	Diffusers, fine bubble, includes 4" PVC laterals	BC-0046	924.00 ea	17.45	-	65.20	-	-	82.65	76,372
	Fine Bubble Diffusers - 924 ea.		**924.00 ea**	**17.45**		**65.20**			**82.65**	**76,372**
46999 Install Weir Gates - 4 ea.										
46-06-08.00	Hydraulic structures, weir gate, 24"x36" aluminum frame and slide, stainless fasteners, self contained, geared handwheel lift	BC-0146	4.00 ea	1,622.63	589.05	4,500.00	-	-	6,711.68	26,847
	Install Weir Gates - 4 ea.		**0.00**							**26,847**
	04 Process Mechanical									**246,905**

05 Electrical and Instrumentation

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
26999 Connect Valve Motor Operator										
26-99-99.99	Connect valve motor operator	MISC	1.00 ea	2,405.33	-	4,500.00		-	6,905.33	6,905
	Connect Valve Motor Operator		**0.00**							**6,905**
26999 New Wiring in Tank 4										
26-99-99.99	Misc. Electrical Work - new wiring to Tank 4	MISC	1.00 LS	-	-	-	25,000.00	-	25,000.00	25,000
	New Wiring in Tank 4		**0.00**							**25,000**
27999 DO Probes										

WWTP CAPACITY STUDY - ALTERNATIVE 1

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
27999 DO Probes										
27-20-57.00	DO - Dissolved Oxygen - Install, Calibrate, Test, Loop Check	BC-0006	2.00 ea	769.71	-	3,800.00	-	-	4,569.71	9,139
26-99-99.99	Conduit and wire for DO probes	MISC	2.00 ea	5.35	-	3,500.00		-	3,505.35	7,011
	DO Probes		**0.00**							**16,150**
	05 Electrical and Instrumentation									**48,055**
	01 Alternative 1									**303,899**
	01 TOTALS									**303,899**

WWTP CAPACITY STUDY - ALTERNATIVE 1

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		1,022 hrs	96,708	
Material			176,618	
Subcontract			25,000	
Equipment		177 hrs	5,572	
Other				
			303,898	**303,898**
Labor Mark-up	15.00 %		14,506	
Material Mark-up	10.00 %		17,662	
Subcontractor Mark-up	10.00 %		2,500	
Construction Equipment Mark-up	10.00 %		557	
Other - Process Equip Mark-up	8.00 %			
			35,225	**339,123**
Material Shipping & Handling	2.00 %		3,532	
Material Sales Tax	8.75 %		15,454	
Other - Process Eqp Sales Tax	8.75 %			
Net Markups			**18,986**	**358,109**
Contractor General Conditions	15.00 %		53,717	
			53,717	**411,826**
Start-Up, Training, O&M	2.00 %		8,237	
			8,237	**420,063**
Undesign/Undevelop Contingency	30.00 %		126,019	
			126,019	**546,082**
Bldg Risk, Liability Auto Ins	2.00 %		10,922	
			10,922	**557,004**
Payment and Performance Bonds	1.50 %		8,355	
			8,355	**565,359**
Escalation to Midpoint (ALL)				
Gross Markups				**565,359**
Total				**565,359**

Estimate Summary Report

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BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATE 2

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATE 2
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

Brown AND Caldwell

Estimate Summary Report

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BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATE 2

Phase	Description	Gross Total Cost with Markups
01 ALTERNATE 2		
02 Basins 1 & 2		
01 Demolition		102,237
03 Structural		139,952
04 Process Mechanical		360,517
05 Electrical and Instrumentation		55,512
02 Basins 1 & 2		658,218
01 ALTERNATE 2		658,218

Estimate Detail Report

BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATE 2

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATE 2
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

Phase	Description	Item	Takeoff Quantity		Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01 ALTERNATE 2											
02 Basins 1 & 2											
01 Demolition											
02301 Pipe Demolition - 4" Drop Legs and Headers											
22-05-05.10	Pipe, metal pipe, 4" to 6" diam., selective demolition	2100	156.00	lf	21.22	-	-	-	-	21.22	3,311
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	25.00	mh	109.78	58.79	-	-	-	168.58	4,214
02-41-19.19	Selective demolition, rubbish handling, dumpster, 20 c.y., 5 ton capacity, weekly rental, includes one dump per week, cost be added to demolition cost	0725	1.00	week	-	-	562.74	-	-	562.74	563
	Pipe Demolition - 4" Drop Legs and Headers		**156.00**	**ft**	**38.82**	**9.42**	**3.61**			**51.85**	**8,088**
02301 _Pipe Demolition for New Motorized BFV											
22-05-05.10	Pipe, metal pipe, 8" to 14" diam., selective demolition	2150	4.00	lf	35.38	-	-	-	-	35.38	142
	_Pipe Demolition for New Motorized BFV		**4.00**	**ft**	**35.38**					**35.38**	**142**
02999 Demo Weir Gates											
02-22-04.50	Site demolition, 48" weir gate	BC-0056	4.00	ea	1,352.98	-	-	-	-	1,352.98	5,412
	Demo Weir Gates		**0.00**								**5,412**
02999 Pressure Wash Basins 1 & 2											
04-01-30.20	High pressure wash, average soil, biological staining, water only, excludes scaffolding	0420	4,520.00	sf	1.54	0.26	-	-	-	1.80	8,157
	Pressure Wash Basins 1 & 2		**0.00**								**8,157**
02999 Demo Diffusers											
02-22-04.52	Equipment dismantling/demolition, aeration diffusers, complete, Includes laterals	BC-0231	1,300.00	ea	14.63	-	-	-	-	14.63	19,015
02-41-19.19	Selective demolition, rubbish handling, dumpster, 20 c.y., 5 ton capacity, weekly rental, includes one dump per week, cost be added to demolition cost	0725	3.00	week	-	-	562.74	-	-	562.74	1,688
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	80.00	mh	109.78	58.79	-	-	-	168.58	13,486

Estimate Detail Report

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BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATE 2

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
	Demo Diffusers		**0.00**							**34,189**
	01 Demolition									**55,988**
03 Structural										
03345 _Concrete Baffle Walls										
03-11-13.85	C.I.P. concrete forms, wall, job built, plywood, over 16' high, 1 use, includes erecting, bracing, stripping and cleaning	2700	1,479.00 sfca	26.60	-	4.22	-	-	30.82	45,577
03-11-13.85	C.I.P. concrete forms, wall, box out for opening, to 16" thick, over 10 S.F. (use perimeter), includes erecting, bracing, stripping and cleaning	0150	64.00 lf	22.32	-	3.73	-	-	26.05	1,667
03-15-05.95	Form oil, up to 800 S.F. per gallon, coverage, includes material only	3050	3.94 gal	-	-	21.91	-	-	21.91	86
03-21-10.60	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	0700	2.95 ton	1,453.35	-	1,041.25	-	-	2,494.60	7,354
03-21-10.60	Reinforcing in place, unloading & sorting, add - walls, cols, beams	2010	2.95 ton	73.05	8.01	-	-	-	81.06	239
03-21-10.60	Reinforcing, crane cost for handling, add to above, walls, cols, beams	2225	2.95 ton	79.40	8.70	-	-	-	88.10	260
03-31-05.35	Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sand,portland cement and water,excludes all additives and treatments	0350	41.27 cy	-	-	118.24	-	-	118.24	4,880
03-31-05.70	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	5350	41.27 cy	53.78	5.41	-	-	-	59.19	2,443
03-35-29.60	Finishing: break ties & patch voids (walls, cols or beams)	0010	1,415.00 sf	1.60	-	0.04	-	-	1.64	2,320
03-82-16.10	Concrete impact drilling, for anchors, 8" d, 3/4" dia, in concrete or brick walls and floors, includes bit cost, layout and set up time, excl anchor	0500	112.00 ea	42.71	-	0.22	-	-	42.93	4,808
03-63-05.10	Chemical anchoring, for rebar dowel, #5 in 3/4" diam hole, 8" embed, incl epoxy cartridge, excl layout, drilling & rebar	BC-0111	112.00 ea	27.45	-	10.82	-	-	38.27	4,286
03-21-11.60	Reinforcing steel, in place, dowels, deformed, 2' long, #5, A615, grade 60	2420	112.00 ea	5.01	-	1.18	-	-	6.19	694
03-35-29.60	Concrete finishing, walls, bush hammer, cured concrete	0350	168.00 sf	7.34	0.74	-	-	-	8.09	1,359
	_Concrete Baffle Walls		**39.31 cy**	**1,517.34**	**10.11**	**405.40**			**1,932.86**	**75,973**
	03 Structural									**75,973**

WWTP CAPACITY STUDY - ALTERNATE 2

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
04 Process Mechanical										
40360 4" AA Drop Leg Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 4 Inch (100mm)	A1310051600S	80.00 lf	-	-	11.28	-	-	11.28	902
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 10S 4 Inch (100mm)	A132112160000	4.00 ea	-	-	46.18	-	-	46.18	185
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 4 Inch (100mm)	A132421176200	8.00 ea	-	-	40.04	-	-	40.04	320
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L133102160000	16.00 ea	-	-	8.45	-	-	8.45	135
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 4 Inch (100mm)	A136434206200	4.00 ea	-	-	227.14	-	-	227.14	909
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 4 Inch (100mm)	L134062006200	4.00 ea	139.66	-	-	-	-	139.66	559
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	80.00 lf	20.37	-	-	-	-	20.37	1,629
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	141.33	27.59	0.20	-	-	169.11	676
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 4 Inch (100mm)	A133400006200	8.00 ea	51.73	-	29.59	-	-	81.31	651
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00 ea	129.32	-	16.69	-	-	146.00	1,168
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00 ea	25.86	-	22.25	-	-	48.11	770
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	80.00 lf	3.62	-	-	-	-	3.62	290
22-20-03.00	Pipe coupling, sleeve-type, Dresser style, 4"	BC-0211	4.00 ea	193.14		494.11			687.25	2,749
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	16.00 mh	109.78	58.79	-	-	-	168.58	2,697
	4" AA Drop Leg Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**80.00 lf**	**92.93**	**13.14**	**64.43**			**170.49**	**13,639**
40360 4" AA Manifold Piping SS316 Butt Welded - Install Only										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	76.00 lf	20.37	-	-	-	-	20.37	1,548
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	141.33	27.59	0.20	-	-	169.11	676

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 4" AA Manifold Piping SS316 Butt Welded - Install Only										
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	16.00 ea	129.32	-	16.69	-	-	146.00	2,336
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	32.00 ea	25.86	-	22.25	-	-	48.11	1,540
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	76.00 lf	3.62	-	-	-	-	3.62	275
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	12.00 mh	109.78	58.79	-	-	-	168.58	2,023
	4" AA Manifold Piping SS316 Butt Welded - Install Only		**76.00 lf**	**86.88**	**10.74**	**12.89**			**110.50**	**8,398**
40360 4" Purge Piping SS316 Butt Welded - Install Only										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	46.00 lf	20.37	-	-	-	-	20.37	937
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	141.33	27.59	0.20	-	-	169.11	676
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00 ea	129.32	-	16.69	-	-	146.00	1,168
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00 ea	25.86	-	22.25	-	-	48.11	770
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	46.00 lf	3.62	-	-	-	-	3.62	167
	4" Purge Piping SS316 Butt Welded - Install Only		**46.00 lf**	**67.76**	**2.40**	**10.66**			**80.82**	**3,718**
40360 8" AA Piping SS316 - Motor Operated BFV anf Air Flow Meter - 2 ea.										
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 8 Inch (200mm)	A162421176200	4.00 ea	-	-	99.12	-	-	99.12	396
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 8 Inch (200mm)	A166434206200	2.00 ea	-	-	595.95	-	-	595.95	1,192
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 8 Inch (200mm)	L164062006200	2.00 ea	180.72	-	-	-	-	180.72	361
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L165102160000	4.00 ea	154.76	30.21	0.47	-	-	185.44	742
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	4.00 ea	48.58	-	57.61	-	-	106.19	425
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	8.00 mh	82.48	44.17	-	-	-	126.65	1,013

Brown AND Caldwell

Estimate Detail Report

7/20/2021 8:16 PM

BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATE 2

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 8" AA Piping SS316 - Motor Operated BFV anf Air Flow Meter - 2 ea.										
27-20-52.00	FE - (Pilot Tube) Flow Element - Install, Calibrate, Test, Loop Check	BC-0010	2.00 ea	772.17	-	238.25	-	-	1,010.42	2,021
40-05-57.23	Valves-Accessories-Motor Operator-8 Inch (200mm)	A166046000000	2.00 ea	-	-	8,137.70	-	-	8,137.70	16,275
	8" AA Piping SS316 - Motor Operated BFV anf Air Flow Meter - 2 ea.		**80.00 lf**	**42.24**	**5.93**	**232.16**			**280.32**	**22,426**
46999 Fine Bubble Diffusers - 1,300 ea.										
46-06-00.00	Diffusers, fine bubble, complete, includes PVC laterals	BC-0046	1,300.00 ea	23.23	-	65.20	-	-	88.43	114,960
	Fine Bubble Diffusers - 1,300 ea.		**1,564.00 ea**	**19.31**		**54.19**			**73.50**	**114,960**
46999 Install Weir Gates - 4 ea.										
46-06-08.00	Hydraulic structures, weir gate, 24"x36" aluminum frame and slide, stainless fasteners, self contained, geared handwheel lift	BC-0146	4.00 ea	2,159.71	784.03	4,545.00	-	-	7,488.74	29,955
	Install Weir Gates - 4 ea.		**0.00**							**29,955**
	04 Process Mechanical									**193,096**
05 Electrical and Instrumentation										
26999 Connect Valve Motor Operator										
26-99-99.99	Connect valve motor operator	MISC	2.00 ea	2,405.33	-	4,500.00		-	6,905.33	13,811
	Connect Valve Motor Operator		**0.00**							**13,811**
27999 DO Probes										
27-20-57.00	DO - Dissolved Oxygen - Install, Calibrate, Test, Loop Check	BC-0006	2.00 ea	935.96	-	3,621.40	-	-	4,557.36	9,115
26-99-99.99	Conduit and wire for DO probes	MISC	2.00 ea	6.50	-	3,335.50		-	3,342.00	6,684
	DO Probes		**0.00**							**15,799**
	05 Electrical and Instrumentation									**29,609**
	02 Basins 1 & 2									**354,666**

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
	01 ALTERNATE 2									354,666

WWTP CAPACITY STUDY - ALTERNATE 2

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		1,405 hrs	172,075	
Material			169,236	
Subcontract				
Equipment		292 hrs	13,355	
Other				
			354,666	**354,666**
Labor Mark-up	15.00 %		25,811	
Material Mark-up	10.00 %		16,924	
Subcontractor Mark-up	10.00 %			
Construction Equipment Mark-up	10.00 %		1,336	
Other - Process Equip Mark-up	8.00 %			
			44,071	**398,737**
Material Shipping & Handling	2.00 %		3,385	
Material Sales Tax	8.75 %		14,808	
Other - Process Eqp Sales Tax	8.75 %			
Net Markups			**18,193**	**416,930**
Contractor General Conditions	15.00 %		62,539	
			62,539	**479,469**
Start-Up, Training, O&M	2.00 %		9,589	
			9,589	**489,058**
Undesign/Undevelop Contingency	30.00 %		146,717	
			146,717	**635,775**
Bldg Risk, Liability Auto Ins	2.00 %		12,716	
			12,716	**648,491**
Payment and Performance Bonds	1.50 %		9,727	
			9,727	**658,218**
Escalation to Midpoint (ALL)				
Gross Markups				**658,218**
Total				**658,218**

Brown AND Caldwell

Estimate Summary Report

7/21/2021 9:07 AM

BC Project Number:	156642
Estimate Version Number:	1
Estimate Date:	06/30/21
Lead Estimator:	Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 3

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATIVE 3
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

WWTP CAPACITY STUDY - ALTERNATIVE 3

Phase	Description	Gross Total Cost with Markups
01 ALTERNATE 3		
01 Basin 4		
01 Demolition		8,883
04 Process Mechanical		410,730
05 Electrical and Instrumentation		87,807
01 Basin 4		507,421
02 Basins 1 & 2		
01 Demolition		116,541
03 Structural		89,892
04 Process Mechanical		277,709
05 Electrical and Instrumentation		59,620
02 Basins 1 & 2		543,762
01 ALTERNATE 3		1,051,183

Estimate Detail Report

7/21/2021 9:08 AM

BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 3

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATIVE 3
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01 ALTERNATE 3										
01 Basin 4										
01 Demolition										
02999 Pressure Wash Basin 4										
04-01-30.20	Cleaning masonry, high pressure wash, average soil, biological staining, water only, excludes scaffolding	0420	2,700.00 sf	1.54	0.26	-	-	-	1.80	4,873
	Pressure Wash Basin 4		**0.00**							**4,873**
	01 Demolition									**4,873**
04 Process Mechanical										
22112 4" Spray Piping A53 Threaded Field Run w/ 60 Nozzles										
22-11-13.44	Pipe, steel, black, threaded, 4" diameter, schedule 40, Spec. A-53, includes coupling and clevis hanger assembly sized for covering, 10' OC	0650	248.00 lf	41.63	-	28.00	-	-	69.63	17,267
22-11-13.45	Elbow, 90 Deg., steel, cast iron, black, straight, threaded, standard weight, 4"	0180	4.00 ea	249.76	-	221.00	-	-	470.76	1,883
22-11-13.45	Tee, steel, cast iron, black, straight, threaded, standard weight, 4"	0620	61.00 ea	374.64	-	335.00	-	-	709.64	43,288
22-11-19.34	Sleeve, pipe, steel with water stop, 12" long, 6" diam. for 4" carrier pipe, includes link seal	0200	1.00 ea	169.42	-	142.00	-	-	311.42	311
22-20-02.95	High impact, flat spray nozzle,2 gpm@40 psi,35 deg spray angle,ball jt	BC-0001	60.00 ea	103.02		28.39	-	-	131.41	7,885
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	248.00 lf	2.72	-	-	-	-	2.72	675
09-91-06.41	Coatings & paints, B & C coating system E-1 (Epoxy, metal pipe)	BC-0001	260.00 sqft	0.96	-	0.89	-	-	1.84	480
	4" Spray Piping A53 Threaded Field Run w/ 60 Nozzles		**248.00 lf**	**167.13**		**122.34**			**289.47**	**71,789**
40360 16" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 16 Inch (400mm)	A2010051600S	33.00 lf	-	-	85.23	-	-	85.23	2,813
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 10S 16 Inch (400mm)	A202112160000	4.00 ea	-	-	356.78	-	-	356.78	1,427
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Tee-Sch 10S 16 Inch (400mm)	A202114160000	1.00 ea	-	-	1,322.76	-	-	1,322.76	1,323

WWTP CAPACITY STUDY - ALTERNATIVE 3

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 16" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S 16 Inch (400mm)	A202421176200	13.00 ea	-	-	471.75	-	-	471.75	6,133
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange Blind-Cls 150 16 Inch (400mm)	A202424006200	1.00 ea	-	-	588.85	-	-	588.85	589
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 16 Inch (400mm)	L203102160000	24.00 ea	-	-	24.39	-	-	24.39	585
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 16 Inch (400mm)	L2040021600P2	33.00 lf	42.63	-	-	-	-	42.63	1,407
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 16 Inch (400mm)	L205102160000	2.00 ea	309.52	60.42	1.16	-	-	371.10	742
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 16 Inch (400mm)	A203400006200	8.00 ea	97.16	-	248.14	-	-	345.30	2,762
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 16 Inch (400mm)	A206043000000	1.00 ea	48.58	-	49.56	-	-	98.14	98
40-05-05.00	Field Testing-Hydrotest-Non-Specific 16 Inch (400mm)	L209048000000	33.00 lf	23.32	-	-	-	-	23.32	769
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	12.00 mh	82.48	44.17	-	-	-	126.65	1,520
	16" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**33.00 lf**	**139.72**	**19.72**	**451.71**			**611.15**	**20,168**
40360 14" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 14 Inch (350mm)	A1910051600S	20.00 lf	-	-	66.19	-	-	66.19	1,324
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell45-Sch 10S 14 Inch (350mm)	A192111160000	2.00 ea	-	-	184.67	-	-	184.67	369
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Reducer 1 Dia-Sch 10S 14 Inch (350mm)	A192116160000	1.00 ea	-	-	288.55	-	-	288.55	289
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Tee-Sch 10S 14 Inch (350mm)	A192114160000	1.00 ea	-	-	892.10	-	-	892.10	892
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S 14 Inch (350mm)	A192421176200	14.00 ea	-	-	330.06	-	-	330.06	4,621
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 14 Inch (350mm)	L193102160000	22.00 ea	-	-	21.71	-	-	21.71	478
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 14 Inch (350mm)	A196434206200	1.00 ea	-	-	1,502.24	-	-	1,502.24	1,502
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 14 Inch (350mm)	L194062006200	1.00 ea	320.04	-	-	-	-	320.04	320

WWTP CAPACITY STUDY - ALTERNATIVE 3

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 14" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 14 Inch (350mm)	L1940021600P2	20.00 lf	37.16	-	-	-	-	37.16	743
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 14 Inch (350mm)	L195102160000	1.00 ea	275.51	53.78	1.02	-	-	330.31	330
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 14 Inch (350mm)	A193400006200	9.00 ea	97.16	-	186.95	-	-	284.11	2,557
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 14 Inch (350mm)	A196043000000	1.00 ea	29.15	-	38.55	-	-	67.70	68
40-05-05.00	Field Testing-Hydrotest-Non-Specific 14 Inch (350mm)	L199048000000	20.00 lf	18.07	-	-	-	-	18.07	361
40-05-57.23	Valves-Accessories-Motor Operator-14 Inch (350mm)	A196046000000	1.00 ea	-	-	13,562.83	-	-	13,562.83	13,563
27-20-52.00	FE - (Pilot Tube) Flow Element - Install, Calibrate, Test, Loop Check	BC-0010	1.00 ea	635.01	-	250.00	-	-	885.01	885
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	10.00 mh	82.48	44.17	-	-	-	126.65	1,267
	14" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**20.00 lf**	**203.18**	**24.78**	**1,250.46**			**1,478.42**	**29,568**
40360 8" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 8 Inch (200mm)	A1610051600S	80.00 lf	-	-	26.65	-	-	26.65	2,132
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 10S 8 Inch (200mm)	A162112160000	3.00 ea	-	-	55.70	-	-	55.70	167
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 8 Inch (200mm)	A162421176200	5.00 ea	-	-	99.12	-	-	99.12	496
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L163102160000	11.00 ea	-	-	12.20	-	-	12.20	134
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 8 Inch (200mm)	A166434206200	2.00 ea	-	-	595.95	-	-	595.95	1,192
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 8 Inch (200mm)	L164062006200	2.00 ea	180.72	-	-	-	-	180.72	361
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L1640021600P2	80.00 lf	17.49	-	-	-	-	17.49	1,399
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L165102160000	4.00 ea	154.76	30.21	0.47	-	-	185.44	742
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	5.00 ea	48.58	-	57.60	-	-	106.18	531

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 8" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves										
40-05-07.00	Pipe Support 8 Inch (200mm)	A166044000000	4.00 ea	97.16	-	27.54	-	-	124.69	499
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	8.00 ea	29.15	-	27.54	-	-	56.68	453
40-05-05.00	Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	80.00 lf	7.48	-	-	-	-	7.48	598
22-20-03.00	Pipe coupling, sleeve-type, Dresser style, 8"	BC-0216	2.00 ea	325.29	-	1,500.00	-	-	1,825.29	3,651
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	16.00 mh	82.48	44.17	-	-	-	126.65	2,026
	8" AA Piping SS316 Butt Welded Shop Fab Piping w/ Flanges & Valves		**80.00 lf**	**72.66**	**10.34**	**96.76**			**179.77**	**14,381**
40360 8" AA Manifold Piping SS316 Butt Welded - Install Only										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L1640021600P2	60.00 lf	17.49	-	-	-	-	17.49	1,049
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L165102160000	3.00 ea	154.76	30.21	0.47	-	-	185.44	556
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	8.00 ea	48.58	-	57.60	-	-	106.18	849
40-05-07.00	Pipe Support 8 Inch (200mm)	A166044000000	4.00 ea	97.16	-	27.54	-	-	124.69	499
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	8.00 ea	29.15	-	27.54	-	-	56.68	453
40-05-05.00	Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	60.00 lf	7.48	-	-	-	-	7.48	449
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	8.00 mh	82.48	44.17	-	-	-	126.65	1,013
	8" AA Manifold Piping SS316 Butt Welded - Install Only		**60.00 lf**	**60.55**	**7.40**	**13.21**			**81.16**	**4,869**
40360 4" Purge Piping SS316 Butt Welded - Install Only										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	46.00 lf	15.30	-	-	-	-	15.30	704
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	106.18	20.73	0.19	-	-	127.10	508
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00 ea	97.16	-	16.52	-	-	113.68	909

Brown AND Caldwell

Estimate Detail Report

7/21/2021 9:08 AM

BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 3

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 4" Purge Piping SS316 Butt Welded - Install Only										
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00 ea	19.43	-	22.03	-	-	41.46	663
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	46.00 lf	2.72	-	-	-	-	2.72	125
	4" Purge Piping SS316 Butt Welded - Install Only		**46.00 lf**	**50.91**	**1.80**	**10.55**			**63.27**	**2,910**
46999 Fine Bubble Diffusers - 924 ea.										
46-06-00.00	Diffusers, fine bubble, includes 4" PVC laterals	BC-0046	924.00 ea	17.45	-	65.23	-	-	82.68	76,397
	Fine Bubble Diffusers - 924 ea.		**924.00 ea**	**17.45**		**65.23**			**82.68**	**76,397**
	04 Process Mechanical									**220,083**

05 Electrical and Instrumentation

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
26999 Connect Valve Motor Operator										
26-99-99.99	Connect valve motor operator	MISC	1.00 ea	2,405.33	-	4,500.00		-	6,905.33	6,905
	Connect Valve Motor Operator		**0.00**							**6,905**
26999 New Wiring in Tank 4										
26-99-99.99	Misc. Electrical Work - new wiring to Tank 4	MISC	1.00 LS	-	-	-	25,000.00	-	25,000.00	25,000
	New Wiring in Tank 4		**0.00**							**25,000**
27999 DO Probes										
27-20-57.00	DO - Dissolved Oxygen - Install, Calibrate, Test, Loop Check	BC-0006	2.00 ea	769.71	-	3,800.00	-	-	4,569.71	9,139
26-99-99.99	Conduit and wire for DO probes	MISC	2.00 ea	5.35	-	3,500.00		-	3,505.35	7,011
	DO Probes		**0.00**							**16,150**
	05 Electrical and Instrumentation									**48,055**
	01 Basin 4									**273,011**

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
02 Basins 1 & 2										
01 Demolition										
02225 Cut and Demo Channel Wall - 3'w x 5.5'h x 8" th										
02-41-19.16	Selective demolition, cutout, concrete, walls, bar reinforced, 6-12 C.F., excludes loading and disposal	1450	11.00 cf	41.76	5.18	-	-	-	46.95	516
02-41-19.25	Sawcutting, concrete walls, rod reinforcing, per inch of depth	0820	112.00 lf	8.26	10.62	0.05	-	-	18.92	2,119
902-41-19.23	Rubbish handling, loading & trucking, chute loaded, including 2 mile haul, cost to be added to demolition cost.	0600	0.41 cy	52.70	13.12	-	-	-	65.82	27
902-41-19.23	Rubbish handling, dumpster, 20 C.Y., 8 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost.	2300	1.00 week	-	-	565.00	-	-	565.00	565
	Cut and Demo Channel Wall - 3'w x 5.5'h x 8" th		**0.00**							**3,227**
02225 Cut Slide Channel for Stop Plates										
02-41-19.16	Selective demolition, cutout, concrete, walls, bar reinforced, 6-12 C.F., excludes loading and disposal	1450	11.00 cf	41.76	5.18	-	-	-	46.95	516
02-41-19.25	Sawcutting, concrete walls, rod reinforcing, per inch of depth	0820	773.36 lf	8.26	10.62	0.05	-	-	18.92	14,634
902-41-19.23	Rubbish handling, loading & trucking, chute loaded, including 2 mile haul, cost to be added to demolition cost.	0600	0.41 cy	52.70	13.12	-	-	-	65.82	27
902-41-19.23	Rubbish handling, dumpster, 20 C.Y., 8 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost.	2300	1.00 week	-	-	565.00	-	-	565.00	565
	Cut Slide Channel for Stop Plates		**0.00**							**15,742**
02301 Pipe Demolition - 4" Drop Legs and Headers										
22-05-05.10	Pipe, metal pipe, 4" to 6" diam., selective demolition	2100	156.00 lf	21.22	-	-	-	-	21.22	3,311
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	25.00 mh	109.78	58.79	-	-	-	168.58	4,214
02-41-19.19	Selective demolition, rubbish handling, dumpster, 20 c.y., 5 ton capacity, weekly rental, includes one dump per week, cost be added to demolition cost	0725	1.00 week	-	-	562.74	-	-	562.74	563
	Pipe Demolition - 4" Drop Legs and Headers		**156.00 ft**	**38.82**	**9.42**	**3.61**			**51.85**	**8,088**

WWTP CAPACITY STUDY - ALTERNATIVE 3

Phase	Description	Item	Takeoff Quantity		Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
02301 _Pipe Demolition for New Motorized BFV											
22-05-05.10	Pipe, metal pipe, 8" to 14" diam., selective demolition	2150	4.00	lf	35.38	-	-	-	-	35.38	142
	_Pipe Demolition for New Motorized BFV		**4.00**	**ft**	**35.38**					**35.38**	**142**
02999 Demo Weir Gates											
02-22-04.50	Site demolition, 48" weir gate	BC-0056	4.00	ea	1,352.98	-	-	-	-	1,352.98	5,412
	Demo Weir Gates		**4.00**	**EA**	**1,352.98**					**1,352.98**	**5,412**
02999 Pressure Wash Basin 2 & Channel											
04-01-30.20	High pressure wash, average soil, biological staining, water only, excludes scaffolding	0420	3,250.00	sf	1.54	0.26	-	-	-	1.80	5,865
	Pressure Wash Basin 2 & Channel		**1.00**	**LS**	**5,004.82**	**860.56**				**5,865.38**	**5,865**
02999 Demo Diffusers											
02-22-04.52	Equipment dismantling/demolition, aeration diffusers, complete, Includes laterals	BC-0231	650.00	ea	14.63	-	-	-	-	14.63	9,507
02-41-19.19	Selective demolition, rubbish handling, dumpster, 20 c.y., 5 ton capacity, weekly rental, includes one dump per week, cost be added to demolition cost	0725	3.00	week	-	-	562.74	-	-	562.74	1,688
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	80.00	mh	109.78	58.79	-	-	-	168.58	13,486
	Demo Diffusers		**650.00**	**EA**	**28.14**	**7.24**	**2.60**			**37.97**	**24,682**
02999 Plug 24" ML Pipe - 2 ea.											
03-31-13.35	Structural concrete, ready mix, flowable fill, structural, 140 psi, includes ash, Portland cement Type I, aggregate, sand and water, delivered, excludes all additives and treatments	4250	0.50	cy	-	-	78.00	-	-	78.00	39
03-92-06.00	Plug pipe, non-shrink grout, 24" hole	BC-0036	2.00	ea	162.54	-	238.74	-	-	401.28	803
	Plug 24" ML Pipe - 2 ea.		**2.00**	**EA**	**162.54**		**258.24**			**420.78**	**842**
	01 Demolition										**63,999**

03 Structural

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
03345 _Concrete Baffle Wall - Basin 2										
03-11-13.85	C.I.P. concrete forms, wall, job built, plywood, over 16' high, 1 use, includes erecting, bracing, stripping and cleaning	2700	739.50 sfca	26.60	-	4.22	-	-	30.82	22,789
03-11-13.85	C.I.P. concrete forms, wall, box out for opening, to 16" thick, over 10 S.F. (use perimeter), includes erecting, bracing, stripping and cleaning	0150	32.00 lf	22.32	-	3.73	-	-	26.05	834
03-15-05.95	Form oil, up to 800 S.F. per gallon, coverage, includes material only	3050	1.97 gal	-	-	21.91	-	-	21.91	43
03-21-10.60	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	0700	1.47 ton	1,453.35	-	1,041.25	-	-	2,494.59	3,677
03-21-10.60	Reinforcing in place, unloading & sorting, add - walls, cols, beams	2010	1.47 ton	73.05	8.01	-	-	-	81.05	119
03-21-10.60	Reinforcing, crane cost for handling, add to above, walls, cols, beams	2225	1.47 ton	79.40	8.70	-	-	-	88.10	130
03-31-05.35	Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sand,portland cement and water,excludes all additives and treatments	0350	20.64 cy	-	-	118.24	-	-	118.24	2,440
03-31-05.70	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	5350	20.64 cy	53.78	5.41	-	-	-	59.19	1,221
03-35-29.60	Finishing: break ties & patch voids (walls, cols or beams)	0010	707.50 sf	1.60	-	0.04	-	-	1.64	1,160
03-82-16.10	Concrete impact drilling, for anchors, 8" d, 3/4" dia, in concrete or brick walls and floors, includes bit cost, layout and set up time, excl anchor	0500	56.00 ea	42.71	-	0.22	-	-	42.93	2,404
03-63-05.10	Chemical anchoring, for rebar dowel, #5 in 3/4" diam hole, 8" embed, incl epoxy cartridge, excl layout, drilling & rebar	BC-0111	56.00 ea	27.45	-	10.82	-	-	38.27	2,143
03-21-11.60	Reinforcing steel, in place, dowels, deformed, 2' long, #5, A615, grade 60	2420	56.00 ea	5.01	-	1.18	-	-	6.19	347
03-35-29.60	Concrete finishing, walls, bush hammer, cured concrete	0350	84.00 sf	7.34	0.74	-	-	-	8.09	679
	_Concrete Baffle Wall - Basin 2		**19.65 cy**	**1,517.34**	**10.11**	**405.40**			**1,932.85**	**37,986**
03345 _Plug Concrete Walls - 3 ea. @ 4'w x 5.5'h x 8" th										
03-11-13.85	C.I.P. concrete forms, wall, job built, plywood, over 8' to 16' high, 1 use, includes erecting, bracing, stripping and cleaning	2400	132.00 sfca	28.38	-	4.66	-	-	33.04	4,362
03-15-05.95	Form oil, up to 800 S.F. per gallon, coverage, includes material only	3050	0.35 gal	-	-	21.50	-	-	21.50	8

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
03345 _Plug Concrete Walls - 3 ea. @ 4'w x 5.5'h x 8" th										
03-21-10.60	Reinforcing steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	0700	0.12 ton	2,172.40	-	1,250.00	-	-	3,422.40	418
03-21-10.60	Reinforcing in place, unloading & sorting, add - walls, cols, beams	2010	0.12 ton	109.20	12.00	-	-	-	121.15	15
03-21-10.60	Reinforcing, crane cost for handling, add to above, walls, cols, beams	2225	0.12 ton	118.70	13.00	-	-	-	131.70	16
03-31-05.35	Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sand,portland cement and water,excludes all additives and treatments	0350	1.71 cy	-	-	133.00	-	-	133.00	228
03-31-05.70	Structural concrete, placing, walls, pumped, 15" thick, includes vibrating, excludes material	5350	1.71 cy	80.75	8.12	-	-	-	88.87	152
03-35-29.60	Finishing: break ties & patch voids (walls, cols or beams)	0010	132.00 sf	2.41	-	0.04	-	-	2.45	323
03-82-16.10	Concrete impact drilling, for anchors, 8" d, 3/4" dia, in concrete or brick walls and floors, includes bit cost, layout and set up time, excl anchor	0500	45.00 ea	59.73	-	0.22	-	-	59.95	2,698
03-63-05.10	Chemical anchoring, for rebar dowel, #5 in 3/4" diam hole, 8" embed, incl epoxy cartridge, excl layout, drilling & rebar	BC-0111	45.00 ea	38.39	-	10.78	-	-	49.17	2,212
03-21-11.60	Reinforcing steel, in place, dowels, deformed, 2' long, #5, A615, grade 60	2420	45.00 ea	7.49	-	1.42	-	-	8.91	401
	_Plug Concrete Walls - 3 ea. @ 4'w x 5.5'h x 8" th		**0.00**							**10,832**
	03 Structural									**48,818**

04 Process Mechanical

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
05999 Stop Plates - 316 SS, 1/2" th										
05-58-09.50	Stainless steel plate, 1/2" thk.	BC-0041	84.50 sqft	8.93	-	7.70	-	-	16.63	1,405
	Stop Plates - 316 SS, 1/2" th		**0.00**							**1,405**
40360 4" AA Drop Leg Piping SS316 Butt Welded - Install Only										
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 4 Inch (100mm)	L134062006200	4.00 ea	139.66	-	-	-	-	139.66	559
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	80.00 lf	20.37	-	-	-	-	20.37	1,629
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	141.33	27.59	0.20	-	-	169.11	676

Phase	Description	Item	Takeoff Quantity		Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 4" AA Drop Leg Piping SS316 Butt Welded - Install Only											
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 4 Inch (100mm)	A133400006200	8.00	ea	51.73	-	29.59	-	-	81.31	651
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00	ea	129.32	-	16.69	-	-	146.00	1,168
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00	ea	25.86	-	22.25	-	-	48.11	770
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	80.00	lf	3.62	-	-	-	-	3.62	290
22-20-03.00	Pipe coupling, sleeve-type, Dresser style, 4"	BC-0211	4.00	ea	193.14		494.11			687.25	2,749
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	16.00	mh	109.78	58.79	-	-	-	168.58	2,697
	4" AA Drop Leg Piping SS316 Butt Welded - Install Only		**80.00**	**lf**	**92.93**	**13.14**	**33.79**			**139.86**	**11,189**
40360 4" AA Manifold Piping SS316 Butt Welded - Install only											
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	38.00	lf	20.37	-	-	-	-	20.37	774
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	2.00	ea	141.33	27.59	0.20	-	-	169.11	338
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00	ea	129.32	-	16.69	-	-	146.00	1,168
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00	ea	25.86	-	22.25	-	-	48.11	770
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	38.00	lf	3.62	-	-	-	-	3.62	138
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	8.00	mh	109.78	58.79	-	-	-	168.58	1,349
	4" AA Manifold Piping SS316 Butt Welded - Install only		**38.00**	**lf**	**92.65**	**13.83**	**12.89**			**119.37**	**4,536**
40360 4" Purge Piping SS316 Butt Welded Shop Fab Piping											
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 4 Inch (100mm)	A1310051600S	44.33	lf	-	-	11.28	-	-	11.28	500
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell45-Sch 10S 4 Inch (100mm)	A132111160000	4.00	ea	-	-	12.51	-	-	12.51	50
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L133102160000	8.00	ea	-	-	8.45	-	-	8.45	68

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 4" Purge Piping SS316 Butt Welded Shop Fab Piping										
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	46.00 lf	20.37	-	-	-	-	20.37	937
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	4.00 ea	141.33	27.59	0.20	-	-	169.11	676
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	8.00 ea	129.32	-	16.69	-	-	146.00	1,168
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	16.00 ea	25.86	-	22.25	-	-	48.11	770
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	46.00 lf	3.62	-	-	-	-	3.62	167
	4" Purge Piping SS316 Butt Welded Shop Fab Piping		**46.00 lf**	**67.76**	**2.40**	**24.08**			**94.24**	**4,335**
40360 8" AA Piping SS316 - Motor Operated BFV and Air Flow Meter - 1 ea.										
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 8 Inch (200mm)	A162421176200	2.00 ea	-	-	99.12	-	-	99.12	198
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 8 Inch (200mm)	A166434206200	1.00 ea	-	-	595.95	-	-	595.95	596
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 8 Inch (200mm)	L164062006200	1.00 ea	180.71	-	-	-	-	180.71	181
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 8 Inch (200mm)	L165102160000	2.00 ea	154.76	30.21	0.47	-	-	185.44	371
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	2.00 ea	48.58	-	57.61	-	-	106.19	212
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	4.00 mh	82.48	44.17	-	-	-	126.65	507
27-20-52.00	FE - (Pilot Tube) Flow Element - Install, Calibrate, Test, Loop Check	BC-0010	1.00 ea	772.17	-	238.25	-	-	1,010.42	1,010
40-05-57.23	Valves-Accessories-Motor Operator-8 Inch (200mm)	A166046000000	1.00 ea	-	-	8,137.70	-	-	8,137.70	8,138
	8" AA Piping SS316 - Motor Operated BFV and Air Flow Meter - 1 ea.		**0.00**							**11,213**
40360 4" CAA Piping at Channel - SS316 Butt Welded Shop Fab Piping										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 10S 4 Inch (100mm)	A1310051600S	95.20 lf	-	-	11.16	-	-	11.16	1,063
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 10S 4 Inch (100mm)	A132112160000	4.00 ea	-	-	45.72	-	-	45.72	183

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 4" CAA Piping at Channel - SS316 Butt Welded Shop Fab Piping										
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Tee-Sch 10S 4 Inch (100mm)	A132114160000	3.00 ea	-	-	82.31	-	-	82.31	247
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Cap-Sch 10S 4 Inch (100mm)	A132117160000	1.00 ea	-	-	5.50	-	-	5.50	6
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 4 Inch (100mm)	A132421176200	9.00 ea	-	-	39.65	-	-	39.65	357
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L133102160000	27.00 ea	-	-	8.37	-	-	8.37	226
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 4 Inch (100mm)	A136434206200	4.00 ea	-	-	224.89	-	-	224.89	900
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 4 Inch (100mm)	L134062006200	4.00 ea	104.93	-	-	-	-	104.93	420
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L1340021600P2	108.00 lf	15.30	-	-	-	-	15.30	1,653
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 10S 4 Inch (100mm)	L135102160000	9.00 ea	106.18	20.73	0.19	-	-	127.10	1,144
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 4 Inch (100mm)	A133400006200	9.00 ea	38.86	-	29.29	-	-	68.16	613
40-05-07.00	Pipe Support 4 Inch (100mm)	A136044000000	3.00 ea	97.16	-	16.52	-	-	113.68	341
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 4 Inch (100mm)	A136043000000	2.00 ea	19.43	-	22.03	-	-	41.46	83
40-05-07.00	Hanger Rod 4 Inch (100mm)	A136045000000	3.00 ea	29.15	-	27.54	-	-	56.68	170
40-05-05.00	Field Testing-Hydrotest-Non-Specific 4 Inch (100mm)	L139048000000	108.00 lf	2.72	-	-	-	-	2.72	294
22-20-03.00	Pipe coupling, sleeve-type, Dresser style, 4"	BC-0211	4.00 ea	193.14	-	494.11	-	-	687.25	2,749
	4" CAA Piping at Channel - SS316 Butt Welded Shop Fab Piping		**108.00 lf**	**45.02**	**1.73**	**49.98**			**96.73**	**10,447**
46999 Fine Bubble Diffusers - 270 ea.										
46-06-00.00	Diffusers, fine bubble, complete, includes PVC laterals	BC-0046	270.00 ea	23.23	-	65.20	-	-	88.43	23,876
	Fine Bubble Diffusers - 270 ea.		**270.00 ea**	**23.23**		**65.20**			**88.43**	**23,876**
46999 Submersible Mixers - 2 ea.										
46-06-00.00	Mixer, propellar type, 5 hp,lightnin, 900 rpm, tefc motor	BC-0616	2.00 ea	1,132.74	-	23,959.80	-		25,092.54	50,185

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
	Submersible Mixers - 2 ea.		**0.00**							**50,185**
46999 Coarse Bubble Diffusers in Channel - 28 ea.										
46-06-00.00	Diffusers, coarse bubble, complete	BC-0041	28.00 ea	660.73	-	45.10	-	-	705.83	19,763
	Coarse Bubble Diffusers in Channel - 28 ea.		**0.00**							**19,763**
46999 Slide Gate - 1 ea.										
35-22-73.16	Slide gates, hydraulic structures, steel, self contained, 36" x 66", incl. anchor bolts & grout	0160	1.00 ea	2,704.37	981.75	8,200.00	-	-	11,886.12	11,886
	Slide Gate - 1 ea.		**0.00**							**11,886**
	04 Process Mechanical									**148,835**
05 Electrical and Instrumentation										
26999 Connect Valve Motor Operator										
26-99-99.99	Connect valve motor operator	MISC	1.00 ea	2,405.33	-	4,500.00		-	6,905.33	6,905
	Connect Valve Motor Operator		**0.00**							**6,905**
26999 Connect Mixers - 2 ea.										
26-99-99.99	Connect mixers in Basin 2	MISC	2.00 ea.	3.85	-	4,500.00	0.00	-	4,503.85	9,008
	Connect Mixers - 2 ea.		**0.00**							**9,008**
27999 DO Probes										
27-20-57.00	DO - Dissolved Oxygen - Install, Calibrate, Test, Loop Check	BC-0006	2.00 ea	935.96	-	3,621.40	-	-	4,557.36	9,115
26-99-99.99	Conduit and wire for DO probes	MISC	2.00 ea	6.50	-	3,335.50		-	3,342.00	6,684
	DO Probes		**0.00**							**15,799**
	05 Electrical and Instrumentation									**31,712**
	02 Basins 1 & 2									**293,364**
	01 ALTERNATE 3									**566,375**

WWTP CAPACITY STUDY - ALTERNATIVE 3

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		2,201 hrs	224,138	
Material			294,156	
Subcontract			25,000	
Equipment		606 hrs	23,081	
Other				
			566,375	**566,375**
Labor Mark-up	15.00 %		33,621	
Material Mark-up	10.00 %		29,416	
Subcontractor Mark-up	10.00 %		2,500	
Construction Equipment Mark-up	10.00 %		2,308	
Other - Process Equip Mark-up	8.00 %			
			67,845	**634,220**
Material Shipping & Handling	2.00 %		5,883	
Material Sales Tax	8.75 %		25,739	
Other - Process Eqp Sales Tax	8.75 %			
Net Markups			**31,622**	**665,842**
Contractor General Conditions	15.00 %		99,876	
			99,876	**765,718**
Start-Up, Training, O&M	2.00 %		15,314	
			15,314	**781,032**
Undesign/Undevelop Contingency	30.00 %		234,310	
			234,310	**1,015,342**
Bldg Risk, Liability Auto Ins	2.00 %		20,307	
			20,307	**1,035,649**
Payment and Performance Bonds	1.50 %		15,535	
			15,535	**1,051,184**
Escalation to Midpoint (ALL)				
Gross Markups				**1,051,184**
Total				**1,051,184**

Estimate Summary Report

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BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 4

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATIVE 4
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

Estimate Summary Report

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Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 4

Phase	Description	Gross Total Cost with Markups
01 ALTERNATE 4		
03 Alternate 4 Additions		
01 Demolition		9,839
04 Process Mechanical		183,033
05 Electrical and Instrumentation		50,624
03 Alternate 4 Additions		243,496
01 ALTERNATE 4		243,496

WWTP CAPACITY STUDY - ALTERNATIVE 4

SEWER AUTHORITY MID-COASTSIDE
WWTP CAPACITY STUDY - ALTERNATIVE 4
CLASS 5 ESTIMATE - PLANNING LEVEL

Estimator	Steve Payne
BC Project Manager	Mike Harrison
BC Office	Sacramento
Est Version Number	1
QA/QC Reviewer	Bill Agster
QA/QC Review Date	06/29/21
BC Project Number	156642

WWTP CAPACITY STUDY - ALTERNATIVE 4

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01 ALTERNATE 4										
03 Alternate 4 Additions										
01 Demolition										
02999 Core Drill for 8" Basin Influent Pipe										
03-82-13.10	Concrete core drilling, bits for core drill, diamond, premium, 12" diameter, included in drilling line items	3120	2.00 ea	-	-	655.00	-	-	655.00	1,310
	Core Drill for 8" Basin Influent Pipe		**0.00**							**1,310**
02999 Pressure Wash Basin 1										
04-01-30.20	High pressure wash, average soil, biological staining, water only, excludes scaffolding	0420	2,220.00 sf	1.54	0.26	-	-	-	1.80	4,007
	Pressure Wash Basin 1		**0.00**							**4,007**
	01 Demolition									**5,317**
04 Process Mechanical										
40360 Piping SS316 Butt Welded Shop Fab Piping w/Optional Flanges & Valves										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 40S/Std 8 Inch (200mm)	A1610051700S	9.27 lf	-	-	56.78	-	-	56.78	526
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell45-Sch 40S/Std 8 Inch (200mm)	A162111170000	2.00 ea	-	-	90.70	-	-	90.70	181
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 40S/Std 8 Inch (200mm)	A162112170000	2.00 ea	-	-	118.91	-	-	118.91	238
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 8 Inch (200mm)	A162421176200	5.00 ea	-	-	99.12	-	-	99.12	496
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 40S/Std 8 Inch (200mm)	L163102170000	13.00 ea	-	-	14.22	-	-	14.22	185
40-05-64.00	Valve Flanged & Bolted-Stainless Steel-Butterfly-Cls 150 (PN20) 8 Inch (200mm)	A166434206200	1.00 ea	-	-	595.95	-	-	595.95	596
40-05-61.00	Valve Flanged & Bolted-Stainless Steel-Gate-Cls 150 (PN20) 8 Inch (200mm)	A166431206200	1.00 ea	-	-	5,049.84	-	-	5,049.84	5,050
40-05-51.00	Pipe Erection-Handle Valves-Metal-Cls 150 (PN20) 8 Inch (200mm)	L164062006200	2.00 ea	180.72	-	-	-	-	180.72	361
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 40S/Std 8 Inch (200mm)	L1640021700P2	20.00 lf	37.16	-	-	-	-	37.16	743
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 40S/Std 8 Inch (200mm)	L165102170000	1.00 ea	340.75	66.52	1.30	-	-	408.57	409

WWTP CAPACITY STUDY - ALTERNATIVE 4

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 Piping SS316 Butt Welded Shop Fab Piping w/Optional Flanges & Valves										
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	5.00 ea	48.58	-	57.60	-	-	106.18	531
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	1.00 ea	29.15	-	27.54	-	-	56.69	57
40-05-05.00	Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	20.00 lf	7.48	-	-	-	-	7.48	150
27-20-03.00	8" Magnetic flowmeters, 150# AWWA flanges	BC-0016	1.00 ea	406.60	-	8,000.00	-	-	8,406.60	8,407
40-05-57.23	Valves-Accessories-Motor Operator-8 Inch (200mm) for butterfly valve	A166046000000	1.00 ea	-	-	8,057.12	-	-	8,057.12	8,057
22-11-19.34	Sleeve, pipe, steel with water stop, 12" long, 12" diam. for 8" carrier pipe, includes link seal	0220	2.00 ea	208.13	-	390.00	-	-	598.13	1,196
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	8.00 mh	82.48	44.17	-	-	-	126.65	1,013
	Piping SS316 Butt Welded Shop Fab Piping w/Optional Flanges & Valves		**20.00 lf**	**167.49**	**21.00**	**1,221.28**			**1,409.76**	**28,195**
40360 8" Submersible Pump Discharge Piping SS316 Butt Welded Shop Fab Piping										
40-05-23.20	Pipe Plain End-Stainless 316/316L-Seamless-Sch 40S/Std 8 Inch (200mm)	A1610051700S	14.83 lf	-	-	56.78	-	-	56.78	842
40-05-23.20	Fitting Butt Weld-Stainless 316/316L-Ell90-Sch 40S/Std 8 Inch (200mm)	A162112170000	2.00 ea	-	-	118.91	-	-	118.91	238
40-05-23.20	Fitting Flanged & Bolted-Stainless 316/316L-Flange WN-Cls 150-Sch 40S/Std 8 Inch (200mm)	A162421176200	3.00 ea	-	-	99.12	-	-	99.12	297
40-05-23.20	Shop Butt Weld-Stainless 316/316L-Sch 40S/Std 8 Inch (200mm)	L163102170000	7.00 ea	-	-	14.22	-	-	14.22	100
40-05-23.20	Pipe Erection-Spools-Stainless 316/316L-Sch 40S/Std 8 Inch (200mm)	L1640021700P2	20.00 lf	37.16	-	-	-	-	37.16	743
40-05-23.20	Field Butt Weld-Stainless 316/316L-Sch 40S/Std 8 Inch (200mm)	L165102170000	1.00 ea	340.75	66.52	1.30	-	-	408.57	409
40-05-05.00	Make Up Bolted Joint incl B-7 Nuts, Bolts, 1/16 Inch Rubber Gasket-Cls 150 (PN20) 8 Inch (200mm)	A163400006200	3.00 ea	48.58	-	57.60	-	-	106.18	319
40-05-07.00	Pipe Support 8 Inch (200mm)	A166044000000	3.00 ea	97.16	-	27.54	-	-	124.69	374
40-05-07.00	Hilti-Chemical Anchor - Pipe Support Size 8 Inch (200mm)	A166043000000	2.00 ea	29.15	-	27.54	-	-	56.68	113
40-05-05.00	Field Testing-Hydrotest-Non-Specific 8 Inch (200mm)	L169048000000	20.00 lf	7.48	-	-	-	-	7.48	150

Estimate Detail Report

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BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 4

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
40360 8" Submersible Pump Discharge Piping SS316 Butt Welded Shop Fab Piping										
27-20-03.00	8" Magnetic flowmeters, 150# AWWA flanges	BC-0016	1.00 ea	406.60	-	8,000.00	-	-	8,406.60	8,407
40-05-05.00	Pipe Erection-Handle Pipe-Construction Equipment	XL609064009000	8.00 mh	82.48	44.17	-	-	-	126.65	1,013
	8" Submersible Pump Discharge Piping SS316 Butt Welded Shop Fab Piping		**20.00 lf**	**139.78**	**21.00**	**489.41**			**650.19**	**13,004**
46999 Submersible Pump - 1 ea. @ 300 GPM										
46-06-22.00	Submersible pump - 300 GPM 50 TDH, includes guide rail,base elbow, & VFD	BC-0086	1.00 ea	4,879.25	700.00	50,000.00	-	0.00	55,579.25	55,579
	Submersible Pump - 1 ea. @ 300 GPM		**0.00**							**55,579**
	04 Process Mechanical									**96,778**
05 Electrical and Instrumentation										
26999 Connect Submersible Pump and VFD										
26-99-99.99	Connect submersible pump w/ VFD	MISC	1.00 ea	4,810.65	-	10,000.00	0.00	-	14,810.65	14,811
	Connect Submersible Pump and VFD		**0.00**							**14,811**
26999 Connect Flowmeters										
26-99-99.99	Connect 8" magnetic flow meters	MISC	2.00 ea	1,539.41	-	4,500.00		-	6,039.41	12,079
	Connect Flowmeters		**0.00**							**12,079**
	05 Electrical and Instrumentation									**26,889**
	03 Alternate 4 Additions									**128,984**
	01 ALTERNATE 4									**128,984**

Estimate Detail Report

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BC Project Number: 156642
Estimate Version Number: 1
Estimate Date: 06/30/21
Lead Estimator: Steve Payne

WWTP CAPACITY STUDY - ALTERNATIVE 4

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		243 hrs	22,333	
Material			104,524	
Subcontract				
Equipment		70 hrs	2,128	
Other				
			128,985	**128,985**
Labor Mark-up	15.00 %		3,350	
Material Mark-up	10.00 %		10,452	
Subcontractor Mark-up	10.00 %			
Construction Equipment Mark-up	10.00 %		213	
Other - Process Equip Mark-up	8.00 %			
			14,015	**143,000**
Material Shipping & Handling	2.00 %		2,090	
Material Sales Tax	8.75 %		9,146	
Other - Process Eqp Sales Tax	8.75 %			
Net Markups			**11,236**	**154,236**
Contractor General Conditions	15.00 %		23,135	
			23,135	**177,371**
Start-Up, Training, O&M	2.00 %		3,547	
			3,547	**180,918**
Undesign/Undevelop Contingency	30.00 %		54,276	
			54,276	**235,194**
Bldg Risk, Liability Auto Ins	2.00 %		4,704	
			4,704	**239,898**
Payment and Performance Bonds	1.50 %		3,598	
			3,598	**243,496**
Escalation to Midpoint (ALL)				
Gross Markups				**243,496**
Total				**243,496**

Attachment B: BioWin Calibration Summary

Table B-1. Summary of primary influent fractions		
Fraction	Reference/Approach	Adjusted Value
Flow [mgd]	Avg of Historical data (daily)	1.296
Alkalinity [mgCaCO3/L]	Avg of Historical data (10 data per month)	340.7
BOD - Total Carbonaceous [mg/L]	Avg of Historical data (10 data per month)	318.1
BOD - Filtered Carbonaceous [mg/L]	BioWin typical fraction	133.0
COD – Total [mg/L]	Assumed BOD:COD ratio of 2.2	700
COD – Filtered [mg/L]	Increased COD from 25 mg/L to 35 mg/L based on COD data:default ratio of 500:700	258.7
COD – FF [mg/L]	BioWin typical fraction	147.0
CODs – Acetate [mg/L]	BioWin typical fraction	16.8
Gas - Dissolved oxygen [mg/L]	Assumed	0.0
Metal soluble – Calcium [mg/L]	Assumed	80.0
Metal soluble – Magnesium [mg/L]	Assumed	15.0
N - Total Kjeldahl Nitrogen [mg/L]	Assumed TKN: Ammonia ratio of 0.66	8.4
N – Ammonia [mg/L]	Assumed BOD: Ammonia ratio of 10	31.81
N - Nitrate [mg/L]	Assumed	0
pH [mg/L]	Historical Data (effluent daily)	7.4
P – Total [mg/L]	Assumed BOD:TP ratio	8.4
P - Soluble phosphate [mg/L]	Assumed	4.2
TSS [mg/L]	Historical Data (10 data per month)	292.8
VSS [mg/L]	Assumed VSS:TSS ratio of 0.85	248.0
S - Total S [mg/L]	Assumed BOD:TS ratio	8.4
S - Soluble Sulfate [mg/L]	BioWin typical fraction	7.2
COD – Filtered [mg/L]	Increased the ratio based on influent COD to match FUS to default value	35

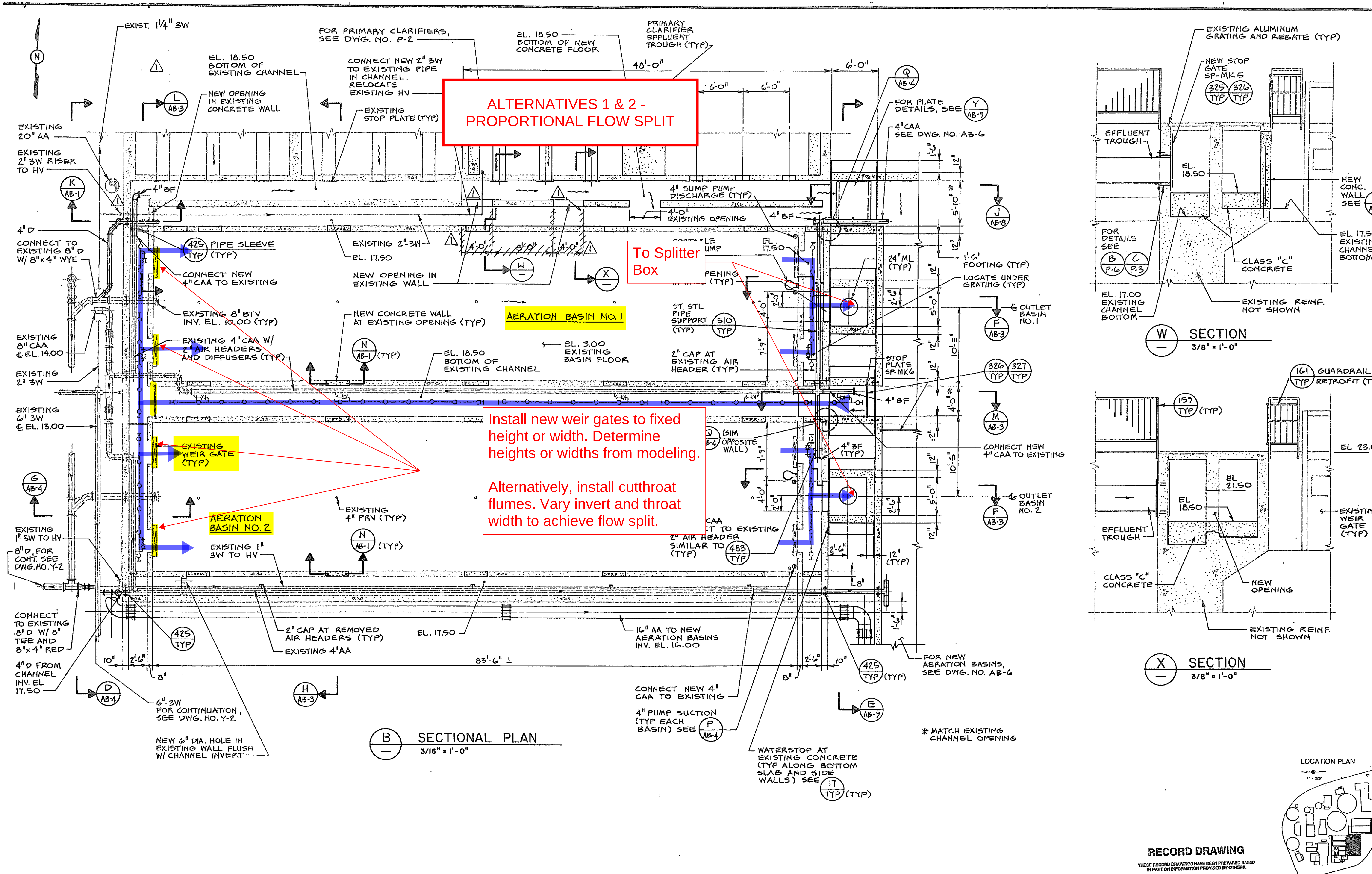
Table B-2 tabulates parameters evaluated during the calibration and validation periods (text in red and blue). In general, there is good agreement on solid balance. This is not the case for aeration, BOD, and nitrification prediction.

Table B-2. Summary of Calibration and Validation Results

Parameter		BioWin	SAM Data	Delta	Approach/Comments	General Recommendation
MLSS, mg/L	Calib	1,347	1,323 1,466	-8.2% -9.8%	Overall |Delta| < 10% variance -> Acceptable	For planning-level a %10-%15 level of agreement is acceptable on a monthly average basis (US EPA, 2010) (1)
	Valid 1	1,592	1,570 1,456	9.3% 7.8%		
	Valid 2	1,302	1,277 1,394	-6.5% -8.4%		
MLVSS, mg/L	Calib	1,151	1,246	-7.7%	MLVSS ratio expected to be close to MLSS since MLVSS is estimated based on VSS:TSS 0.85	Particulate BOD and VSS relationship can be adjusted. Match MLVSS before matching MLSS (US EPA, 2010) (1)
	Valid 1	1,363	1,238	10.1%		
	Valid 2	1,116	1,185	-5.8%		
WAS TSS, mg/L	Calib	3,721	4,044	-8.0%	Overall |Delta| < 12% variance -> Acceptable	Less critical to match RAS and WAS TSS concentration, as this parameter varies depending on the time of grab sampling (US EPA, 2010) (1)
	Valid 1	4,524	4,370	3.5%		
	Valid 2	3,694	4,287	-13.8%		
SRT, d	Calib	2.17	2.10	3.2%	Overall |Delta| < 14% variance -> Acceptable	-
	Valid 1	2.04	1.81	13.0%		
	Valid 2	2.11	1.88	12.0%		
AB3 Airflow, cfm	Calib	1,881	2,311	-18.6%	BioWin estimates was consistently Less than historical data records (Hourly from Historian). The fouling factor was set at 0.5. This brought the BioWin calculated air much closer the plant records. One assumption is that the diffusers may be torn or aeration flowmeter data not reliable. In aeration capacity evaluation, consider adding a safety factor or clearly stating BioWin predictions were lower than actual plant data.	-
	Valid 1	2,277	2,381	-4.4%		
	Valid 2	1,868	2,230	-16.2%		
Primary TSS Removal, %	Calib	75.29%	77.48%	-2.83%	Average value Inputted to BioWin based on historical data during the specific calib/valid period	-
	Valid 1	70.95%	73.54%	-3.5%		
	Valid 2	74.16%	76.46%	-3.0%		
Secondary TSS, mg/L	Calib	8.53	9.90	-14%	Revised to match eff TSS (-/+ 2 mg/L)	-
	Valid 1	10.01	14.41	-31%		

Table B-2. Summary of Calibration and Validation Results						
Parameter		BioWin	SAM Data	Delta	Approach/Comments	General Recommendation
	Valid 2	6.42	8.40	-24%		
Influent Flow, mgd	Calib	1.30	1.30	-0.21%	Entered hourly data that were based on Daily data multiplied by diurnal profile multipliers achieved from actual hourly historian data	-
	Valid 1	1.58	1.58	-0.2%		
	Valid 2	1.25	1.25	-0.2%		
Effluent Flow, mgd	Calib	1.30	1.32	-2.1%		-
	Valid 1	1.58	1.54	2.7%		
	Valid 2	1.25	1.36	-8.1%		
Final Effluent BOD, mg/L	Calib	6.6	17.6	-63%	BioWin estimates consistently better BOD removal than plant records	
	Valid 1	7.7	15.3	-49.3%		
	Valid 2	5.3	13.4	-60.6%		
Final Effluent Ammonia, mg N/L	Calib	39.5	42.9	-8.0%	Note the extent of nitrification is minimal. The MLSS and temperature puts the plant at the tipping point for nitrification. Note: Since we are not certain about alkalinity data, that's why I compared alkalinity removal rather than absolute alkalinity values. The Effluent Nitrate data (not summarized here) are in very good agreement.	-
	Valid 1	38.5	42.3	-8.8%		
	Valid 2	38.5	39.8	-3.3%		
Final Effluent Nitrite, mg N/L	Calib	0.078	0.144	-45%	No effluent Nitrate data is available from SAM. In general the model predicts very low nitrification. We assumed the DO levels in the first zone is significantly lower than the second zone (avg 1 mg/L in first zone, compared to avg 3-4 mg/L in the second zone). If we assume high DO in the first zone, significant nitrification would occur.	
	Valid 1	0.012	0.099	-88%		
	Valid 2	0.498	0.213	134%		

Attachment C: Hydraulic Upgrade Schematics



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AB-2	AB-2	1	11/99	PG	RECORD DRAWING
TBA	TB	REV.	DATE	BY	DESCRIPTION

DESIGNED RCM/NH/TOB
DRAWN RWW
CHECKED DMM/TDH
DATE APRIL 1996

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SEWER AUTHORITY MID-COASTSIDE

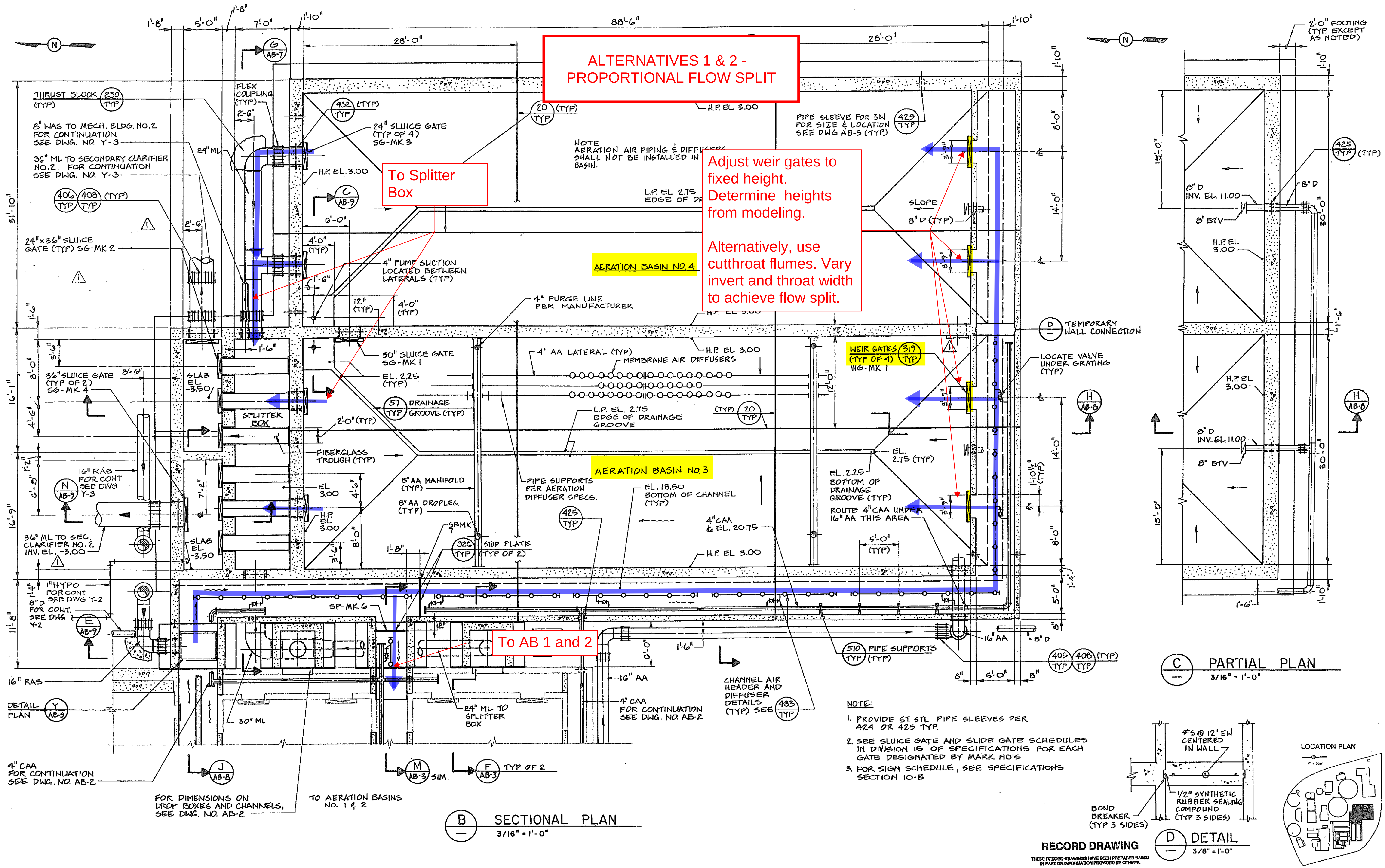
EXPANSION OF REGIONAL WASTEWATER TREATMENT FACILITY

AERATION BASINS

SECTIONAL PLAN AND SECTIONS - BASINS 1 AND 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 4249A.10
DRAWING NO. AB-2
SHEET NO. 37 of 132



△	11/99	PG	RECORD DRAWING	
REV.	DATE	BY	DESCRIPTION	

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EXPANSION OF REGIONAL WASTEWATER TREATMENT FACILITY
AERATION BASINS
SECTIONAL PLANS, BASINS 3 AND 4

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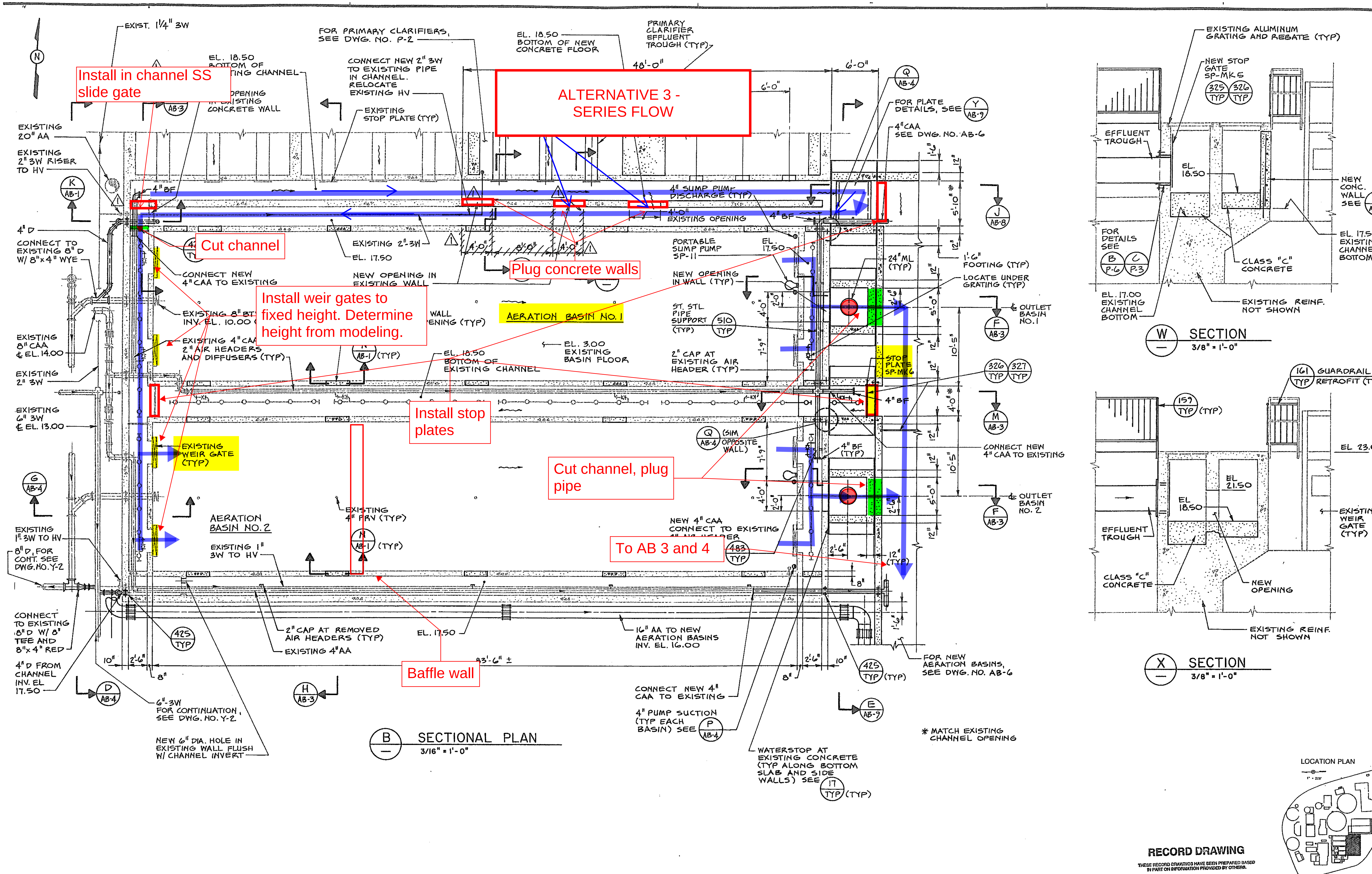
JOB NO. 4249A.10
DRAWING NO. AB-6
SHEET NO. 41 OF 132



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AB-2	AB-2	△	11/99	PG	RECORD DRAWING
TBA	TB	REV.	DATE	BY	DESCRIPTION

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AERATION BASINS

SECTIONAL PLAN AND SECTIONS - BASINS 1 AND 2

VERIFY SCALES
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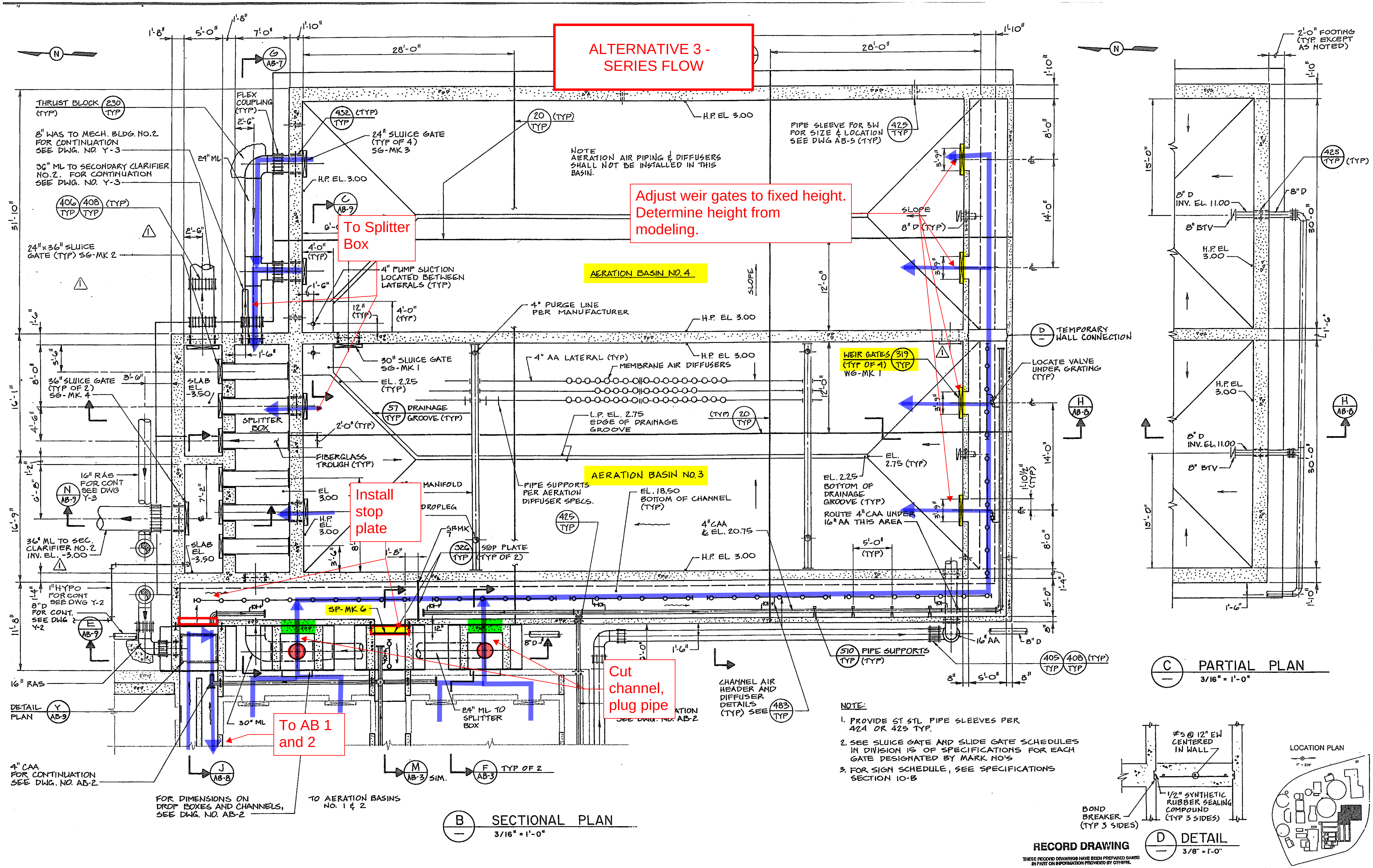
JOB NO. 4249A.10
DRAWING NO. AB-2
SHEET NO. 37 of 132



NOTE:

1. PROVIDE ST STL PIPE SLEEVES PER 424 OR 425 TYP.
2. SEE SLUICE GATE AND SLIDE GATE SCHEDULES IN DIVISION IS OF SPECIFICATIONS FOR EACH GATE DESIGNATED BY MARK NO'S
3. FOR SIGN SCHEDULE, SEE SPECIFICATIONS SECTION 10-B

RECORD DRAWING

THESE RECORD DRAWINGS HAVE BEEN PREPARED BASED IN PART ON INFORMATION PROVIDED BY OTHERS.

		1	11/99	PG	RECORD DRAWING
		REV.	DATE	BY	DESCRIPTION

DESIGNED RCM/NH
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AERATION BASINS
SECTIONAL PLANS, BASINS 3 AND 4

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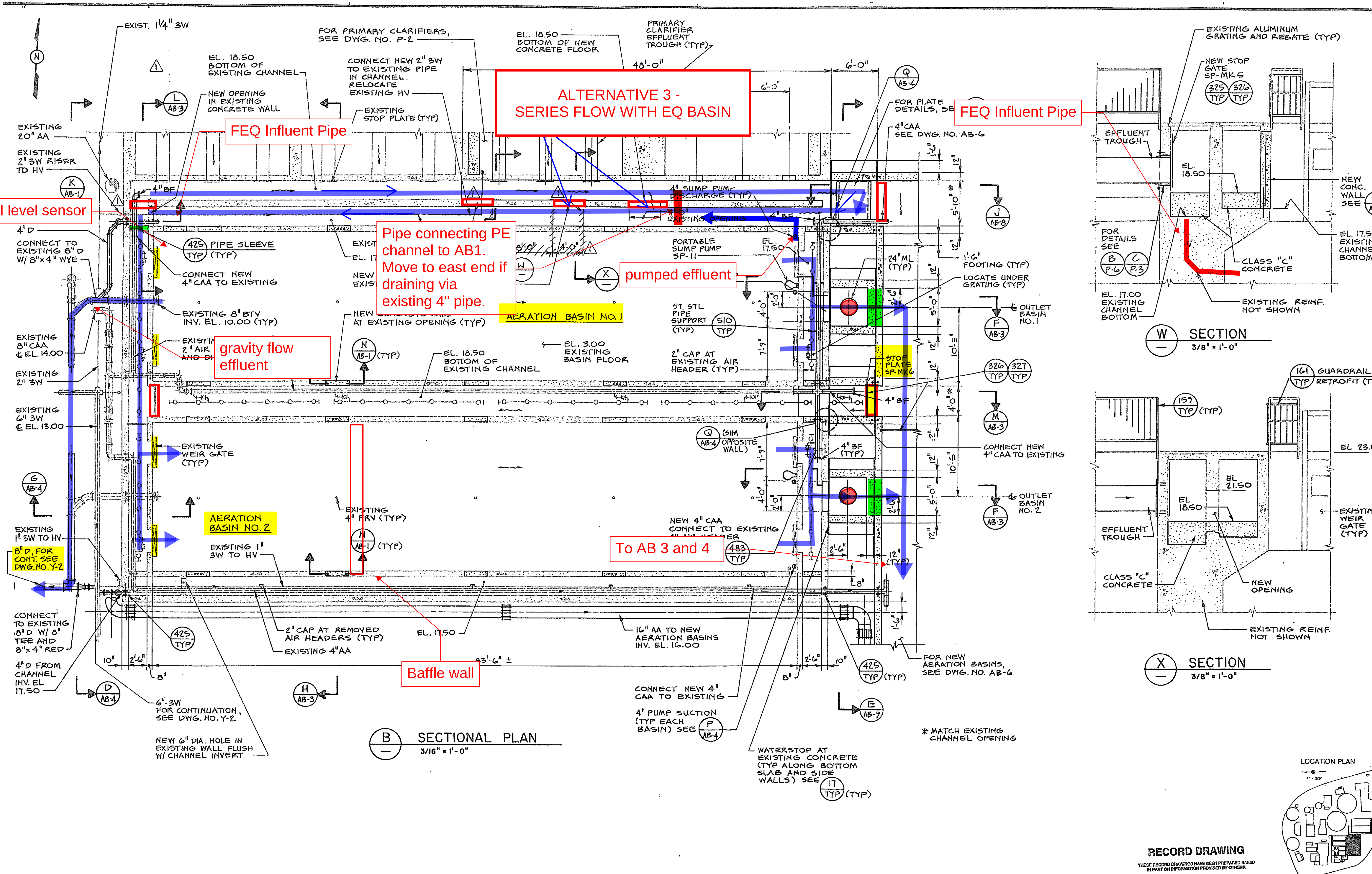
DRAWING NO AB-6
SHEET NO. 41 OF 132



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AB-2	AB-2	1	11/99	PG	RECORD DRAWING
TBA	TB	REV.	DATE	BY	DESCRIPTION

DESIGNED RCM/NH/TOB
DRAWN RWW
CHECKED DMM/TDH
DATE APRIL 1996

DISCIPLINE ENGINEER — PROJECT ENGINEER — PARTNER

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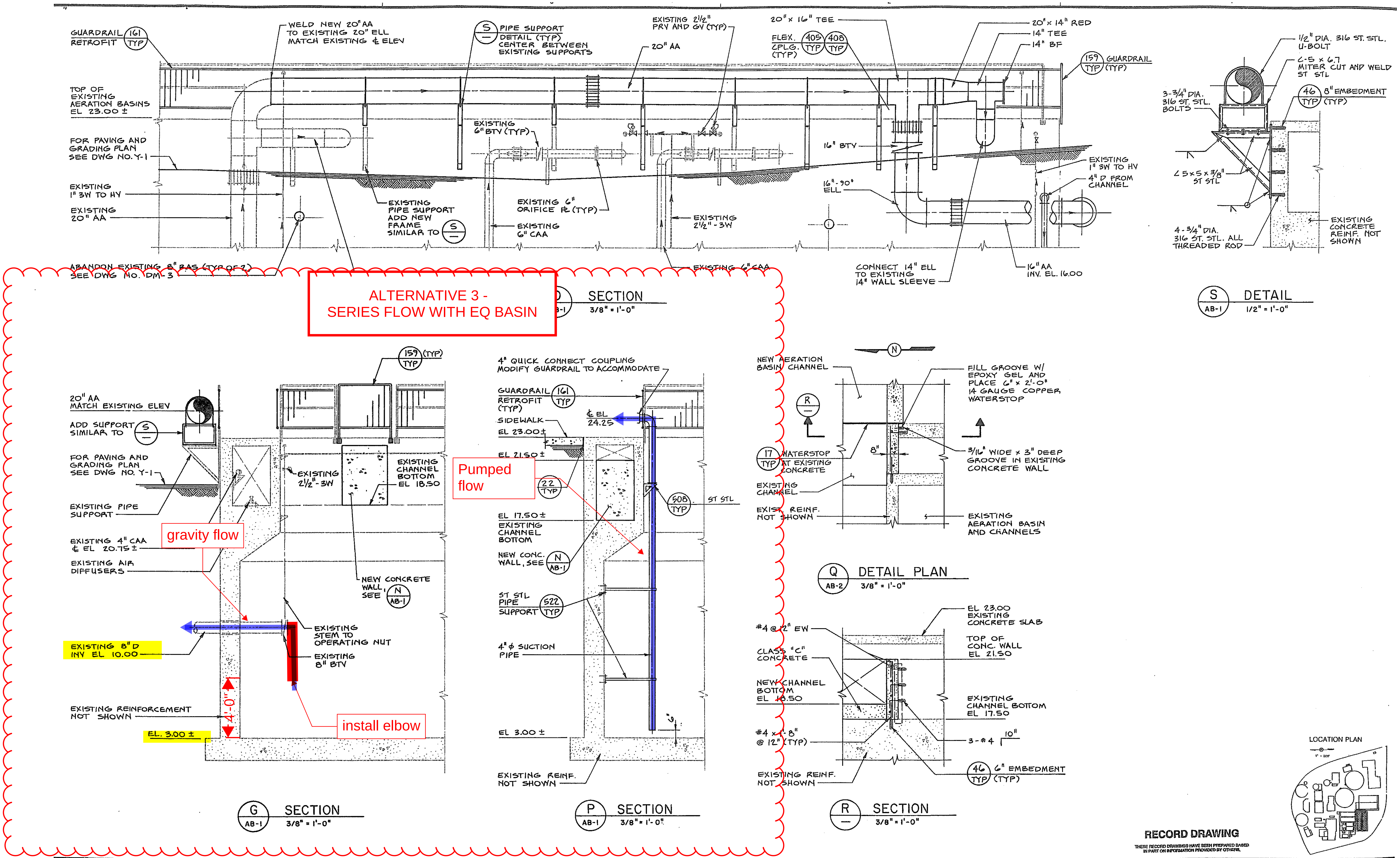
EXPANSION OF REGIONAL WASTEWATER TREATMENT FACILITY
AERATION BASINS
SECTIONAL PLAN AND SECTIONS - BASINS 1 AND 2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 4249A.10
DRAWING NO. AB-2
SHEET NO. 37 OF 132



RECORD DRAWING

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-4	AB-4		11/99		RECORD DRAWING
BA	TB	REV.	DATE	BY	DESCRIPTION

DESIGNED RCM / TOB
DRAWN RWW
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EXPANSION OF REGIONAL WASTEWATER TREATMENT FACILITY

AERATION BASINS

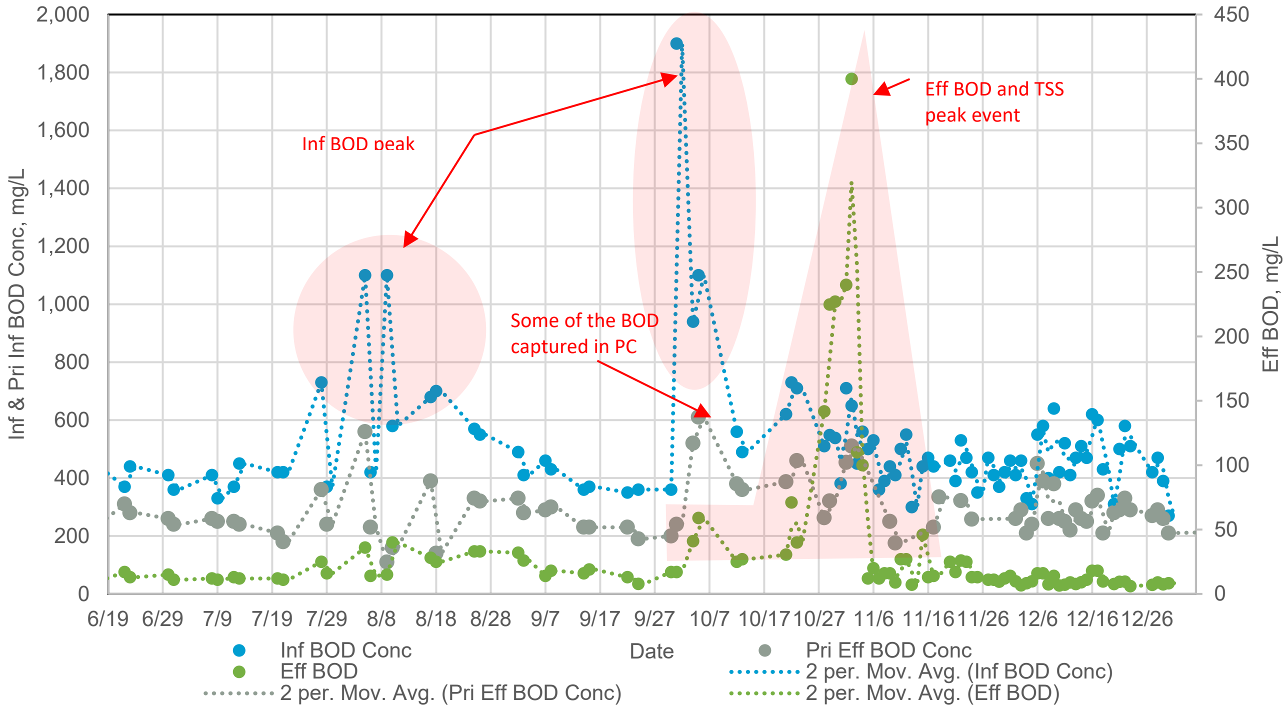
SECTIONS AND DETAILS - BASINS 1 AND 2

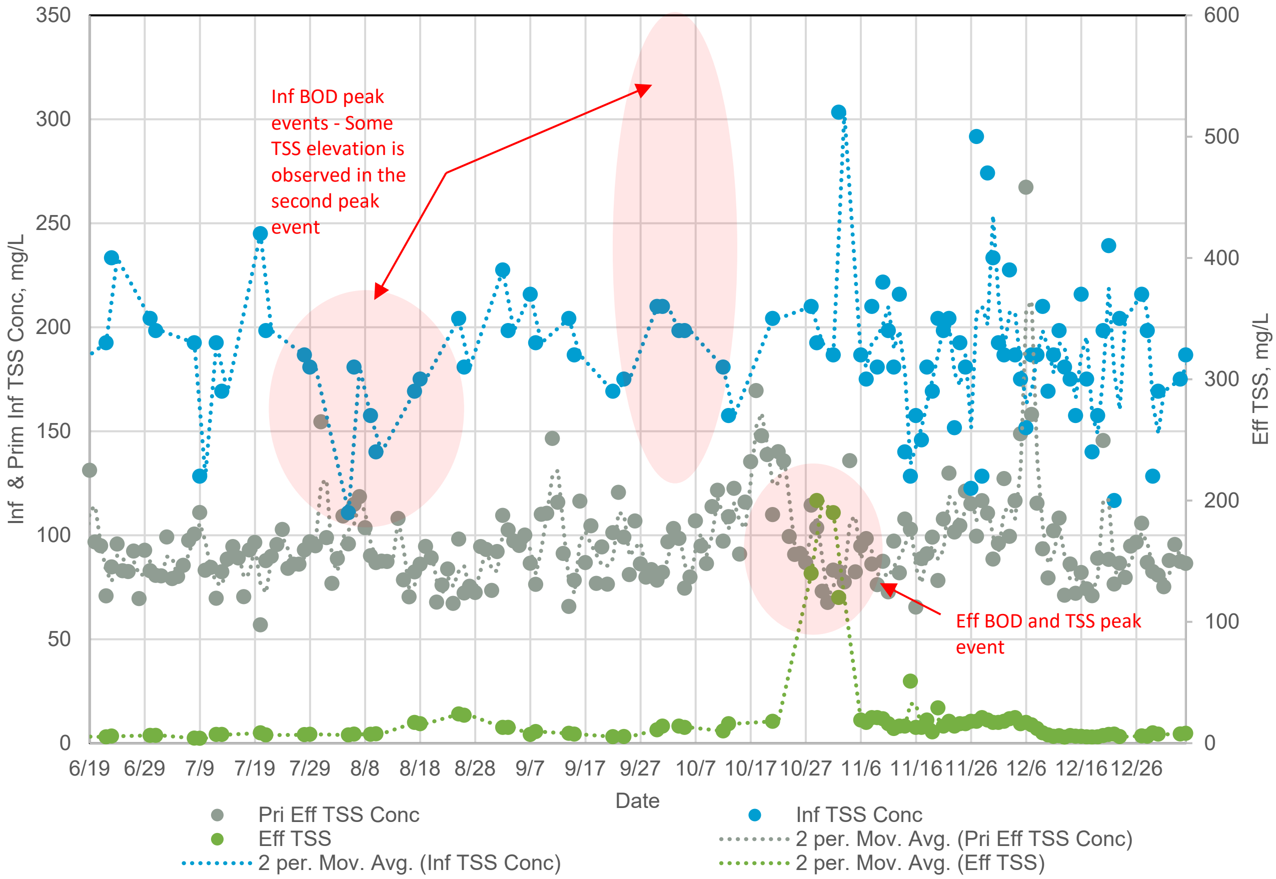
VERIFY SCALES: BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO. 4249A.10
DRAWING NO. AB-4
SHEET NO. 39 OF 132

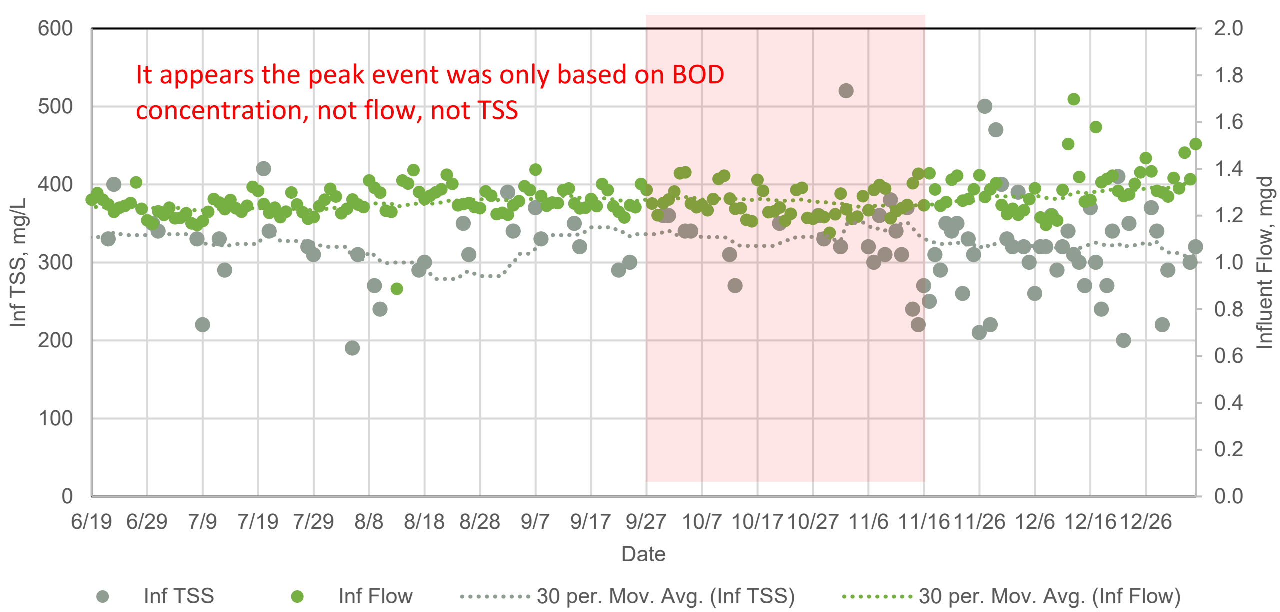
Attachment D: BOD Spike Period Plots

The following plots are provided to document the water quality data associated with the various BOD spikes that occurred in 2020.

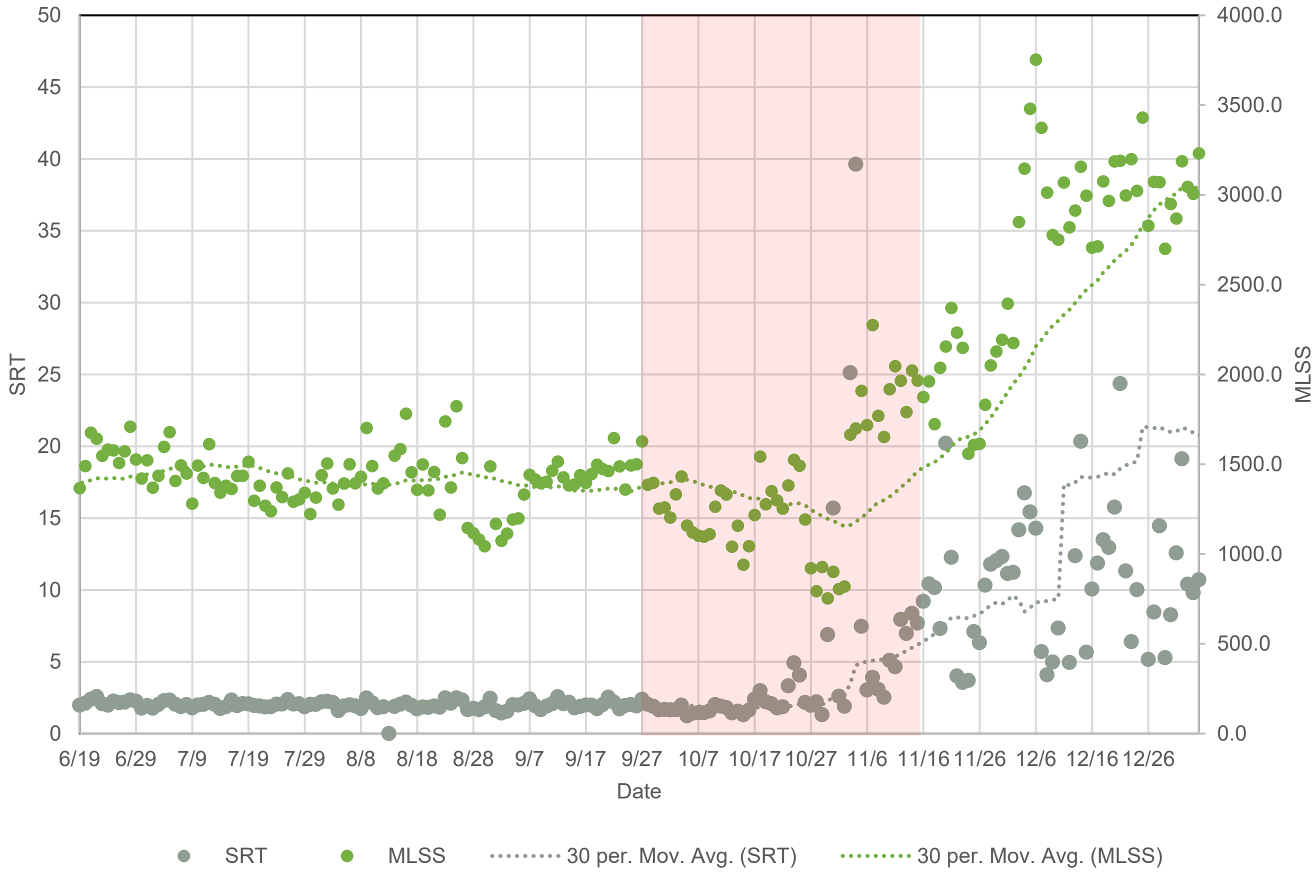




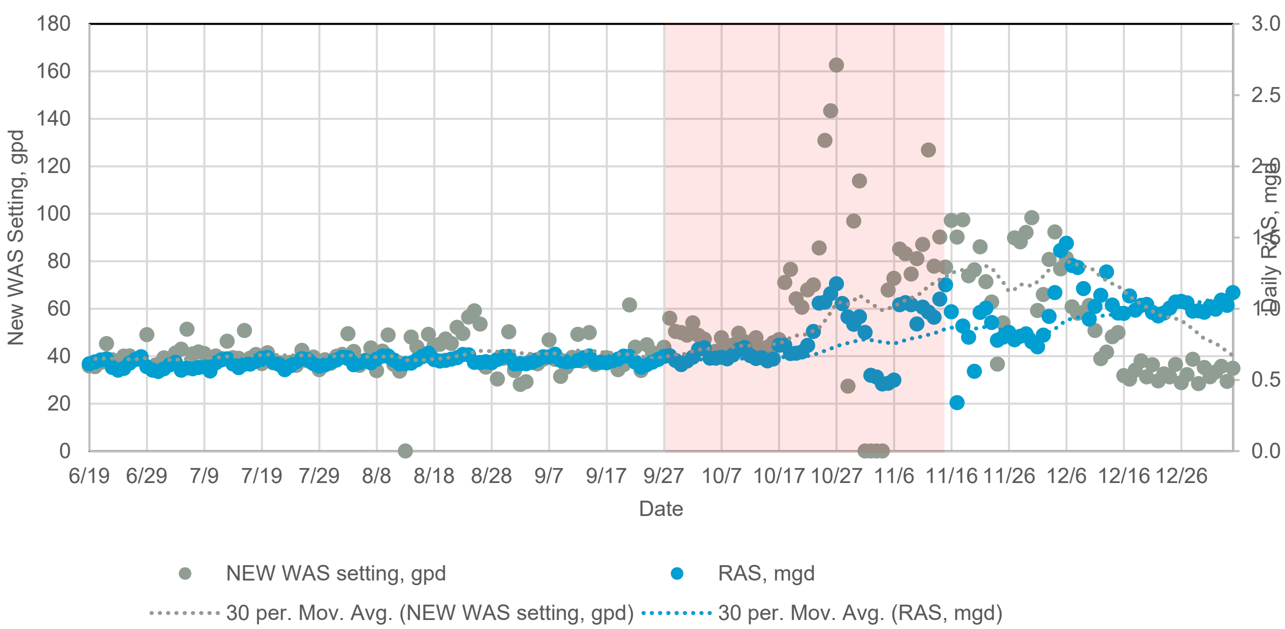
Inf BOD peak events - Some TSS elevation is observed in the second peak event
Eff BOD and TSS peak event
Inf & Prim Inf TSS Conc, mg/L
Eff TSS, mg/L
Date
Pri Eff TSS Conc
Eff TSS
2 per. Mov. Avg. (Inf TSS Conc)
Inf TSS Conc
2 per. Mov. Avg. (Pri Eff TSS Conc)
2 per. Mov. Avg. (Eff TSS)



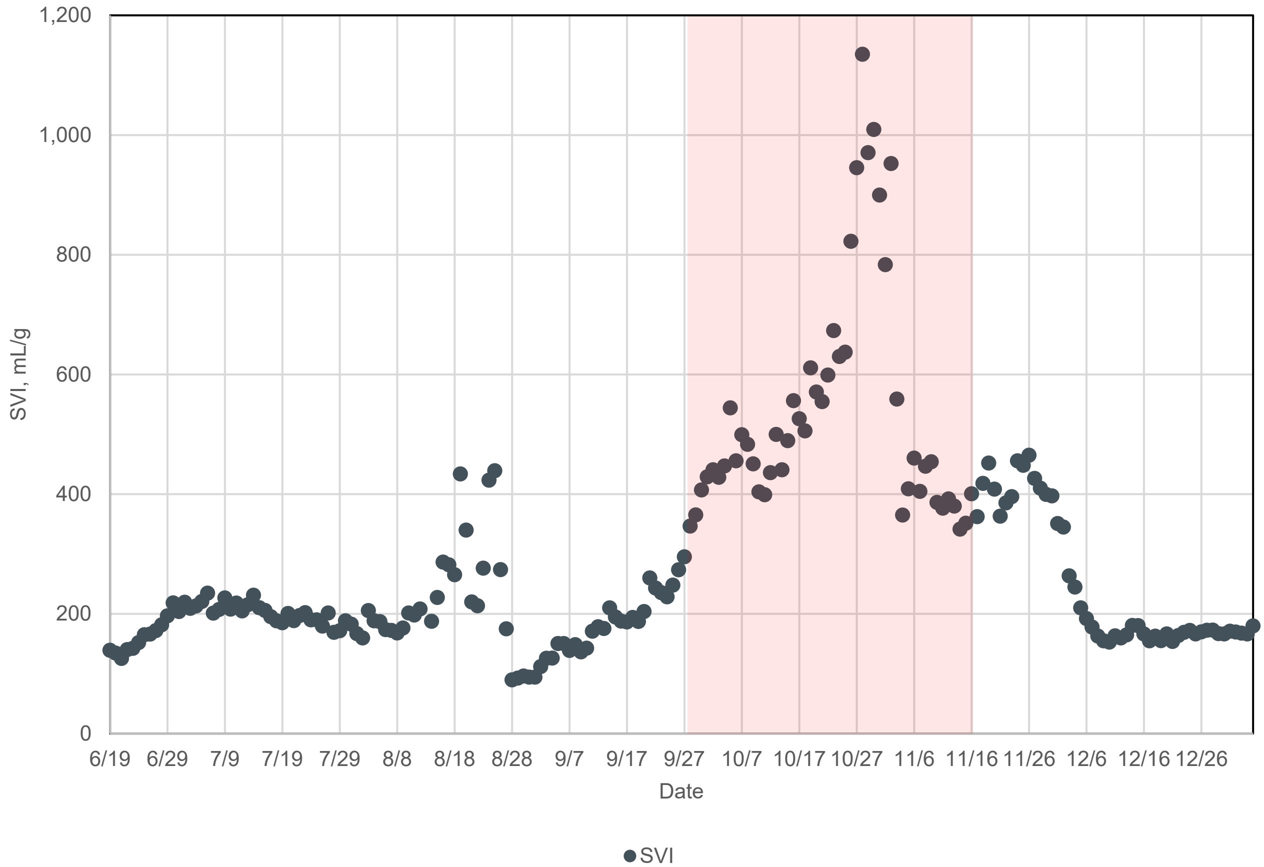
It appears the peak event was only based on BOD concentration, not flow, not TSS
Inf TSS, mg/L
Influent Flow, mgd
Date
Inf TSS
Inf Flow
30 per. Mov. Avg. (Inf TSS)
30 per. Mov. Avg. (Inf Flow)



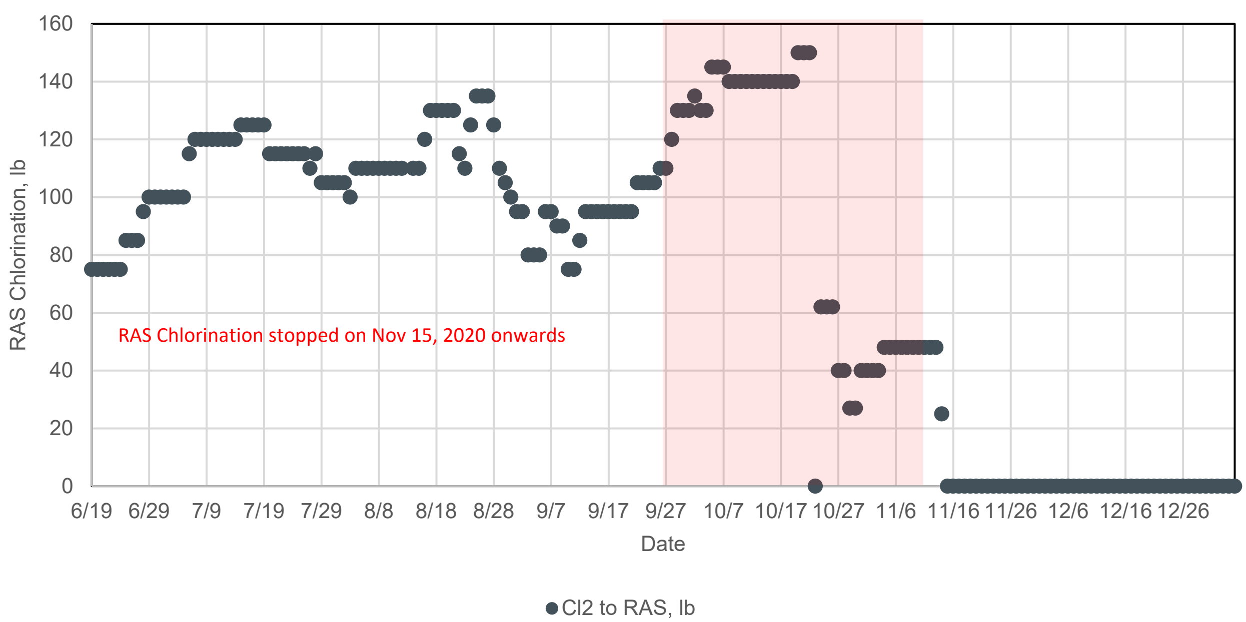
SRT
MLSS
Date
6/19 6/29 7/9 7/19 7/29 8/8 8/18 8/28 9/7 9/17 9/27 10/7 10/17 10/27 11/6 11/16 11/26 12/6 12/16 12/26
0 5 10 15 20 25 30 35 40 45 50
0.0 500.0 1000.0 1500.0 2000.0 2500.0 3000.0 3500.0 4000.0
SRT
MLSS
30 per. Mov. Avg. (SRT)
30 per. Mov. Avg. (MLSS)



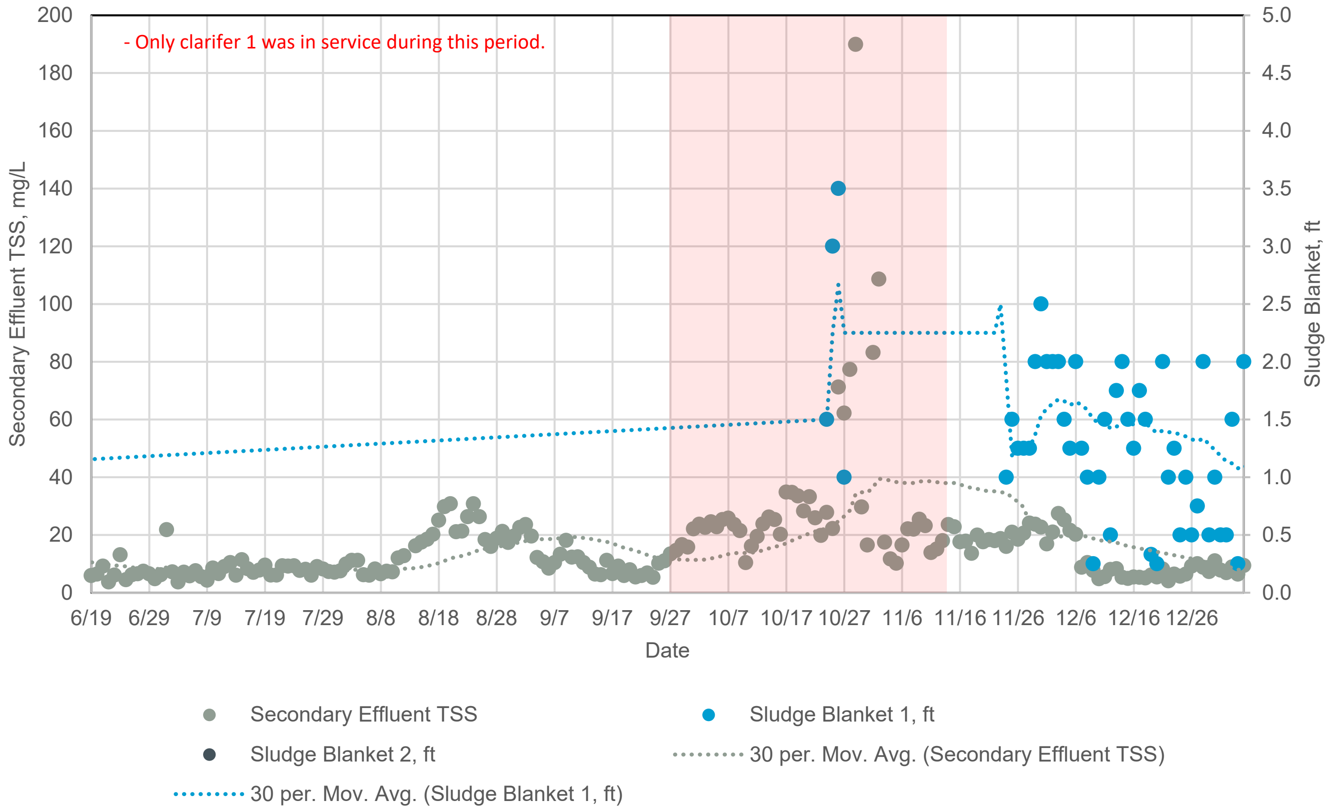
New WAS Setting, gpd
Daily RAS, mgd
Date
6/19 6/29 7/9 7/19 7/29 8/8 8/18 8/28 9/7 9/17 9/27 10/7 10/17 10/27 11/6 11/16 11/26 12/6 12/16 12/26
0 20 40 60 80 100 120 140 160 180
0.0 0.5 1.0 1.5 2.0 2.5 3.0
NEW WAS setting, gpd
RAS, mgd
30 per. Mov. Avg. (NEW WAS setting, gpd)
30 per. Mov. Avg. (RAS, mgd)



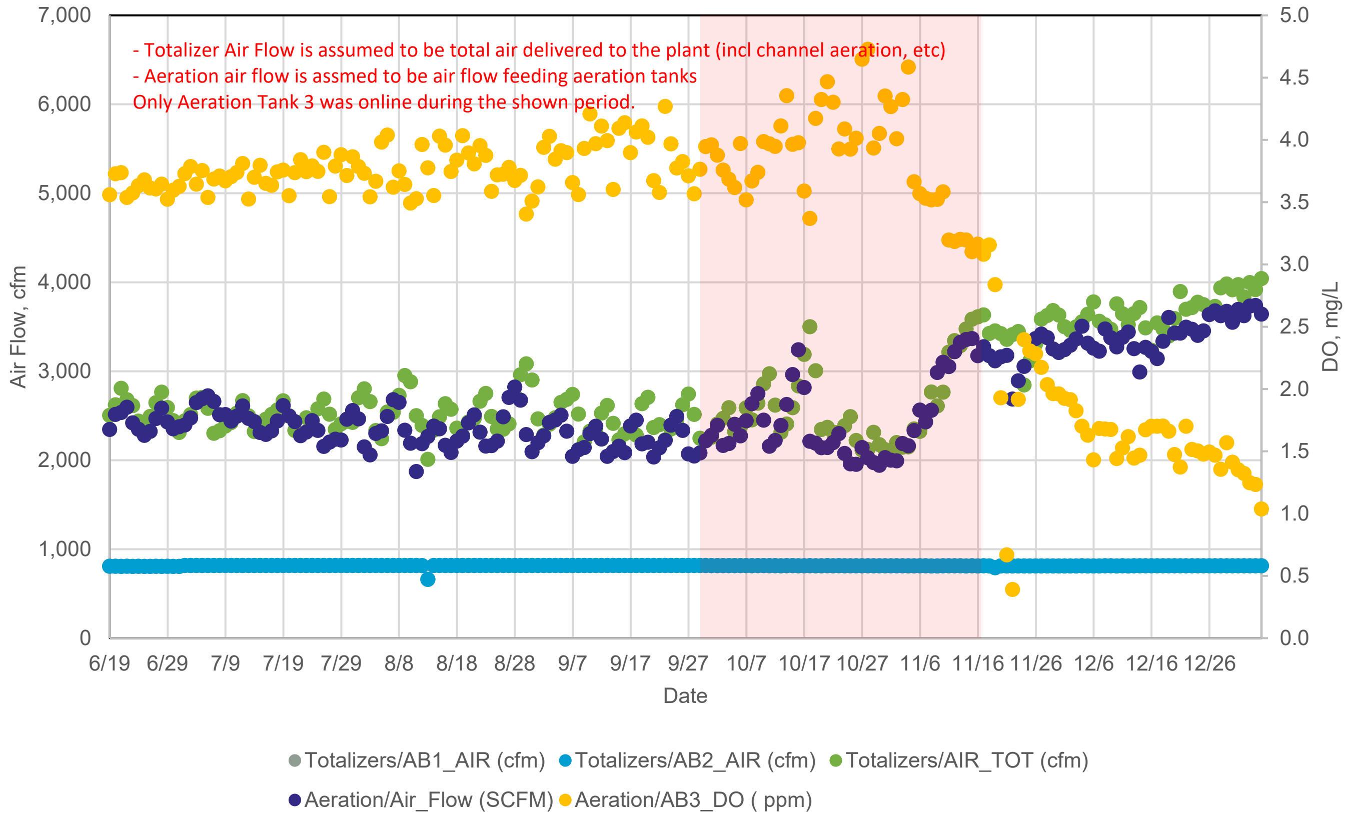
1,200
1,000
800
600
400
200
0
SVI, mL/g
6/19 6/29 7/9 7/19 7/29 8/8 8/18 8/28 9/7 9/17 9/27 10/7 10/17 10/27 11/6 11/16 11/26 12/6 12/16 12/26
Date
SVI



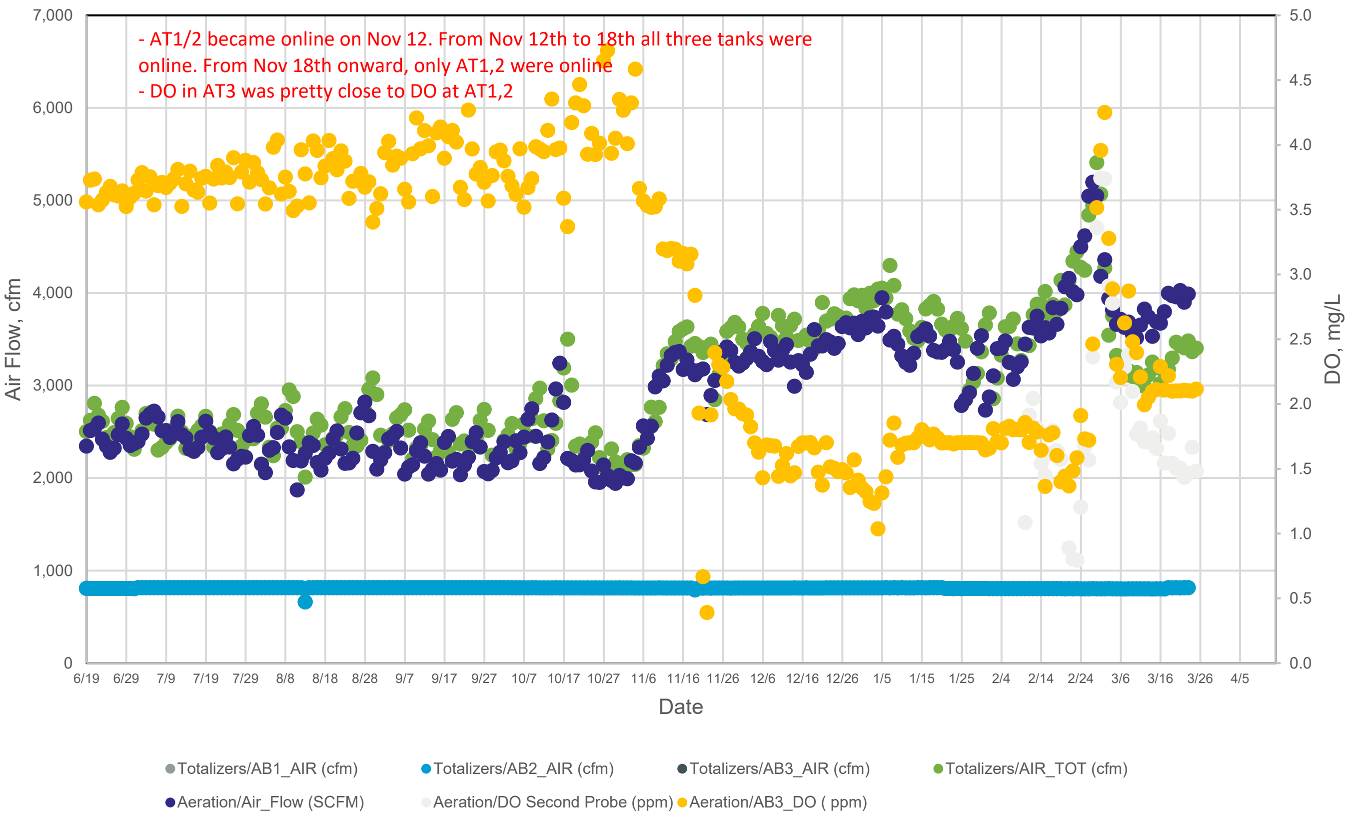
160
140
120
100
80
60
40
20
0
RAS Chlorination, lb
RAS Chlorination stopped on Nov 15, 2020 onwards
6/19 6/29 7/9 7/19 7/29 8/8 8/18 8/28 9/7 9/17 9/27 10/7 10/17 10/27 11/6 11/16 11/26 12/6 12/16 12/26
Date
Cl2 to RAS, lb



- Only clarifer 1 was in service during this period.
Secondary Effluent TSS, mg/L
Sludge Blanket, ft
200
180
160
140
120
100
80
60
40
20
0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6/19 6/29 7/9 7/19 7/29 8/8 8/18 8/28 9/7 9/17 9/27 10/7 10/17 10/27 11/6 11/16 11/26 12/6 12/16 12/26
Date
Secondary Effluent TSS
Sludge Blanket 1, ft
Sludge Blanket 2, ft
30 per. Mov. Avg. (Secondary Effluent TSS)
30 per. Mov. Avg. (Sludge Blanket 1, ft)



- Totalizer Air Flow is assumed to be total air delivered to the plant (incl channel aeration, etc)
- Aeration air flow is assmed to be air flow feeding aeration tanks
Only Aeration Tank 3 was online during the shown period.
Air Flow, cfm
DO, mg/L
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6/19 6/29 7/9 7/19 7/29 8/8 8/18 8/28 9/7 9/17 9/27 10/7 10/17 10/27 11/6 11/16 11/26 12/6 12/16 12/26
Date
Totalizers/AB1_AIR (cfm)
Totalizers/AB2_AIR (cfm)
Totalizers/AIR_TOT (cfm)
Aeration/Air_Flow (SCFM)
Aeration/AB3_DO (ppm)



The above documented actual data from the BOD spike. The following describes a modeling effort to

Attachment E: Operations TM

18500 Von Karman Avenue, Suite 1100
Irvine, CA 92612

T: 714.730.7600

DRAFT Technical Memorandum

Subject: Operations Support for Recent Sludge Bulking Event

Date: June 24, 2021

To: Kishen Prathivadi, P.E., PMP

From: Lance P. Salerno, QEP, Senior Principal O&M Consulting

Copy to: Michael Harrison, P.E., Director

Section 1: Introduction

1.1 Purpose and Background

Purpose

The purpose of this memorandum is to summarize initial observations, findings, and recommendations implemented to evaluate the process upset situation over the period from June 09, 2021 to June 21, 2021.

While findings here may be incorporated or considered by the final long term process evaluation study, this TM is intended to be near term in response to the process upset.

Background

Brown and Caldwell has been conducting a treatment process and capacity evaluation for the Sewer Authority Mid-Coastside (SAM) to evaluate long term improvements to the process and supporting SAM through the recent rehabilitation of Aeration Tank 3 with fine bubble diffusers. The Aeration Tank 3 work was completed and brought on-line at the end of May 2021. There are several long-term alternatives currently under consideration by the SAM and BC Team to improve performance and increase capacity:

- Option 1- Use Aeration Tanks 3 and 4 – Add diffusers, piping, instrumentation, foam sprays and rehabilitate the weir gates in Basin 4.

- Option 2- Use Aeration Tanks 1,2, and 3 –Replace the coarse bubble diffusers with fine bubble diffuser in Tanks 1 and 2, add new weir gates, install new baffle walls in Tanks 1 and 2.

- Option 3- Operate tanks 2 and 3 in series, converting tank 2 into an anaerobic biological selector zone followed by an aerobic zone to help with filament control. Install fine bubble diffuser and mixer and baffle wall in Tank 2. Provide flow distribution modifications to the Tank 2 effluent side so that flow goes back into the mixed liquor channel and it flows to basin 3. Additionally, to add redundancy Basin 4 would also be outfitted.

- Option 4 – Operate Tanks 2 and 3 in series as in Option 3, and use tank 1 as an equalization basin. Provide modifications in primary effluent channel to allow higher flows to overflow into Basin 1 and install return pumps in basin 1 to pump out during low diurnal flow periods.

While undertaking this study the SAM wastewater treatment plant experienced a condition of poor settling in the secondary clarifiers and decreasing Mixed Liquor Suspended Solids (MLSS) in early June 2021.

SAM requested BC to assist in evaluating the immediate problem and to help identify mitigation measures. BC sent an operations subject matter expert (SME), Mr. Lance Salerno to the site June 09, 2021, June 16, and June 21, 2021 accordingly.

Section 2: Results

2.1 Aeration Basin MLSS and SVI (5/30-6/21)

After the changeover to fine bubble diffuser in aeration basin 3 was completed in May, the MLSS continued to increase to 2,320 mg/L as of June 4, 2021 with an associated SVI of 226 mL/gm. After this point the MLSS decreased daily, settleability decreased and the associated SVI increased rapidly for the next four days even though the plant was reducing wasting. Aeration basin MLSS reached a low of 1,228 mg/L on June 8th. A profile of MLSS and SVI are shown in Figure 1.

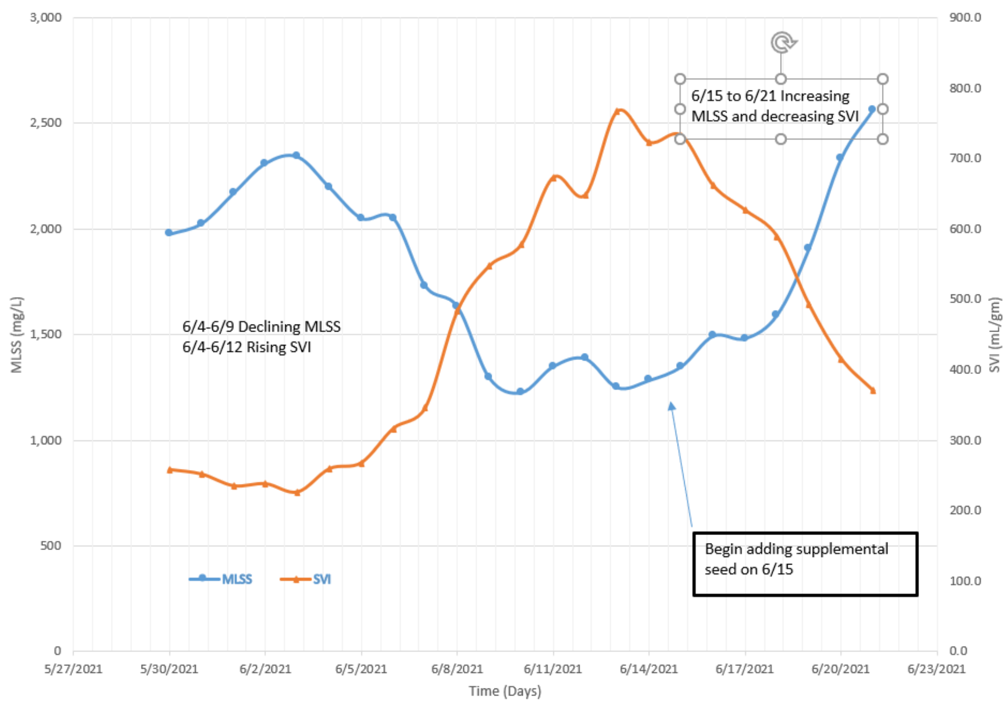


Figure 1. MLSS and SVI (May 30-June 21, 2021)

Field observations by plant staff and initial microscopic exam indicated high amounts of filamentous growth and bulking conditions causing the poor settling. The secondary sludge blanket readings indicated poor compaction with between zero and two feet of heavier good settling sludge and an increased dispersed layer that reached up to fourteen feet on June 15. During this period, a second final settling tank was brought online by plant operations to help with maintaining effluent quality, which helped for a few days. After that, the plant ended up with two clarifiers with dispersed and bulking blankets. This resulted in a low aeration basin sludge retention time but a high mean cell retention time, with most of the sludge inventory in the secondary clarifiers. Wasting concentrations were very low as the sludge was not compacting sufficiently to waste sufficient mass out of the secondary clarifiers. The plant adjusted wasting from 8 hours during the day to a 14-hour cycle overnight, to increase the duration and volume of wasting. Waste sludge was pumped to an out of service aeration tank and fed to the rotary drum thickener during the day.

Normally the plant adds a maintenance dose of chlorine, however, the bulking event still occurred. Due to the dramatic decrease in MLSS and potential concerns about over chlorination, chlorine addition was stopped for a few days, without benefit to reducing the filaments. After that, the dose was increased to as high as 10 pounds of chlorine per 1,000 pounds of MLSS at the RAS for several straight days, again without benefit to reducing filaments. Once the MLSS began to increase after June 15, a chlorine dose was maintained at about the historical maintenance level of 3-4 pounds per 1,000 pounds of MLSS.

Due to suspected bio-inhibition or toxicity to the biomass, the plant began adding daily supplemental seed using a proprietary product called EBS Biostar™ on June 15, 2021 at a dose of five gallons per day. EBS Biostar™ is a dry concentrated form that contains a wide spectrum of both aerobic and facultative bacteria plus enzymes.

Since beginning addition of the product, the MLSS has continuously increased, SVI steadily decreased and wasting volumes are approaching normal, however, settling was still impaired. As of the June 21 time frame, plant operations microscopic examination reports the same 021N filament in abundance, with an increase amount of normal floc and an increase in the number of free swimmers.

2.2 Microscopic Examination of the Activated Sludge

Aeration basin mixed liquor samples were collected and sent to two separate Micro Labs for analysis to confirm the type of filament present and evaluate root cause. Results from both laboratories are provided in Appendix A. Both laboratories identified the predominant filament as type 021N. This type of filament can be caused or proliferate with conditions of septicity, nutrient imbalance and/or low D.O. Type 021N has been reported as sometimes being highly resistant to chlorination. Plant microscopic exams did not indicate any fracturing of the filaments when dosing went up to 10 pounds per 1,000 pounds of MLSS, which is on the high side of the range of what can be added to an aeration basin. Doses at these levels or higher are risky as it can potentially impact the good bacteria.

A higher extra polymeric substances (EPS) value of 23% was reported by the lab report, which may indicate nutrient deficiency. However, higher EPS can also result from toxicity such as over-chlorination. An initial soluble phosphorus analysis was conducted with the microorganism test and reported almost no available soluble ortho-phosphate indicating possible deficiency. However, a test on the cells estimated that sufficient phosphorus was present in the actual biomass; thus the results were not clear.

Ferric chloride which is known to precipitate phosphorus is dosed at the influent to the plant and is not flow paced at the headworks, so there is the potential to overdose or underdose at times of the day due to the diurnal variability in flow. Ammonia, organic nitrogen, total and ortho-phosphate are not tested by the plant in the process, thus there is insufficient information to comment on whether actual nutrient imbalance relates to the 021N observations. Testing of nutrients in the future for the primary effluent and secondary effluent has been identified and the plant will be implementing ammonia testing accordingly. It is recommended that the plant implement testing for primary effluent and secondary effluent filtered total phosphorus and ortho-phosphorus on a regular basis.

2.3 Polymer

Since the chlorination was not effective to control the filaments, use of polymer was implemented. The plant has not historically used polymer for settling, so the polymer product typically used to thicken the waste activated sludge in the rotary drum thickener was used as an immediate measure. Dosing was attempted at several locations, including the aeration influent and the secondary center ring; however, dosing and mixing was not optimal. A temporary addition location in the aeration tank effluent channel was selected for polymer addition as it has high turbulence and drops to a pipe and comes up through the bottom of the secondary clarifier providing an opportunity for increased contact time and flocculation.

A representative from the polymer provider, Polydyne came out to the site on June 16, 2021 to screen various wastewater polymer products to help with settling. A high charge high molecular weight polymer product was identified that provided clearer supernatant relative to the current polymer product at a dose as low as 2.5 ppm and seemed to be optimal at a jar test dose of 4 ppm. Figure 2, below, shows a picture from the polymer testing, after about 20 minutes of settling.

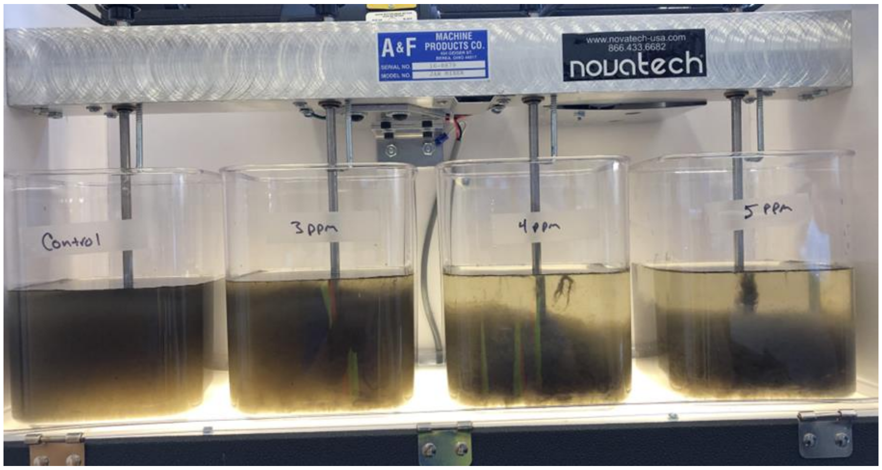


Figure 2. Polymer jar testing.

The doses identified in jar testing are relatively high for secondary polymer addition, without specialized mixing equipment, and the application dose should be verified based on full scale application. A recommendation is to initially target a lower dose of 1 to 2 ppm on full scale, and slowly increase based on observed performance as it benefits settling. Once excess polymer is observed on the surface and/or benefits to settling diminish, the application dose should be reduced.

A settleometer test was conducted using aeration sludge from before the polymer addition point and after polymer addition, and plant reported a 30-minute settleometer test that improved from about 950 mL/L settled in 30 minutes without polymer to 350 mL/L and an SVI of 119 mL/gm with the existing polymer. A target dose of about 2 ppm polymer from a 0.6 percent make-up solution in the day tank was in use at the time. These observations suggest that polymer addition results in a significant improvement in settling. It is recommended that the plant continue to conduct settleometer tests with and without polymer. This will help track if there is improvement in the settling without polymer and when it can be reduced or discontinued.

The new polymer product and a temporary blending unit to make up the polymer is expected the week of June 21, 2021. It will be dosed on an as-needed basis to help settling and discontinued once it is no longer needed.

2.4 Septicity Evaluation

Type 021N and various other filaments grow with conditions of septicity are present due largely tothe associated sulfides and organic acids. There were several sources of septicity identified during conversations with plant staff and steps taken to address the area to the extent possible. These include:

- There is a rather large collection system with several pump stations. The distances and dry weather were identified as potential sources of septicity formation. The pump stations are known sources, and two of them have sodium hypochlorite that is added. We visited one pump station, Princeton Pump Station, and noticed an excess amount of grease buildup in the wet well. As grease and associated fatty acids can lead to filamentous growth, cleaning the pump stations regularly was identified as a step that can be taken towards mitigating septicity. The plant also identified that sampling was conducted recently to try and identify the potential source of the upset. While the data was not provided as part of this study, a particular sample was reported with a very high level of BOD. Since filaments grow very rapidly, it is recommended to repeat sample any locations above a normal level of constituents to assess whether there may be a source system in the system that needs to be addressed.
- Bubbles, which are characteristic of degassing, have been observed in the primary clarifiers early in the morning. Historically, it was reported that two primary clarifiers were used during dry weather and three during wet weather. Three primary clarifiers were in service at the time the event started. The process team reviewed model predictions and confirmed that under normal dry weather conditions only two primary clarifiers are needed. The plant removed one of the three primary clarifiers in service to decrease the hydraulic retention time and associated potential for septicity formation, particularly during low flow periods of the day.
- To to evaluate septicity sources, a surrogate screening parameter was tested by measuring oxidation reduction potential (ORP) at several locations in the plant. ORP was tested at several locations in the plant using a pre-calibrated rental ORP probe and meter to help rapidly screen whether there are potential sources of septicity and whether there could be steps taken to control it. Table 1 summarizes the data from one snapshot in time collected on June 21, 2021 at about 11:00 AM, which is a time during relatively higher diurnal flows. The lowest measured ORP values were at the bottom of the aeration basin near the effluent weir. However, the dissolved oxygen (DO) in the tank was 3.4 mg/L at the deepest point to 4.3 mg/L closer to the surface that while reduced conditions may be present, there is still measurable dissolved oxygen (DO) throughout. This could indicate a heavier layer of organic material towards the bottom creating reduced conditions and should be checked. This could be evaluated using a portable TSS meter to check whether there is a layer of sludge near the bottom creating organic acids that could lead to filaments. There was at least one or two locations in the aeration basin where excessive bubbling was observed, which is indicative of a loose or broken diffuser.

Table 1. ORP and DO Data from 6/21/21				
Headworks	Primary Effluent	Aeration Effluent	Belt Filter Press Filtrate	Secondary Clarifier #1/ #2
ORP -90 mv	PST 3 ORP -83 mv PST 2 ORP -90 mv	ORP -58 mv (3 feet) ORP -150 mv (near bottom)	ORP -110 mv	Outer portion bottom: ORP -134/-148 mv Center Well: -134/-139 mv
DO 4.0 mg/L	PST 3 DO 2.7 mg/L PST 2 DO 2.6 mg/L	DO 4.3 mg/L (near surface) DO 3.8 mg/L (in-situ probe) DO 3.4 mg/L (near bottom)	D.O. 7.0 mg/L	Outer portion bottom: DO 2.0 /1.8 mg/L Center Well: 2.0 mg/L/ -

Section 3: Summary and Recommendations

Summary

The bulking event of early June 2021 was the result of poor settling caused by excessive growth of aa filamentous bacteria identified as 021N. There are various causes of 021N that are commonly described as septicity, nutrient deficiency and/or low dissolved oxygen. Whether the root cause of the actual event was transient or persistent cannot be determined at this time based on the information available. This is based on the observation that the poor settling event was accompanied by a rapid decrease in aeration mixed liquor concentration, reduced good floc formation, decrease in free swimming micro-organisms and a reduction in BOD_5 removal performance, indicating that it may have been an inhibitory or transient event that caused the 021N to proliferate. However, even though growth has returned to normal and settling has improved, the filaments are still present indicating that the activated sludge treatment system is still vulnerable to a recurrence.

Septicity is one potential cause of 021N proliferation. Septicity is potentially generated in many areas of the collection system and the wastewater plant. The collection system was not evaluated, however, it is a known source of odors (and associated septicity), and any steps that can be taken to mitigate septicity are prudent.

The plant is considering adding a product to the headworks to help reduce septicity. While it has not been evaluated, a trial period with close observation is supported. Primary clarifiers operations were modified to reduce the number in service to reflect the dry weather operating conditions. The recently modified aeration basin should be checked to evaluate whether there is a layer of sludge beneath the diffuser, and if so, whether the upwelling observed is due to a broken diffuser(s).

A potential area for septicity and risk in the plant has been the sludge inventory in the secondary clarifiers associated with the very deep blankets, which far exceeded the mass in the aeration basin during the upset period. The plant should continue to use wasting and filament mitigation to reduce the amount of inventory in the secondary clarifiers, then return to only one in service.

As an addendum to the onsite study, as of June 22 and June 23, plant data indicate that settling has continued to improve and blankets have decreased to 0.5 feet in one clarifier and 2.5 fee in the second clarifier. While settling has improved it is suggested to continue to be proactive with wasting and polymer addition until filaments are back to historical normal levels and observations confirmed by a laboratory that specializes in advance microscopic examinations and filament identification.

3.1 Recommendations

Since the root cause of the filaments has not yet been identified, the following recommendations are made holistically to continue proactive mitigation efforts to evaluate septicity, nutrients and process operations considerations. The numbering is for convenience only.

Septicity Related Recommendations

1. Reduce number of in-service primary settling tanks from three to two during dry weather flows. Complete.
2. Check the aeration basin total suspended solids concentration near the bottom of the tank using a handheld TSS meter.
3. Check the aeration basin for broken diffusers in locations of upwelling and replace/repair as necessary. Since the plant is on one aeration basin currently and DO is being maintained at or above setpoint, this may not be a near term activity, but should be considered pending the outcome of the TSS evaluation.
4. Remove accumulated surface grease on the pump stations on a regular basis (e.g., annually).
5. Follow-up on elevated BOD observed in the collection system until a source is identified.
6. Continue to collect and evaluate ORP data, aqueous sulfides and organic acids (VOAs) periodically to assist in efforts to reduce septicity in the overall collection and treatment system.
7. Return secondary clarification to one secondary clarifier, after the process stabilizes, and minimize blanket levels to less than 2 feet at all times.
8. The plant has identified a product (from Aquafix) used with septic influent wastewater and filament problems to help freshen up the influent entering the plant and reduce septicity. The goal of the product is consistent with the current situation, however, this product was not and the plant will need to work out dosing and details with the provider directly.

Nutrient Related Recommendations

9. Flow pace the chemically enhanced primary treatment (CEPT) chemicals. Until this is complete, reduce the amount of ferric chloride, if possible, with close evaluation and monitoring of digester sulfides.
10. Test for filtered total phosphorus and ortho-phosphorus in the primary effluent and the secondary effluent on at least a weekly basis.
11. Begin testing primary effluent and secondary effluent for ammonia nitrogen when nitrite and nitrate samples are collected. Evaluate the RDT side stream and filter press side stream for nutrients and COD.
12. Avoid operating the RDT and Filter Press at the same times, and alternate days if possible, to help mitigate surges of nutrients back to the aeration tank.

Process Related Recommendations

13. Identify a polymer, addition and storage system that can be used to aid settling on an as necessary basis.

14. Conduct daily settleometer testing before and after polymer addition.
15. Establish a methodology for conducting jar testing to optimize the polymer dose, if necessary.
16. Continue to waste sludge over as long a period as possible to mitigate rapid swings in mixed liquor concentration during the day.
17. Maintain a lower chlorine addition rate to the RAS, and only add if necessary.
18. Continue to add a bio-augmentation product until the activated sludge process stabilizes. Maintain supplemental bio-augmentation product at the plant in the event a future recurrence happens involving reduced or no growth of aeration biomass. The EBS Biostar™ bio-augmentation product showed effective performance. Sources of seed sludge from nearby municipalities may also be considered but need to be vetted in advance for compatibility.
19. Conduct external micro-biology examination on a regular (e.g., weekly) basis until the activate sludge process fully stabilizes and filaments are reduced to normal levels.
20. Increase the DO setpoint from 3.2 mg/L to the extent possible, while the secondary blankets are deep (4' or greater) to reduce possibility of organic acid formation.

Microbiology Laboratory Reports

ENVIRONMENTAL
BUSINESS SPECIALISTS, LLC

Activated Sludge Microbiological and Chemical Evaluation
Sewer Authority Mid Coastline (SAM)
Half Moon Bay, CA
June 15, 2021

Purpose:

The following report provides data, pictures, and comments regarding the analysis of two samples (MLSS and RAS) collected from the Sewer Authority Mid Coastline wastewater treatment plant (WWTP) in Half Moon Bay, CA. An EBS employee was contacted due issue surrounding solids carryover from the secondary clarifier. The samples were collected on June 15th, 2021 and received by the EBS laboratory in Mandeville, LA, the following day. The samples underwent microscopic examinations with filament identification, advanced microbiological analyses, and chemical analyses. Comments regarding sample analysis can be found below. Appendices A, B, and C containing tables, photos, and the EBS reference guide, are attached to this report.

Executive Summary:

- After a thirty-minute settling test, neither the MLSS or RAS sample settled.
- Filament abundance was observed in excessive amounts in both the MLSS and RAS samples. This level of filaments is likely creating the issues with settling and compaction.
- The filaments present showed no observable effects from recent chlorination efforts.
- Exocellular polymeric substances (EPS) made up 23% of the volatile suspended solids. Elevated EPS concentrations can also negatively impact sludge settleability.
- Our analysis determined the phosphorus percent in biomass to be 3.0%, indicating the biomass has sufficient phosphorus.
- While there was a sufficient percentage of phosphorus in the biomass, there was virtually no residual orthophosphate present.

Results and Discussion

- There are a few environmental conditions that can exist which prevent the bacterial solids from settling and compacting well in a secondary clarifier. First, a low concentration of solids could inhibit settling as there is not a critical mass. This is needed to form a proper sludge layer. Secondly, high levels of filamentous bacteria and/or polysaccharide production can physically inhibit the floc from forming larger, more dense pieces that would hopefully settle well leaving behind a low solids in the clarifier overflow. These samples exhibited all three traits: a low solids, elevated levels of EPS and an overgrowth filamentous bacteria.

- The sludge did not settle after the thirty-minute settling test but did eventually settle some after six hours. The supernatant collected after the extended settling was low in solids The SVI values calculated for both the thirty-minute and extended settling were above the expected 75-150 mg/L range and indicate bulking conditions.

- When analyzing a sample for filamentous bacteria, filament abundance and effect on the floc are two important parameters that are taken into account. EBS employs a filamentous rating scale of 0 to 6. No filaments would be ranked at a 0 while an excessive amount will be rated a 6. Excessive filament proliferation can sometimes be attributed to several environmental conditions, such as nutrient conditions, retention time, and the constitutes of the incoming BOD. Some species of filaments can be associated with specific environmental conditions. It is also important to keep in mind that it is not so much the abundance of filaments that can cause bulking issues, but it is their effect on the floc that can negatively impact sludge settleability. During our analysis of this sample, we observed the filaments at an excessive level (6 out of 6). Filaments were observed growing well beyond the floc pieces creating a bridging effect. This creates large open spaces between the floc and prevents it from being able to compact into larger, more dense pieces. The two identified filaments were *Type 021N* and *S. natans*. These filaments are typically both associated with low nutrient content , low DO, and septic conditions and soluble readily-metabolizable substrates (SRMS). SRMS are substrates that are easy for the bacteria to biodegrade such as fatty acids, simple sugars, and starches,.

- Extracellular polymeric substances (EPS) are high molecular weight compounds excreted by microorganisms and stored into their external cell walls. EPS is mostly composed of polysaccharides and proteins but also consists of DNA, lipids, humic substances, and cations. The EPS test is run to determine how much of these substances are present in the the volatile solids and then normalized to the MLVSS and expressed as a percentage of the biomass. Zoogloea bacteria are a species of bacteria that tend to excrete high levels of these polysaccharides. Conditions such as low pH, low nutrients, and low oxygen availability or chlorination can stress the Zoogloea bacteria and cause them to produce excessive levels of polysaccharides as a defense mechanism. As with filaments, the level of production can affect the system's performance. A moderate amount can be beneficial as it encourages the floc to stick together. However, an overabundance can produce high levels of hydrophobic layers that prevent the floc from forming compact pieces and disrupt settling. EPS measured at 23% in the MLSS and 28% in the RAS sample. Although this value is higher than what we typically see in other systems, without historical data, it is difficult to say what is normal for this system.

- Total Phosphorus in the MLVSS was measured by subtracting the filtered nutrient value from the unfiltered nutrient value then normalized to the mixed liquor volatile suspended solids (MLVSS). Sufficient nutrients ensure the bacteria have the ability to perform important functions without leaving behind high levels of residual nutrients that may carry over into the final effluent. In most municipal wastes, nitrogen is often available while phosphorus can be the limiting factor. Based on our results, the Total Phosphorus was measured at 3.0% in the MLVSS which suggests the system is not phosphorus limited. One thing to point out is most of the phosphorus was measured in the unfiltered sample which includes the concentration that bacteria have taken up rather than in the soluble "bio-available" form in the bulk water.

- Microscopically, the floc appeared to be mostly pin to small with some medium size pieces having fairly compact centers with large open areas caused by the excessive filaments. Dispersed bacteria were observed in a low amount and often signal that BOD conversion is near complete. Once the food source has been depleted, the bacteria will floc together to conserve energy instead of staying active in the bulk water.

- The identification and enumeration of higher life forms can demonstrate the health and maturity of a wastewater treatment system. EBS employs a Maturity Index, which is a weighted average of the higher life form distribution with a target range of 1.5-2.5. Systems with a high microorganism abundance and diversity indicate that BOD conversion is likely to complete. The overall environmental conditions must be stable and non-toxic, as higher life forms are very susceptible to changes in the environment. There was a good diversity of higher life forms observed in this sample. A maturity index rating of 2.9 was assigned for the MLSS sample as there were many free-swimming and stalked ciliates observed. Their presence indicates a non-toxic environment existed during the time of sample collection. Consistent monitoring of these higher life forms is suggested as they can quickly help determine if any major shifts in the environment have occurred.

- Bioflocculation potential is a set of tests that measure the potential for good floc formation. Mixed Liquor Surface Charge (MLSC) and Hydrophobicity are two characteristics that can impact the density of the floc. Mixed Liquor Surface Charge (MLSC) is a test that measures the available charge on the bacteria. The reported range for good floc formation should fall between -0.150 to -0.600 meq/g. This indicates there is enough charge available to the floc to form larger pieces of floc. Hydrophobicity comes into play after surface charge forces have brought the floc together. It is a measure of the ability of the floc to force water out of the pore spaces. The higher the relative hydrophobicity, the more compact the floc should be. Typically, good floc has a hydrophobicity index of greater than 80%. The results for this sample indicate the floc has enough available charge to form a compact floc. However, the hydrophobicity measured 68% in the MLSS and 66% in the RAS sample.

- The pH is also a very important parameter in wastewater. The recommended range for optimal bacterial health is 6.5-8.5. Any fluctuations outside of this target can be detrimental to the bacterial population, resulting in a hindered rate of BOD removal. This sample measured a pH of 7.2, which is in the middle of the suggested range.

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Appendix A
Table 1: Analytical Data

Basic Chemistry	MLSS	RAS
pH	6.9	6.9
MLSS (mg/L)	1125	1575
MLVSS (mg/L)	1075	1450
MLVSS (%)	96%	92%
30 Minute Settling (mL/L)	1000	1000
30 Minute SVI (mL/g)	889	635
Six hour Settling (mL/L)	250	267
Six hour SVI (mL/g)	222	170
Turbidity (NTU) after six hours of settling.	5	5
Nutrient Content		
Total P Unfiltered (mg/L)	33	
Total P Filtered (mg/L)	0.2	
P in MLVSS (%)	3.0%	

Table 2: Basic Microscopic Evaluation

Basic Microscopy	MLSS	RAS
Floc Structure	Some pin, Small to Medium size floc. Fairly compact	Some pin, Small to Medium size floc. Fairly compact
Dispersed Bacteria (0-3)	0.5	0.5
Pin Floc (0-3)	1.0	1.0
Filament Rating (0-6)	6.0	6.0
Zoogloeal Bacteria (0-3)	0.5	0.5
India Ink Stain (0-3)	1.5	1.5

* **Floc Size (µm)** - Pin (<75 µm), Small (75-150 µm), Medium (150-500 µm), Large (>500 µm)

Table 3: Higher Life Form Distribution

Higher Life Forms	MLSS	RAS
Flagellates	2	1
Free-swimming/Crawling Ciliates	4	5
Stalked Ciliates/Suctorians	73	38
Rotifers/Chaetonotus	0	0
Nematodes/ Oligochaetes	0	1
Maturity Index	2.9	2.8

Table 4: Filamentous Bacteria Abundance and Causes

MLSS and RAS Filament Types & Causes	H_2S and/or septicity	Mature Biomass	Nutrient Deficiency	SRMS*	Low F:M	Low DO
1. Type 021N	X	X	Esp(N)	X		
2. S. natans			Esp (P)	X		X

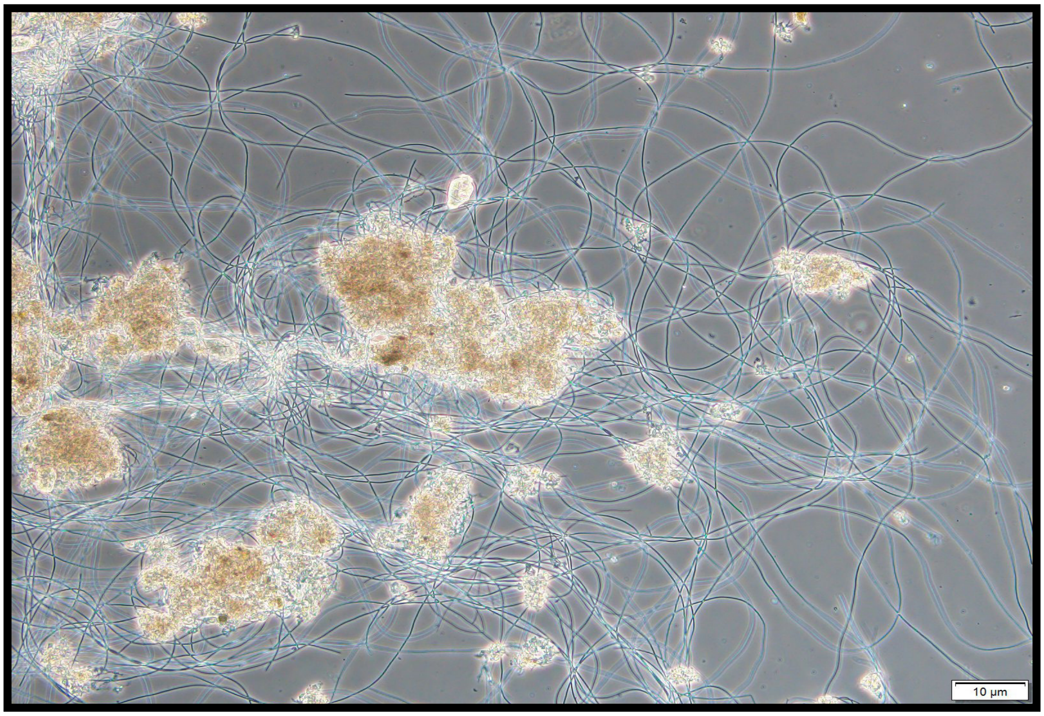
***Soluble readily-metabolizable substrates (SRMS)**: substrates that are easy for the bacteria to biodegrade.*

Table 5: Advanced Microbiology

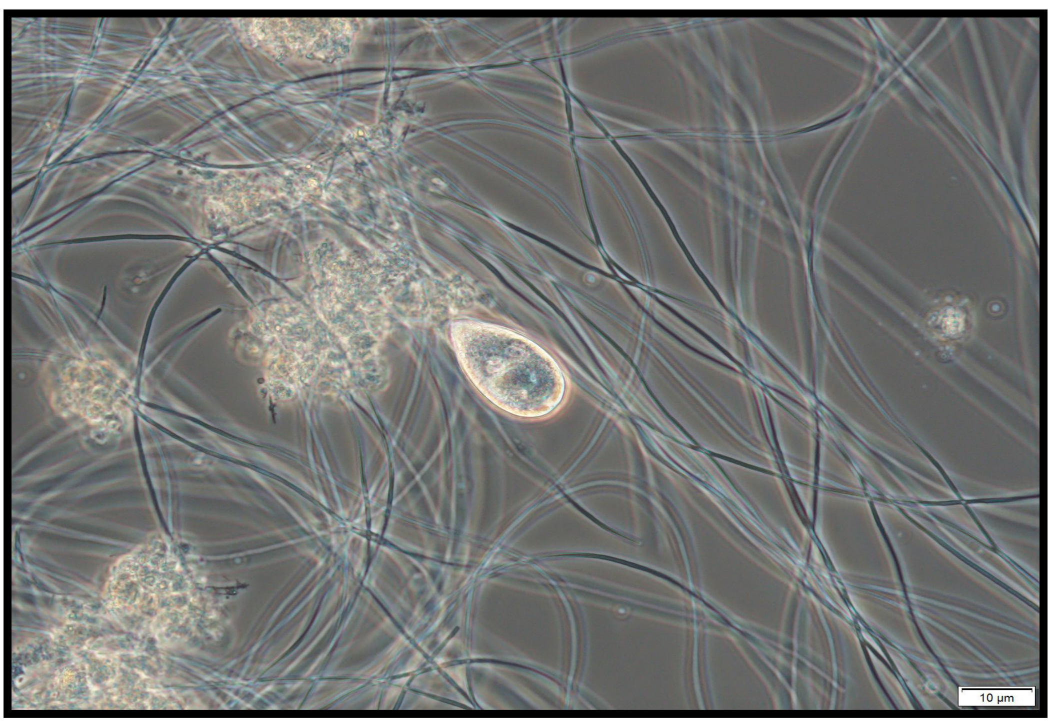
Bioflocculation potential	MLSS	RAS
EPS		
EPS (mg/L)	250	407
EPS in MLVSS (%)	23%	28%
Surface Charge		
Mixed Liquor Surface Charge (meq/g)	-0.651	-0.465
Hydrophobicity		
Relative Hydrophobicity (%)	68%	66%

Appendix B

MLSS Photos:

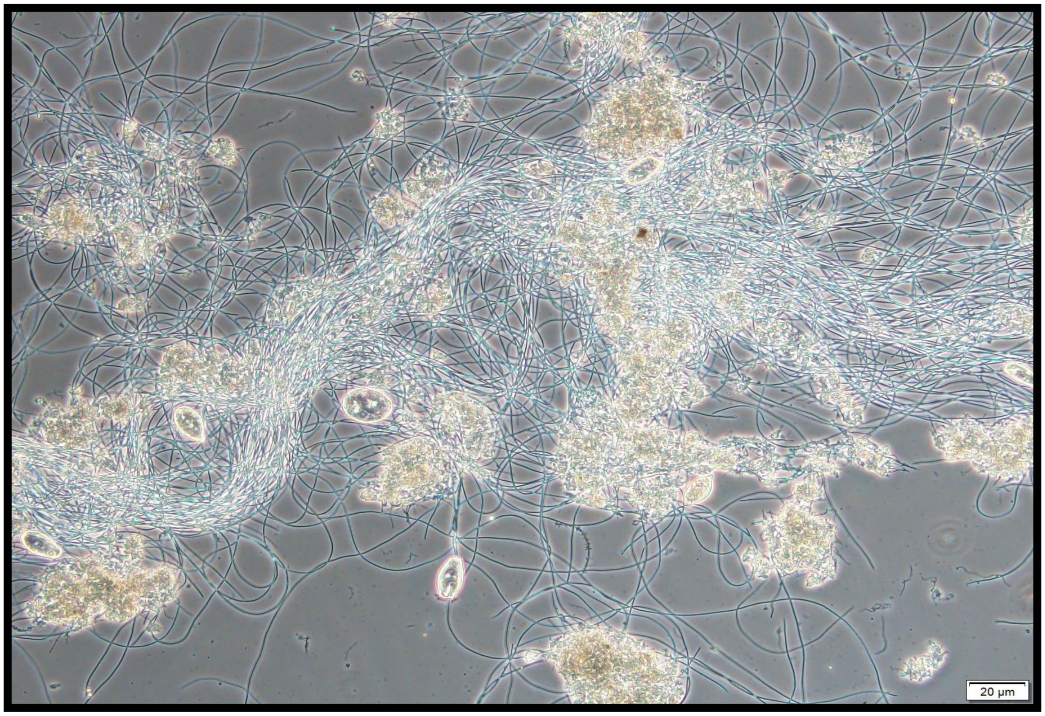


100X phase contrast, wet mount. Some pin, small to medium size floc.

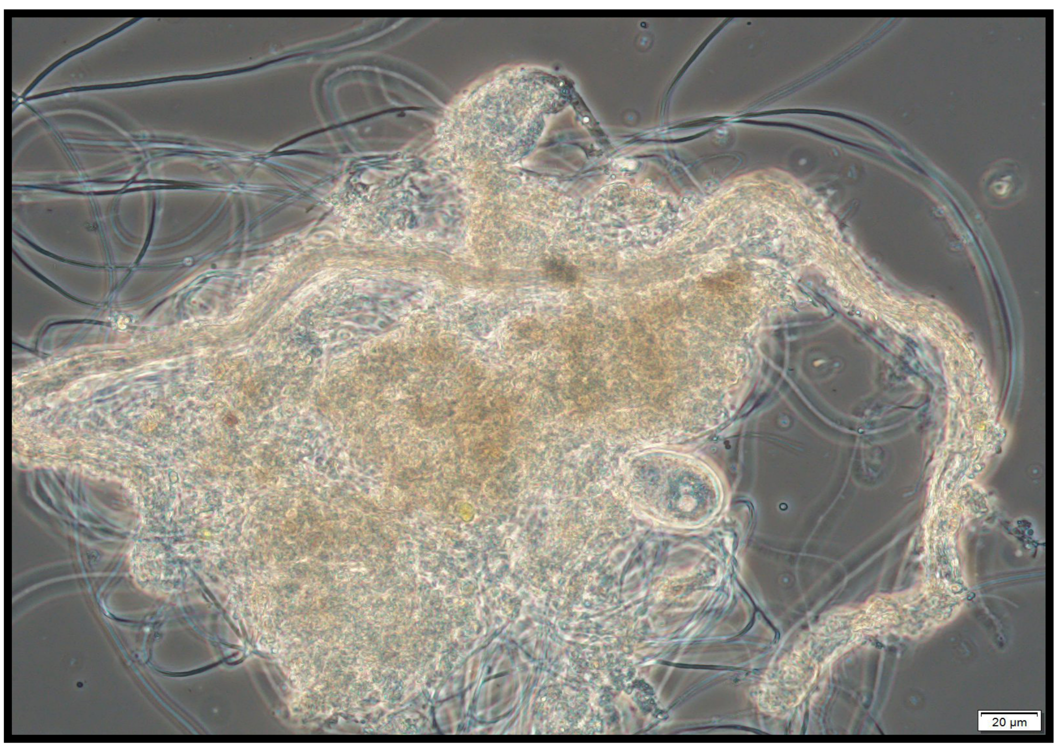


400X phase contrast, wet mount. Closer look at the MLSS with excessive amounts of filaments.

RAS Photos:

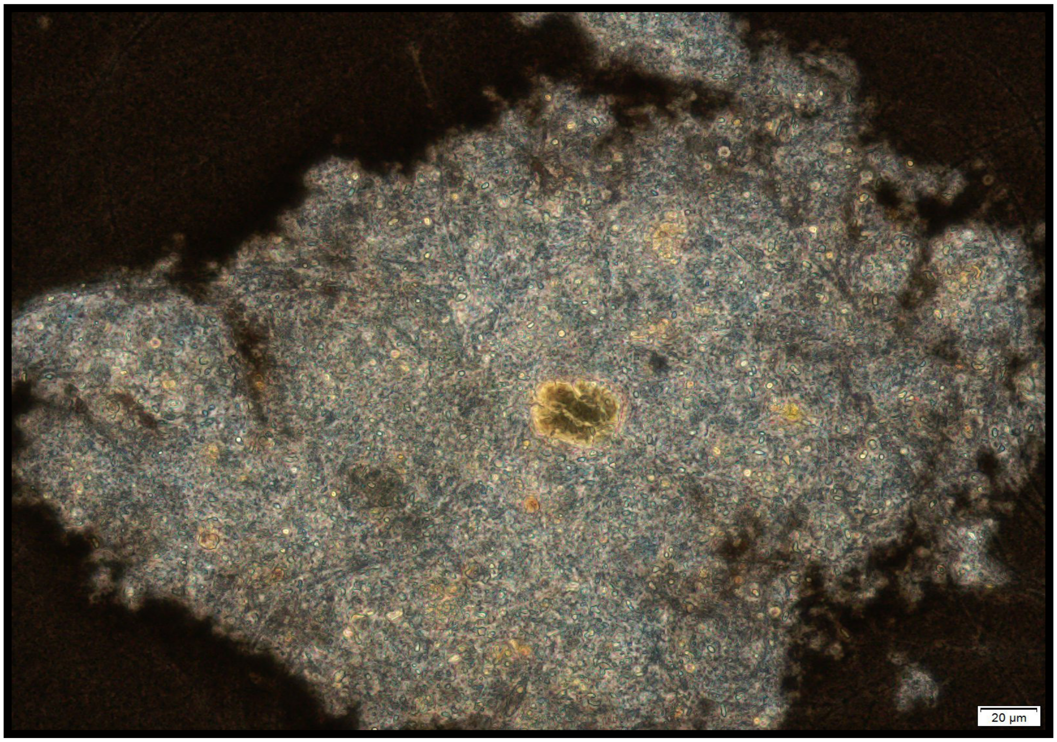


100X phase contrast, wet mount. Note the bridging occurring between floc pieces.

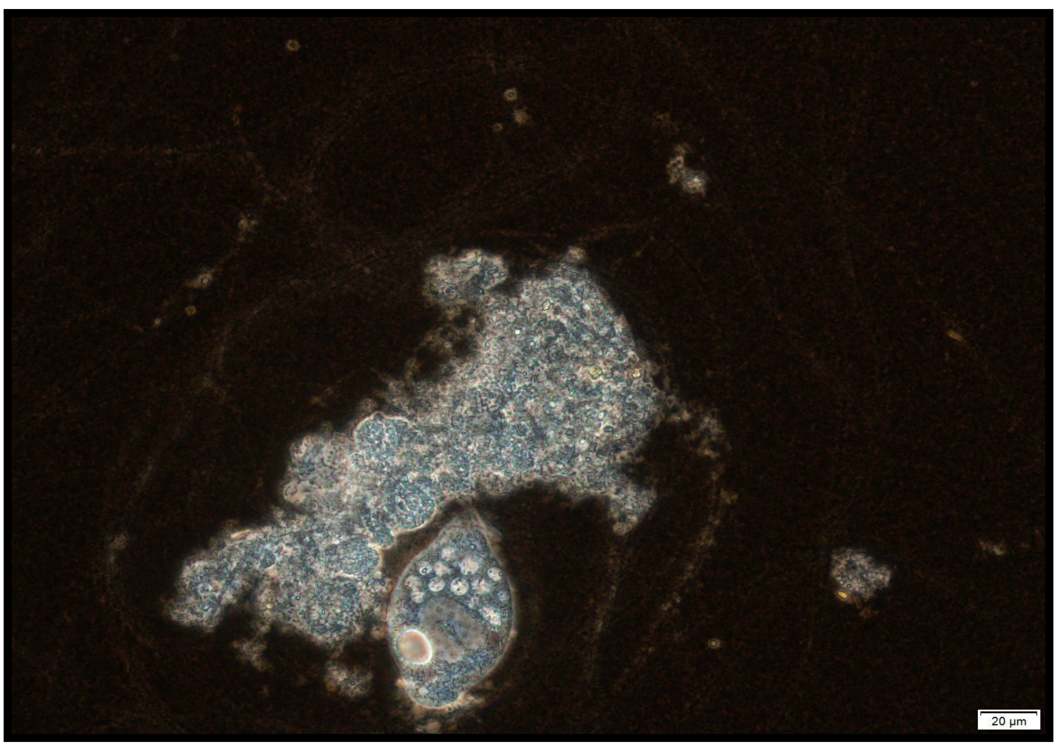


400X phase contrast, wet mount. Closer look at the RAS sample.

India Ink Photos:

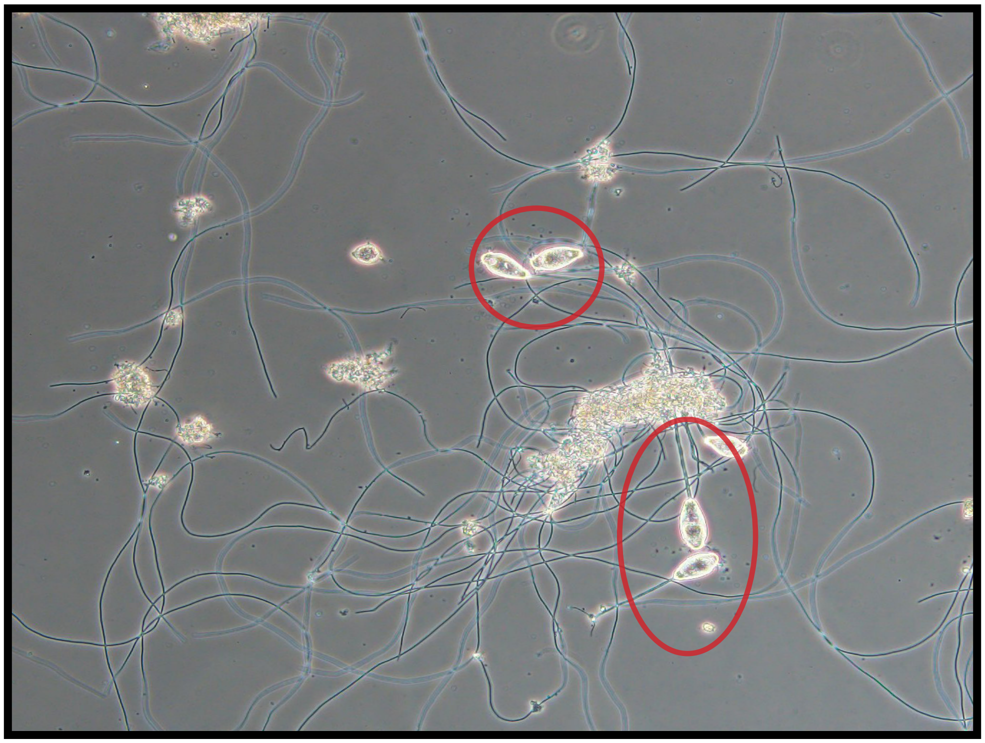


400X phase contrast, India Ink. A moderate level of polysaccharides were measured in the MLSS sample during the india ink stain.



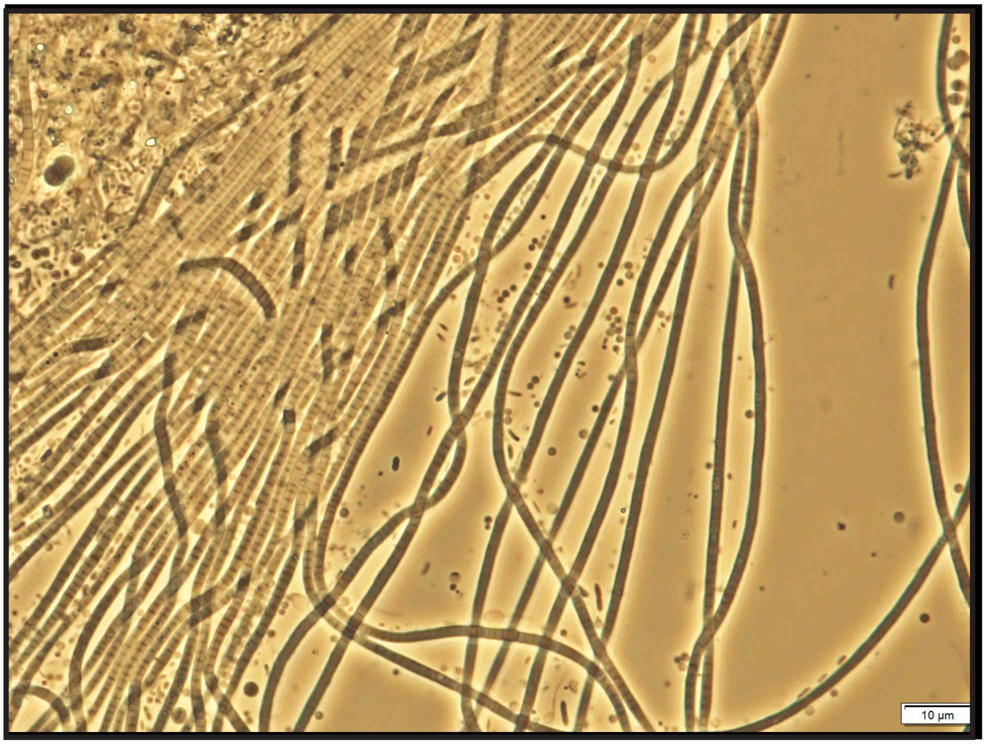
400X phase contrast, India Ink. The RAS sample was also observed having a moderate amount of polysaccharides.

Higher Life Form Photos:

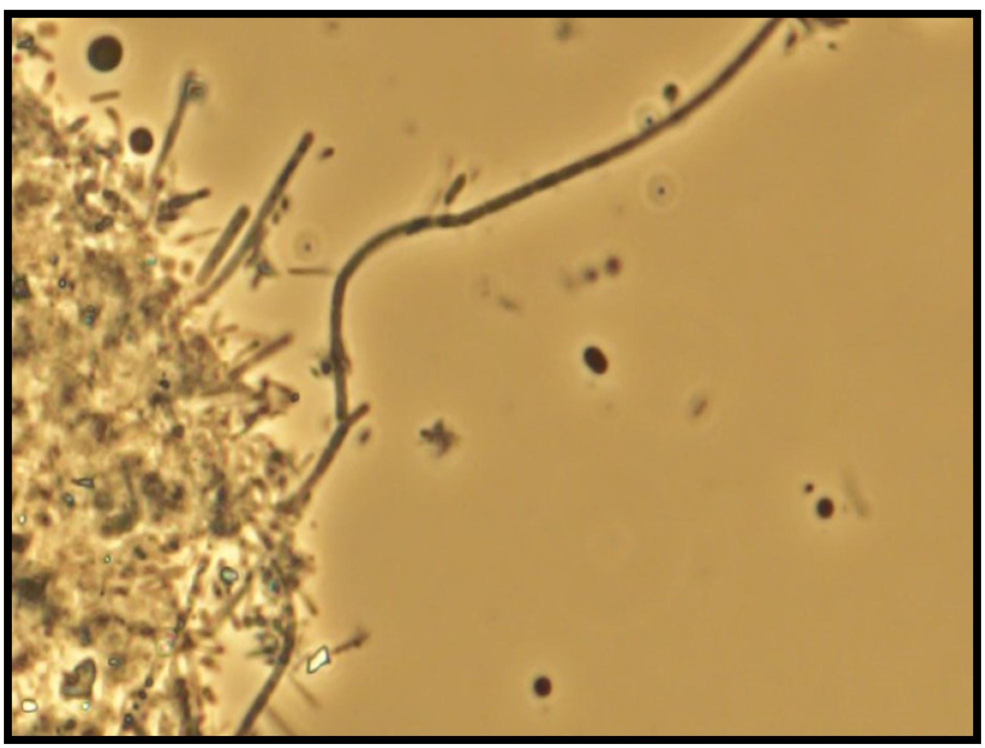


400X phase contrast, wet mount. Basin 2-3. Stalked ciliates.

Filamentous Bacteria Photos Continued:

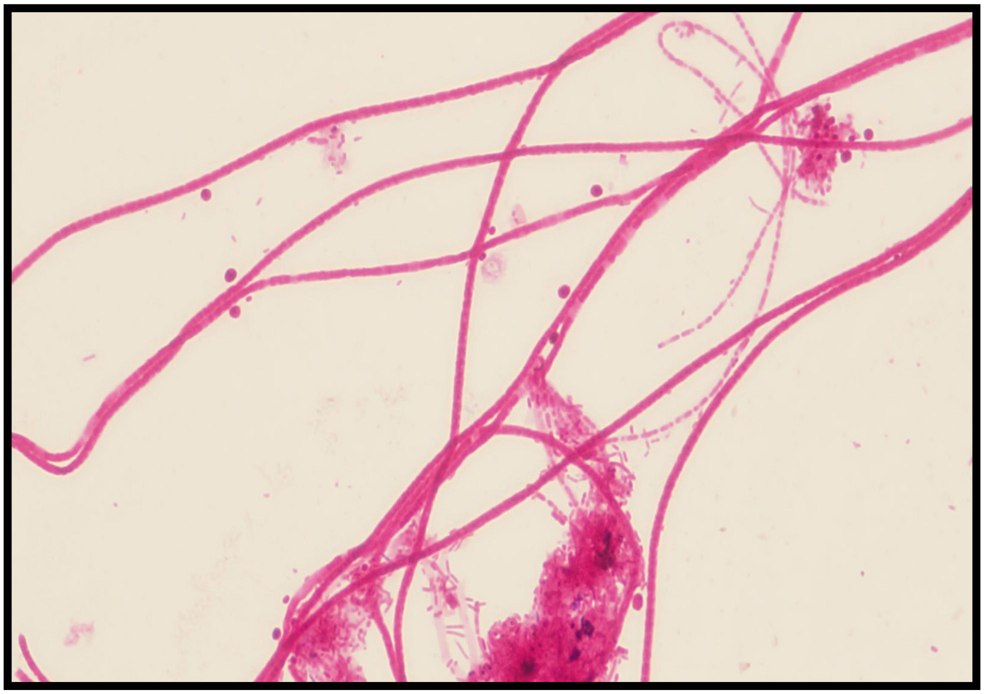


1000X phase contrast, wet mount. *Type 021N* was the most common filament observed.

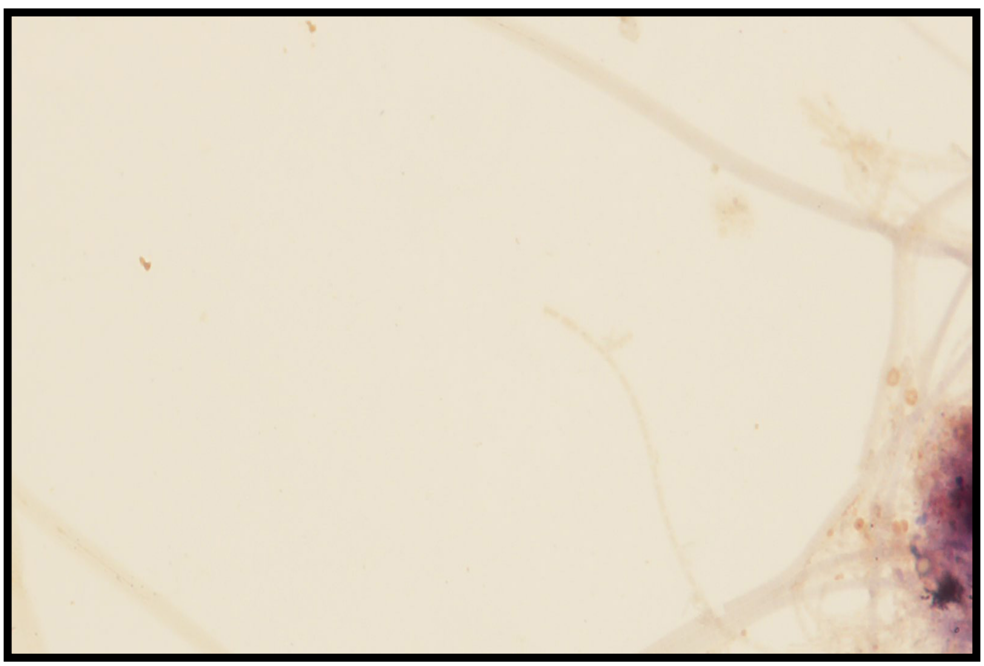


1000X phase contrast, wet mount. S. natans has sausage shaped cells.

Filamentous Bacteria Stain Photos:



1000X bright field, Gram stain. MLSS All filaments stained Gram negative.



1000X bright field, Neisser stain. All filaments stained Neisser negative.

Appendix C
EBS Reference Guide

Term	Description	Activated Sludge Target Range
30 Minute Settling Test	This test is used to determine the settled sludge volume of mixed liquor samples in activated sludge systems.	
Biochemical Oxygen Demand (BOD)	The quantity of oxygen required by bacteria to biologically oxidize organic material under aerobic conditions, usually expressed in mg/L. The organic matter serves as food for the bacteria and energy is released to the cell during its oxidation.	
Bioflocculation	The act of bacteria excreting exocellular polymeric substances that are sticky in nature that allow small floc to come together forming large floc.	
Chemical Oxygen Demand (COD)	The amount of oxygen required for the chemical oxidation of organic material using chemicals as oxidants, usually expressed in mg/L.	
Culturable Bacteria	Bacteria that are able to grow and reproduce using a basic plating technique.	
Culturable (Viable) Cell Count	Cell count based on the bacteria in the system that are capable of reproducing and BOD degradation.	10^5-10^8 CFU/mL
Deflocculation	The physical or chemical act of breaking up larger floc into pin floc and dispersed bacteria.	
Dissolved Oxygen Uptake Rate (DOUR)	A test that measures the respiration rate of the biological organisms in a wastewater sample by measuring the rate at which oxygen is used in mg O_2/L/Hr.	
Exocellular Polymeric Substances	Substances that are "sticky" in nature produced by bacteria and aid in floc formation. The percentage of EPS in a system typically exceeds 12% outside of the pulp and paper industry and are typically run on activated sludge systems.	8-12%
Filamentous Bulking	Occurs when filamentous bacteria rapidly grow and hinder the settling of sludge or inhibit settling completely.	
Hydrophobicity	Used to determine the hydrophobicity of the biomass. A more hydrophobic biomass should form tighter floc and will not trap as much water in the pore space.	
India Ink	Used to determine the presence and abundance of polysaccharides. It is rated on a scale of 1(low), 2(abundant), and 3(excessive). Polysaccharides aid in floc formation.	
Live Cell Count	Cell count based on the bacteria in the system that are live/actively respiring and are capable of BOD degradation using flow cytometry.	Varies

EBS Reference Guide Continued:

Term	Description	Activated Sludge Target Range
Maturity Index	The maturity index is a numerical value derived to estimate the health and maturity of the sludge based upon the higher life form population. It is calculated by multiplying specific higher life forms by a designated number and dividing by the total number of higher life forms present.	1.5-2.5
Mixed Liquor Surface Charge	The surface charge of the biomass affects the flocculation process and floc stability, which can further affect the settleability and dewaterability. The surface charge is affected by C/N ratio, sludge age, ion balance, etc. The reported surface charge range is -0.15 to -0.60 meq/g MLSS, and a surface charge value closer to the middle of this range indicates optimal health of the sludge. However, this may be system-specific.	-0.15 to -0.60 meq/g
Mixed Liquor Suspended Solids (MLSS)	The concentration of insoluble materials suspended or dispersed in water or wastewater. Generally expressed in mg/L on a dry weight basis and determined by filtration methods.	Varies
Mixed Liquor Volatile Suspended Solids (MLVSS)	The quantity of organic or volatile solids that will burn off when heated to 550° C for 30 minutes.	
Nutrients	Substances that are required to support living plants and organisms, including carbon, hydrogen, oxygen, sulfur, nitrogen, and phosphorus. Nitrogen and phosphorus are commonly fed to wastewater to enhance its treatability. A theoretical nutrient balance of 100:5:1 (C:N:P) is required for efficient biological oxidation of BOD. Supplemental nutrients are sometimes required in nutrient poor waste streams.	
Sludge Volume Index (SVI)	A value used to determine the settling properties of the sludge based on the amount of MLSS in the sample. This number is derived using the 30 minute settling test and MLSS.	75-150 mL/g
Soluble Readily-Metabolizable Substrates (SRMS)	Soluble readily-metabolizable substances are simple sugars and starches that are easily processed as food by bacteria.	
Specific Oxygen Uptake Rate (SOUR)	Measures use of oxygen as a terminal electron acceptor. This value is derived by multiplying the DOUR value by the VSS in grams/L.	
Supernatant TSS	This test measures the total amount of suspended material, organic or inorganic matter, in the supernatant collected after 30 minute settling.	<50 mg/L
Total Cell Count	Cell count based on all the bacteria in the system, dead or alive, using flow cytometry.	Varies

EBS Reference Guide

Maturity Index Example:

Indicator Group	Point Value	Number Observed in 10 Fields	Group Points (Point Value x Number Observed)
Flagellate/Naked Amoeba	1	18	18
Crawling Ciliate/Free Swimming Ciliate	2	15	30
Stalked Ciliate/Suctorian	3	5	15
Rotifer/Chaetonotus	4	3	12
Nematode	5	4	20
Total for Maturity Index		45	95
Maturity Index		(Group Points) / (# Observed)	(95) / (45) = **2.1**

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TECHNICAL UPDATE

Date:	**06/14/2021**
To:	**Sewer Authority Mid-Coastside**
Sample(s):	**Influent ML, Influent Foam, Effluent ML and Effluent Foam**
Date Received:	**06/10/2021**
Date(s) Analyzed:	**06/10/2021**
Sample Analyzed By:	**Deborah Lee, Aquafix**
Objective:	**Determine cause of poor settling and high TSS.**

Microscopic Observations Influent ML

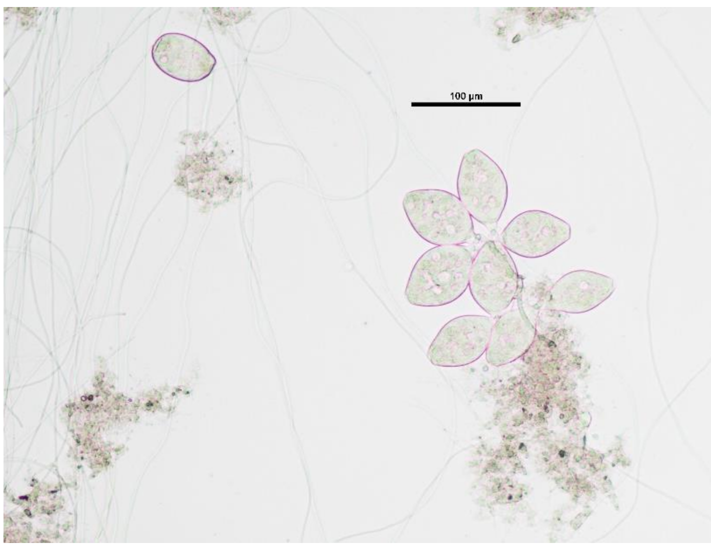

Figure 1. 100X magnification (m): The Influent ML sample contained low colonies of stalked ciliates and overall medium levels of stalked ciliates. There were also low to medium levels of swimming ciliates.

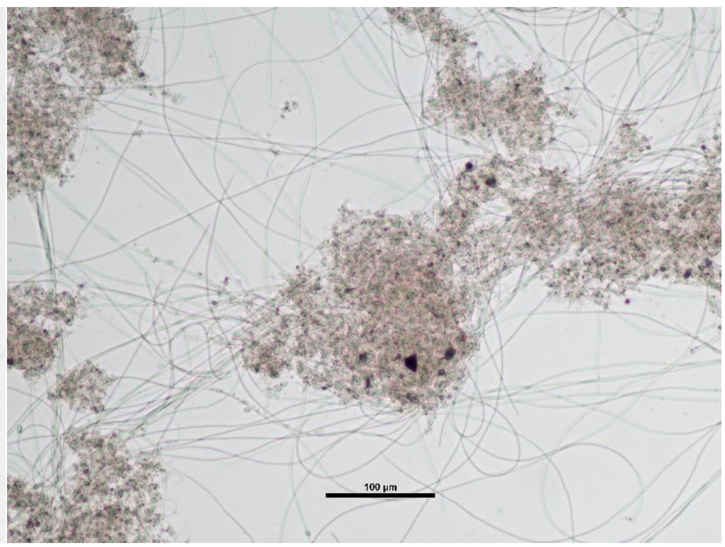

Figure 2. 100X (m): There were high levels of filaments outside of the floc in the Influent ML sample. These filaments are long and can promote inter-floc bridging, which will increase sludge volume and lead to sludge bulking.

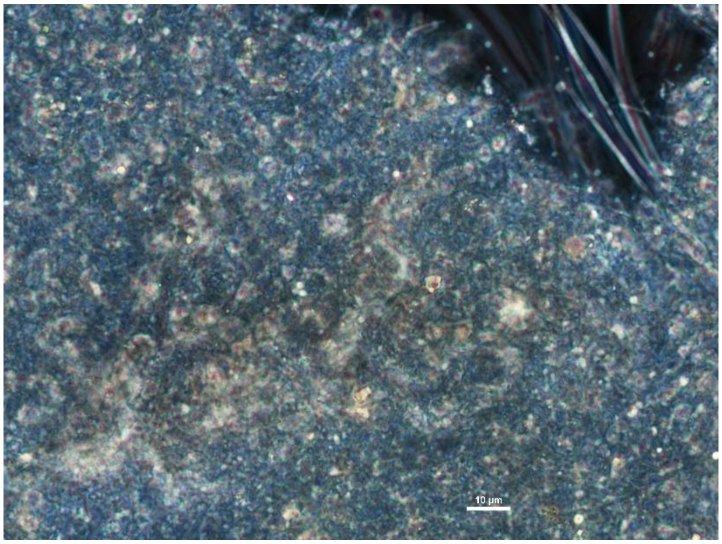

Figure 3. 400X (m), Phase contrast: The flocs in the Influent ML sample were mostly small (<100um) and condensed. There were medium levels of very large floc (>500um). The average floc size was 119.14um and white in color indicating good oxygen penetration. This is expected with small flocs that are not very dense. There were also high levels of free bacteria in this sample.

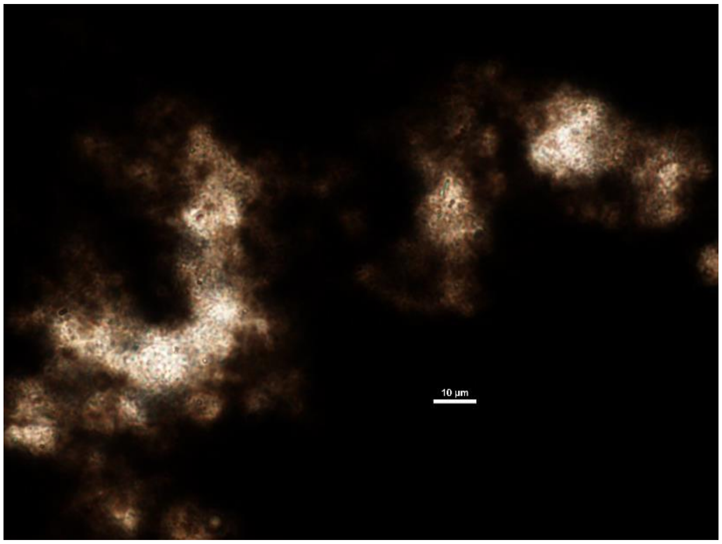

Figure 4. 400X (m), India ink stain: The floc in the Influent ML sample overall had medium levels of extracellular polymeric substances (EPS) in the condensed areas. EPS is a glue-like substance that allows bacteria to stick together to produce floc. Medium levels of EPS are necessary to produce floc with a strong structure that can withstand sheer force.

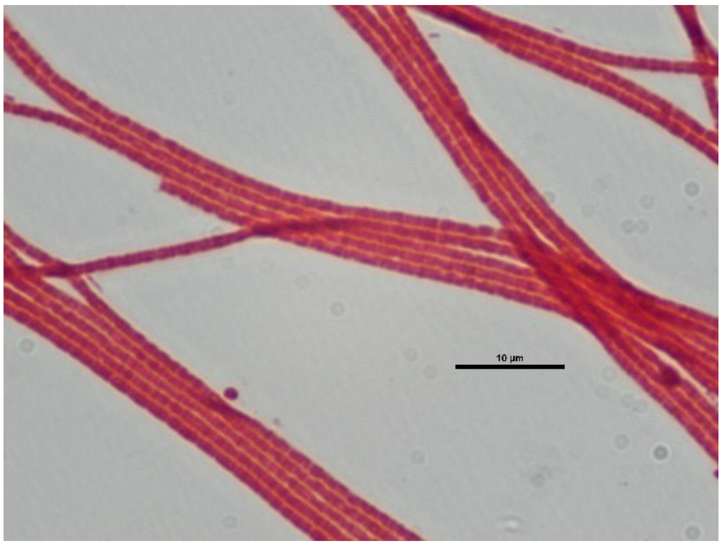

Figure 5. 1000X (m), Gram Stain: There were high levels of Type 021N present in the Influent ML sample. Type 021N grows in environments with septic compounds, low DO, and/or low levels of usable nitrogen.

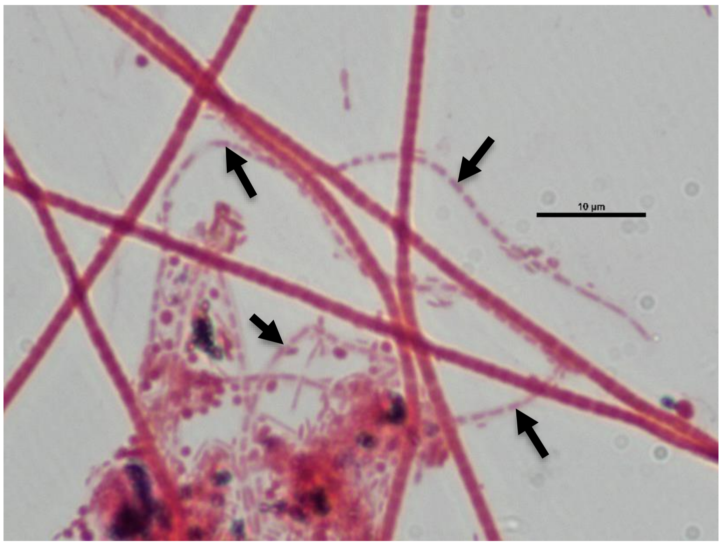

Figure 6. 1000X (m), Gram Stain: The Influent ML sample contained medium levels of *S. natans*/Type 1701 (arrows). *S. natans*/Type 1701 is found in environments with septic compounds, low DO, and high BOD loading.

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Microscopic Observation Influent Foam

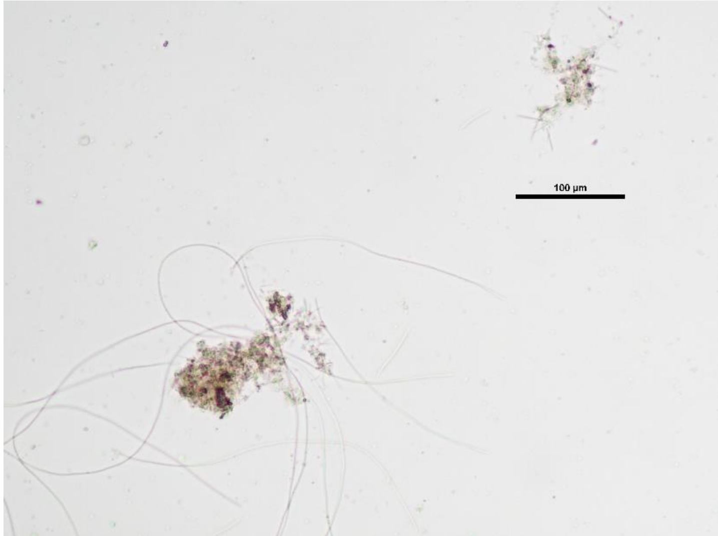

Figure 7. 100X (m): The Influent Foam sample was similar in composition to the Influent ML sample. this indicates that the foam is composed of small floc and other light particles being pushed to the water-air interface.

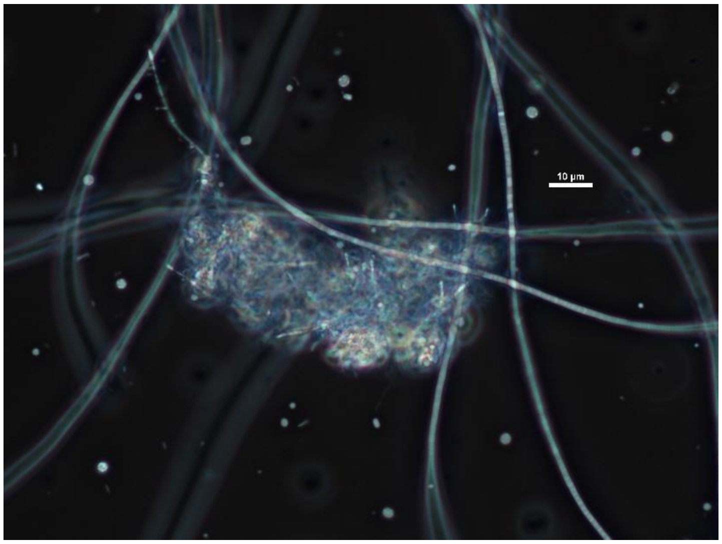

Figure 8. 400X (m), Phase contrast: There were also high levels of free bacteria in this sample (glowing spots) along with the mentioned small flocs and filaments of Type 021N growing free in the bulk liquid. Type 021N is known to sometimes form a slimy scum at the surface of aeration basins when this filament becomes abundant.

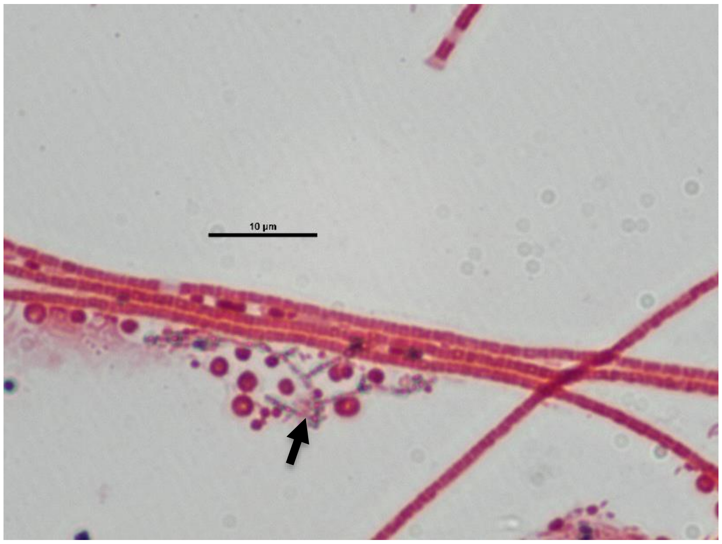

Figure 9. 1000X (m), Gram Stain: There were high levels of Type 021N (red filaments) in the Foam sample and medium levels of Nocardia-like filaments (arrow). Nocardioforms are known to cause foaming when present in high levels.

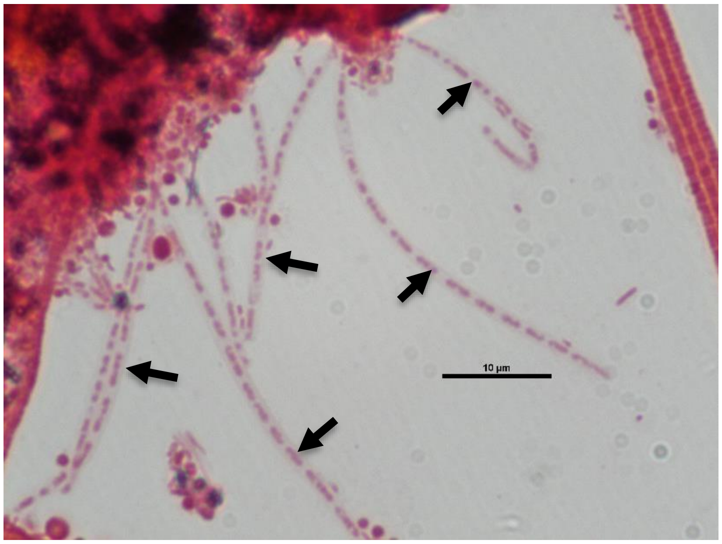

Figure 10. 1000X (m), Gram Stain: As with the Influent ML sample, the Influent Foam sample had low to medium levels of *S. natans*/Type 1701 (arrows).

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Microscopic Observation Effluent ML

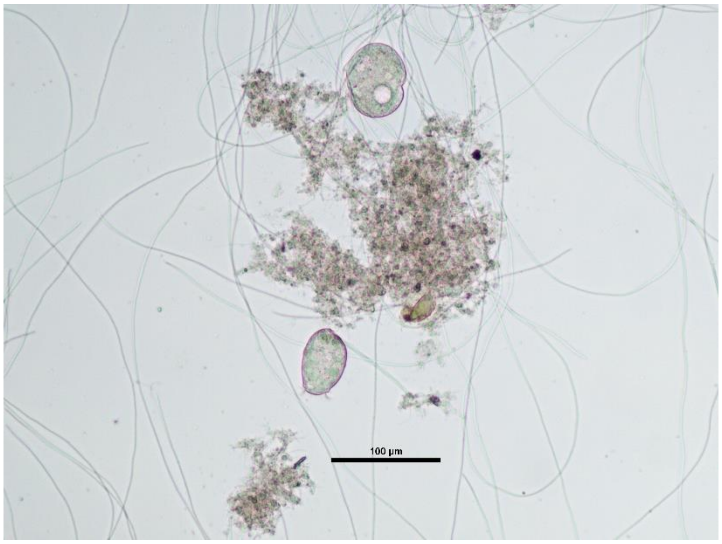


Figure 11. 100X (m): The Effluent ML sample was similar to the Influent ML samples but have had more branched filaments free in the bulk liquid. There were also low levels of nematodes present (not shown).

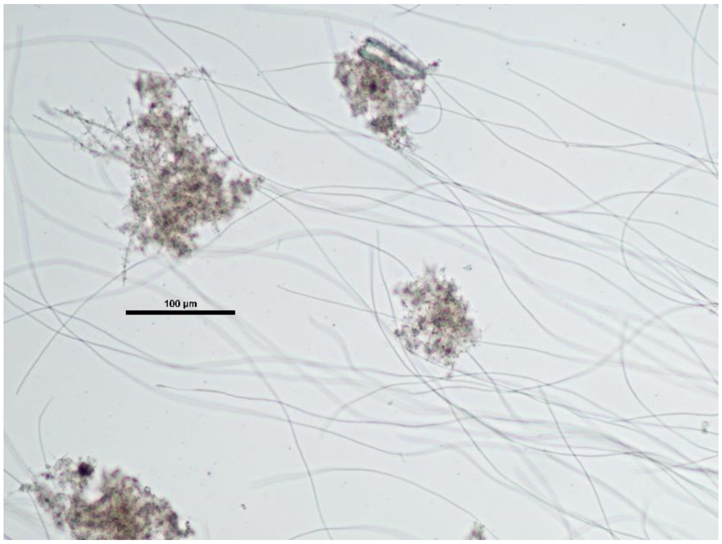


Figure 12. 100X (m): The Effluent ML sample also contained floc that were mostly small in size with an average diameter of 114.96um. There were also high levels of filaments mostly free in the bulk liquid.

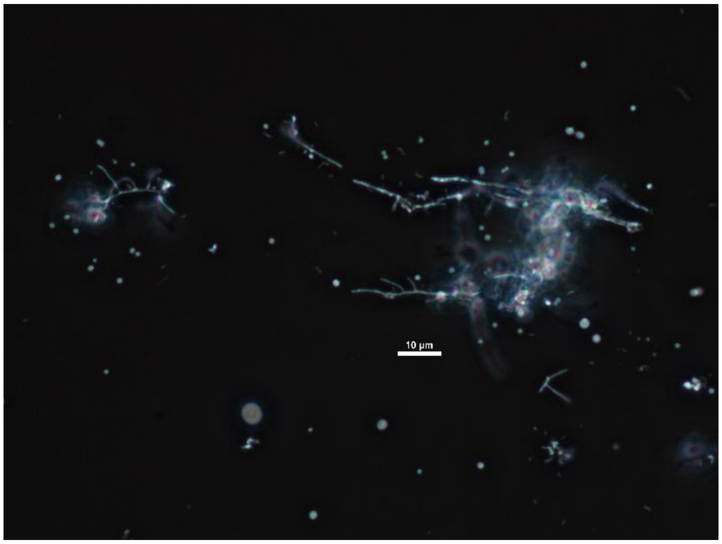


Figure 13. 400X (m), Phase contrast: The small flocs in the Effluent ML were white in color indicating good oxygen penetration. This is expected with small flocs that are not very dense. There were also high levels of free bacteria and free small clusters of branched filaments in this sample.

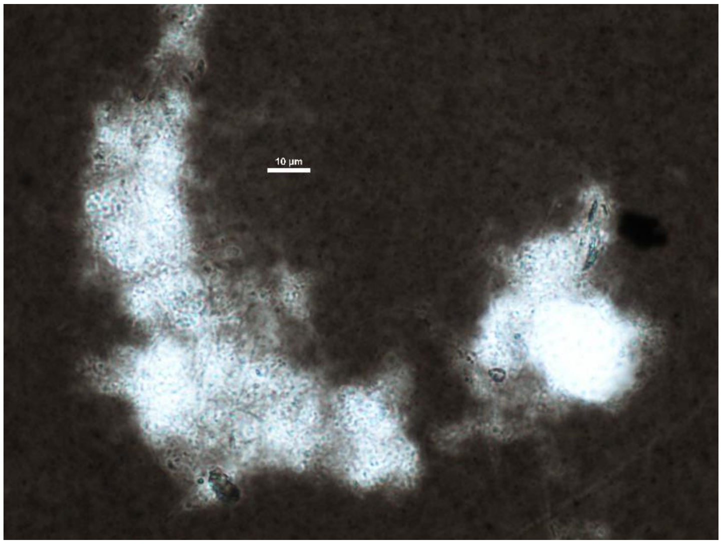


Figure 14. 400X (m), India ink stain: The Effluent ML flocs had mostly areas of medium levels of EPS with a few condensed areas with high EPS. There was possibly oil in this sample since the bulk liquid excluded the stain in some areas and there may have been a few oil droplets observed.

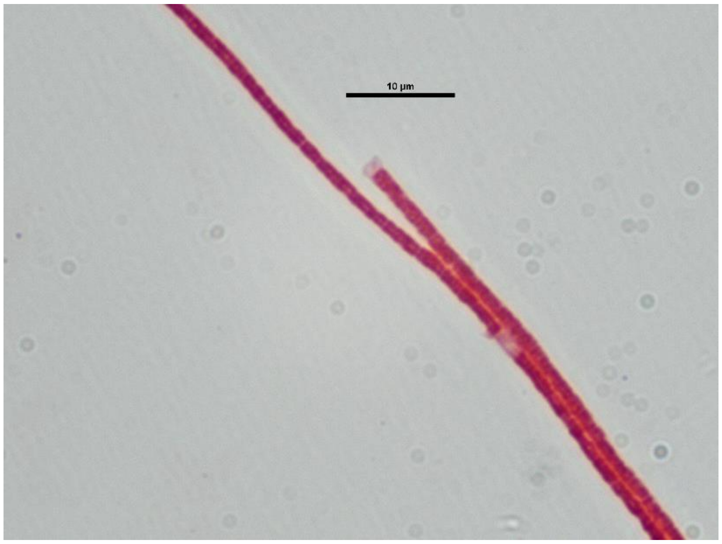


Figure 15. 1000X (m), Gram Stain: There were medium to high levels of Type 021N mostly observed outside of the floc structure in the Effluent ML sample.

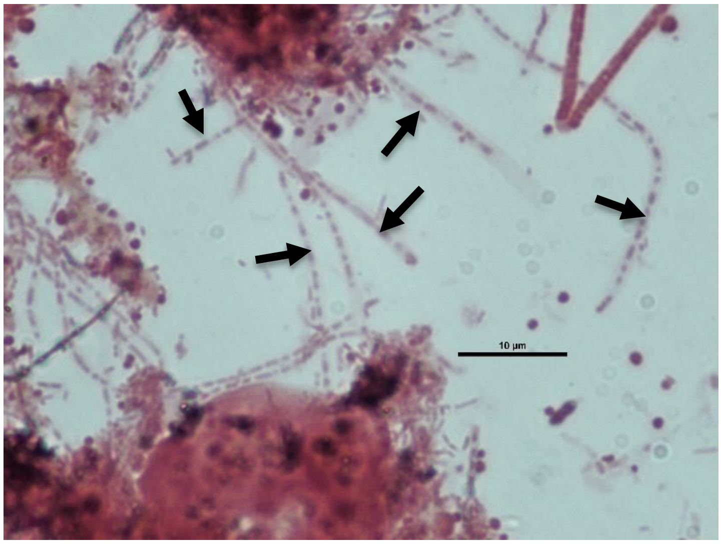


Figure 16. 1000X (m), Gram Stain: There were high levels of *S. natans*/Type 1701 (arrows) observed extending from the flocs in the Effluent ML sample.

Microscopic Observation Effluent Foam

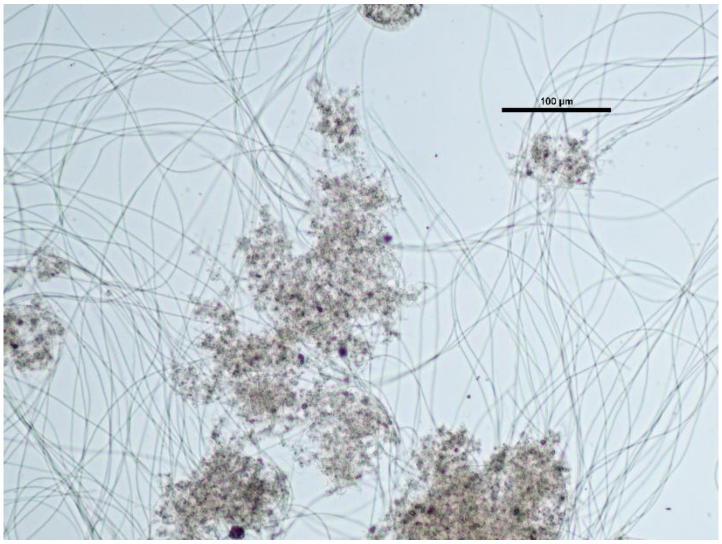


Figure 17. 100X (m): The Effluent Foam sample contained stringy solids of mostly small to medium sized flocs and high levels of filaments free in the bulk liquid.

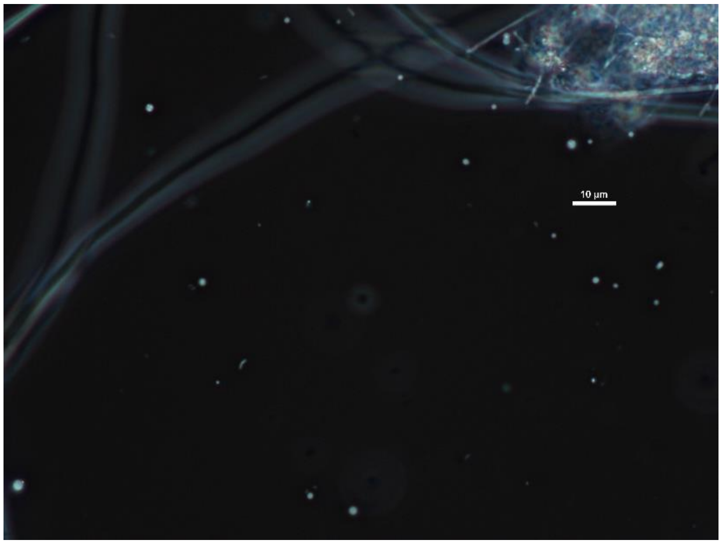


Figure 18. 400X (m), Phase contrast: There were also high levels of free bacteria (bright dots) present in the Effluent Foam sample.

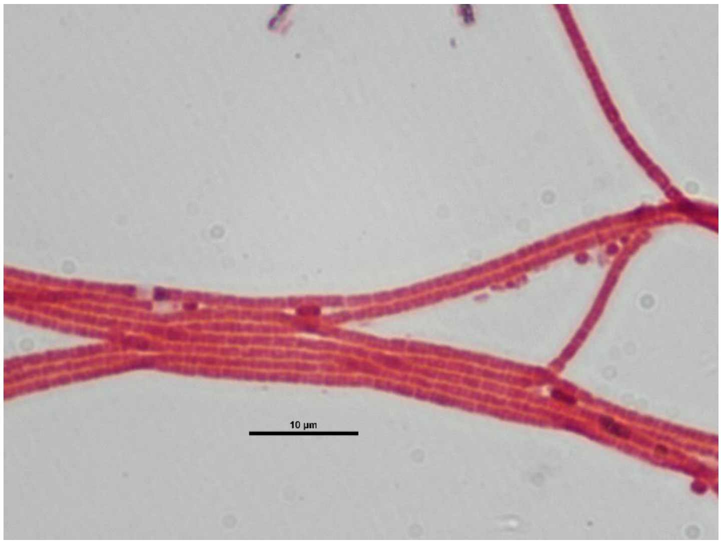


Figure 19. 1000X (m), Gram Stain: The Effluent Foam was much like the Influent Foam with high levels of Type 021N and low to medium levels of *S. natans*/Type 1701.

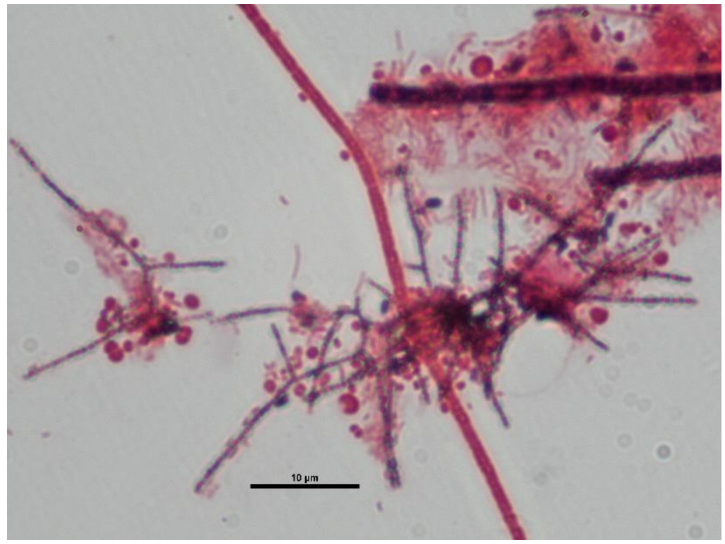


Figure 20. 1000X (m), Gram Stain: The Effluent Foam sample had medium levels of Nocardia-like branched filaments. There may have been slightly more Nocardioforms in this sample than the Influent Foam sample.

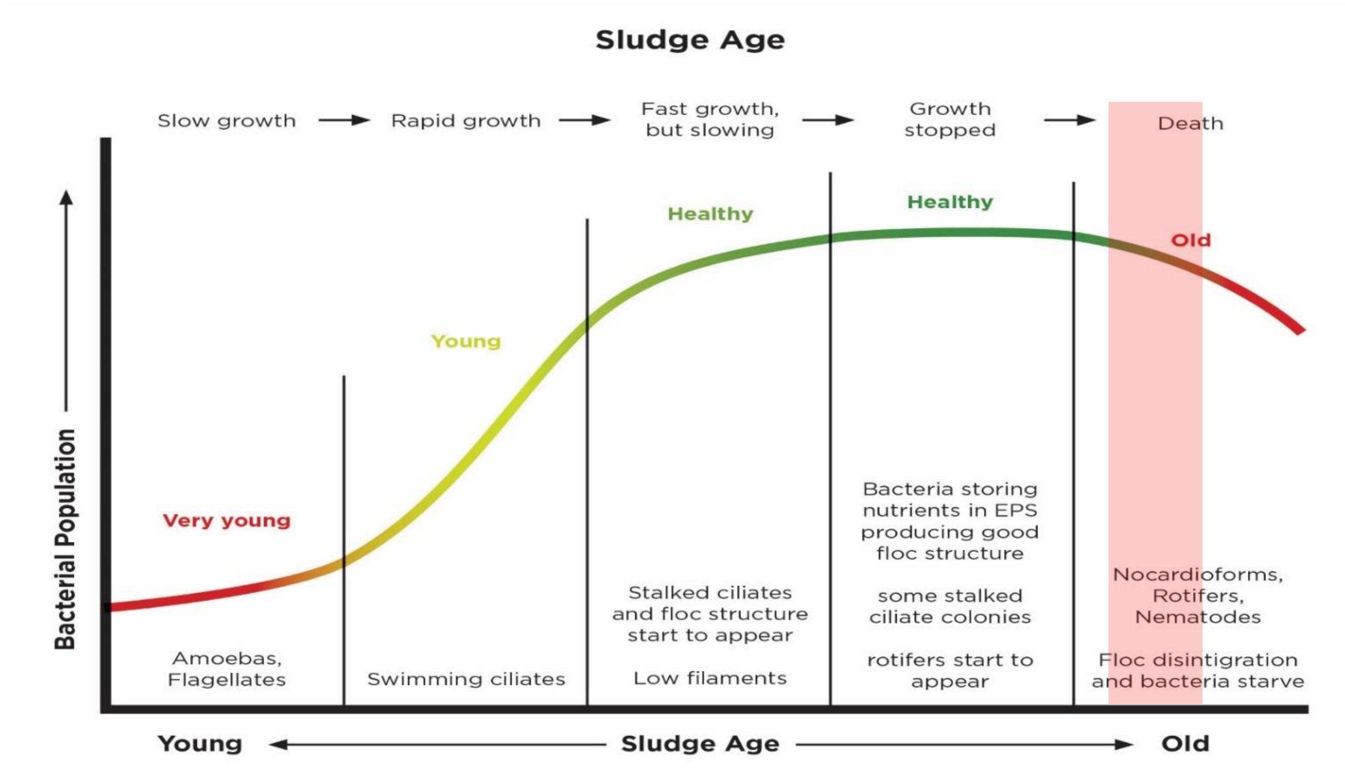
Summary:

Overall the cause of bulking and high TSS is due to the excessive growth of filaments such as Type 021N that can form a scum in aeration basins. There were also filaments within the floc structure that may cause the floc to break apart into smaller units as the filaments grow outward. This will result in a high amount of small flocs that will not settle and also in high levels of free bacteria in the effluent. It is possible that low levels of useable nitrogen are the cause of excessive growth of Type 021N in this system.

There were medium levels of Nocardia-like filaments observed in the floc and a little free in the bulk liquor. These branched filaments are known to cause foaming, however in this system, the Nocardia-like filaments may be mostly contributing to floc breakup as the filaments extend and become more buoyant. The resulting smaller flocs will be too light to settle during normal settling times and will contribute to higher effluent TSS. There were low to medium levels overall of *S. natans*/Type 1701 extending from the medium sized flocs and may indicate septicity or periodic high BOD loading.

The sludge age of the Sewer Authority ML was on the older end in both the Influent and Effluent ML samples. There were colonies of stalked ciliates present, Nocardioforms which can grow in low to medium amounts with old sludge age, and low nematodes observed.

(The red shaded area in the diagram below represents the effective sludge age of the Sewer Authority ML samples)



Influent ML

Rank	Filament	Relative Abundance	Cause
1	Type 021N	High	Septic compounds, low N, low DO
2	Nocardioforms	Medium in floc	FOG, long MCRT
3	*S. natans*/Type 1701	Medium	Low DO, septic compounds, high BOD load

Influent Foam

Rank	Filament	Relative Abundance	Cause
1	Type 021N	High	Septic compounds, low N, low DO
2	Nocardioforms	Medium in floc	FOG, long MCRT
3	*S. natans*/Type 1701	Low - Medium	Low DO, septic compounds, high BOD load

Effluent ML

Rank	Filament	Relative Abundance	Cause
1	*S. natans*/Type 1701	High	Low DO, septic compounds, high BOD load
2	Type 021N	Medium - High	Septic compounds, low N, low DO
3	Nocardioforms	Low	FOG, long MCRT

Effluent Foam

Rank	Filament	Relative Abundance	Cause
1	Type 021N	High	Septic compounds, low N, low DO
2	Nocardioforms	Medium in floc	FOG, long MCRT
3	*S. natans*/Type 1701	Low - Medium	Low DO, septic compounds, high BOD load
4	Type 0675/0041	Low	Low F:M

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Add for filaments:
https://teamaquafix.com/common-wastewater-filaments/#021N

https://teamaquafix.com/common-wastewater-filaments/#1701

https://teamaquafix.com/common-wastewater-filaments/#nocardioforms

Recommendations:

- If there are long sewer lines leading to the plant, it is recommended to meter in OxyFresh along the lines to decrease the amount of septicity coming into the plant. If septic is being accepted, OxyFresh could also be added directly into the influent at the same time. OxyFresh is an easy to apply liquid micronutrient that promotes metabolic activity of aerobic bacteria.
- If possible, waste out the small flocs and filaments. If wasting is not possible, add SmartBOD into the aeration basin. SmartBOD contains bioavailable sources of amino acids, complex proteins, carbohydrates, and micronutrients that bacteria in biological wastewater processes require in order to build floc and effectively remove nutrients.
- It is recommended to add Accelerator VII, a fast-acting source of amino acids and micronutrients, into the aeration basin to promote the growth of floc-forming bacteria over filaments such as Type 021N.