NOTICE OF SPECIAL MEETING
OF THE
SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

PC-15 COMMITTEE
TELECONFERENCE MEETING

November 3, 2021
9:30 a.m.

Join Zoom Meeting by clicking on the link below:

https://socwa.zoom.us/

Meeting ID: 848 8709 5131
Passcode: 917717

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NOTICE IS HEREBY GIVEN that a Special Meeting of the South Orange County Wastewater Authority (SOCWA) PC-15 Committee was called to be held by Teleconference on **November 3, 2021** at **9:30 a.m.** SOCWA staff will be present and conducting the call at the SOCWA Administrative Office located at 34156 Del Obispo Street, Dana Point, California. This meeting is being conducted via Teleconference pursuant to the California Governor Executive Order N-29-20.

MEMBERS OF THE PUBLIC ARE INVITED TO PARTICIPATE IN THIS TELECONFERENCE MEETING AND MAY JOIN THE MEETING VIA THE TELECONFERENCE PHONE NUMBER AND ENTER THE ID CODE. THIS IS A PHONE CALL MEETING AND NOT A WEB-CAST MEETING SO PLEASE REFER TO AGENDA MATERIALS AS POSTED WITH THE AGENDA ON THE WEBSITE AT WWW.SOCWA.COM. ON YOUR REQUEST, EVERY EFFORT WILL BE MADE TO ACCOMMODATE PARTICIPATION IF YOU REQUIRE ANY SPECIAL DISABILITY RELATED ACCOMMODATIONS. PLEASE CONTACT THE SOUTH ORANGE COUNTY WASTEWATER AUTHORITY SECRETARY'S OFFICE AT (949) 34-5452 AT LEAST TWENTY-FOUR (24) HOURS PRIOR TO THE SCHEDULED MEETING TO REQUEST DISABILITY RELATED ACCOMMODATIONS. THIS AGENDA CAN BE OBATINED IN ALTERNATE FORMATS UPON REQUEST TO THE SOUTH ORANGE COUNTY WASTEWATER AUTHORITY'S SECRETARY AT LEAST TWENTY-FOUR (24) HOURS PRIOR TO THE SCHEDULED MEETING.

AGENDA EXHIBITS AND OTHER WRITINGS THAT ARE DISCLOSABLE PUBLIC RECORDS DISTRIBUTED TO ALL, OR A MAJORITY OF, THE MEMBERS OF THE SOUTH ORANGE COUNTY WASTEWATER AUTHORITY PROJECT COMMITTEE NO. 15 IN CONNECTION WITH A MATTER SUBJECT FOR DISCUSSION OR CONSIDERATION AT AN OPEN MEETING OF THE PROJECT COMMITTEE NO. 15 ARE AVAILABLE BY PHONE REQUEST MADE TO THE AUTHORITY ADMINISTRATIVE OFFICE AT (949) 234-5452. THE AUTHORITY ADMINISTRATIVE OFFICES ARE LOCATED AT 34156 DEL OBISPO STREET, DANA POINT, CA ("AUTHORITY OFFICE"). IF SUCH WRITINGS ARE DISTRIBUTED TO MEMBERS OF THE PROJECT COMMITTEE 15 LESS THAN TWENTY-FOUR (24) HOURS PRIOR TO THE MEETING, THEY WILL BE SENT TO PARTICIPANTS REQUESTING VIA EMAIL DELIVERY. IF SUCH WRITINGS ARE DISTRIBUTED IMMEDIATELY PRIOR TO, OR DURING, THE MEETING, THEY WILL BE AVAILABLE IMMEDIATLELY ON VERBAL REQUEST TO BE DELIVERED VIA EMAIL TO REQUESTING PARTIES.

AGENDA

1. **Call Meeting to Order**

2. **Public Comments**

*THOSE WISHING TO ADDRESS THE **PROJECT COMMITTEE NO. 15** ON ANY ITEM LISTED ON THE AGENDA SHOULD SUBMIT A "REQUEST TO BE HEARD" FORM TO THE CLERK OF THE BOARD BEFORE THE PRESIDING OFFICER ANNOUNCES THAT AGENDA ITEM. YOUR NAME WILL BE CALLED TO SPEAK AT THAT TIME.*

3. **Coastal Treatment Plant Feasibility Study Final Report Update** **[Project Committee 15]**

- Presentation by Hazen & Sawyer on Final Feasibility Report

Recommended Action: Board discussion and direct staff for the next steps

Adjournment

I hereby certify that the foregoing Notice was personally emailed or mailed to each member of the SOCWA Project Committee No. 15 at least 24 hours prior to the scheduled time of the Special Meeting referred to above.

I hereby certify that the foregoing Notice was posted at least 24 hours prior to the time of the above-referenced Project Committee No. 15 meeting at the usual agenda posting location of the South Orange County Wastewater Authority and at www.socwa.com.

Dated this 1st day of November 2021.

B. Burnett

Betty Burnett, General Manager/Secretary
SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

Hazen

South Orange County Wastewater Authority

CTP Feasibility Study Final Summary

November 3, 2021

Agenda

- Project Overview
- Review of Shortlisted Alternatives
- Cost Estimate Summary
- CTP Future AWT Considerations
- Next Steps

CTP Feasibility Study Road Map

The following summarizes this project road map noting the project progression and additional elements/enhancements that were added.

- **Evaluated CTP Data for Evaluation Basis**
- **Developed High-Level Concepts of 5 Leading Alternatives (layouts, sizing, etc.) and Presented to PC 15**
- **Evaluation & Screening of 5 Leading Alternatives and Presentation to PC 15**
- **Screened to 2 Leading Alternatives (BNR & MBR)**
- *Requested to Enhance Project w/ AGS Alterative*
- **Progressed 3 Leading Alternatives (layouts, sizing, costing, MOPO)**
- *Requested to Enhance Project w/ Future Synergies/Advanced Reuse Evaluation*
- **Considered Potential Synergies with Future Regulations**
- **March 2021 Presented Draft Evaluation (Concepts, Costs & MOPO)**
- **April 2021 Final Presentation (Concepts, Costs & MOPO)**
- **May 2021 Submitted Draft Final Report**
- *Received Report Comments*
- **August 2021 Submitted Final Report - Project Completion**
- *Final Recap Discussion*

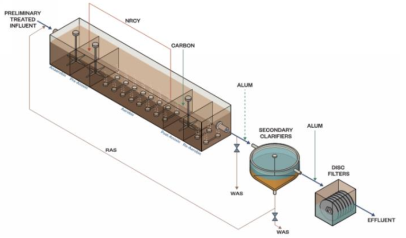
Shortlisted Alternatives

Future Alternatives For Consideration

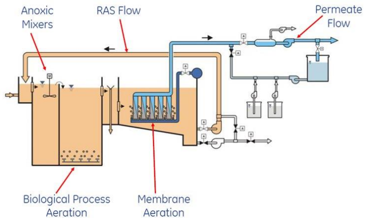
- ✓ Conventional Activated Sludge with Nutrient Removal **(BNR)** (selector/nutrient removal)
- ✓ Membrane Bioreactor **(MBR)**
- ✓ Aerobic Granular Sludge **(AGS)**

- ☐ Membrane Aerated Biofilm Reactors **(MABR)**
- ✗ Sequencing Batch Reactors **(SBR)**

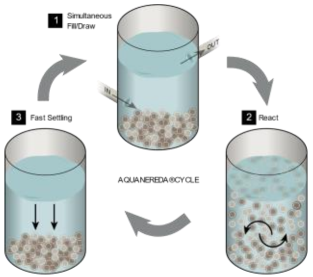
The BNR and AGS alternatives assume disk filtration to provide approximate equivalently effluent quality to the MBR alternative



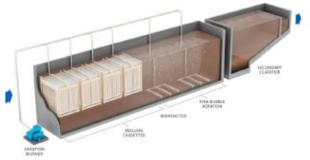
✓ CAS BNR



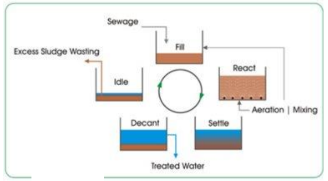
✓ MBR



✓ AGS



☐ MABR

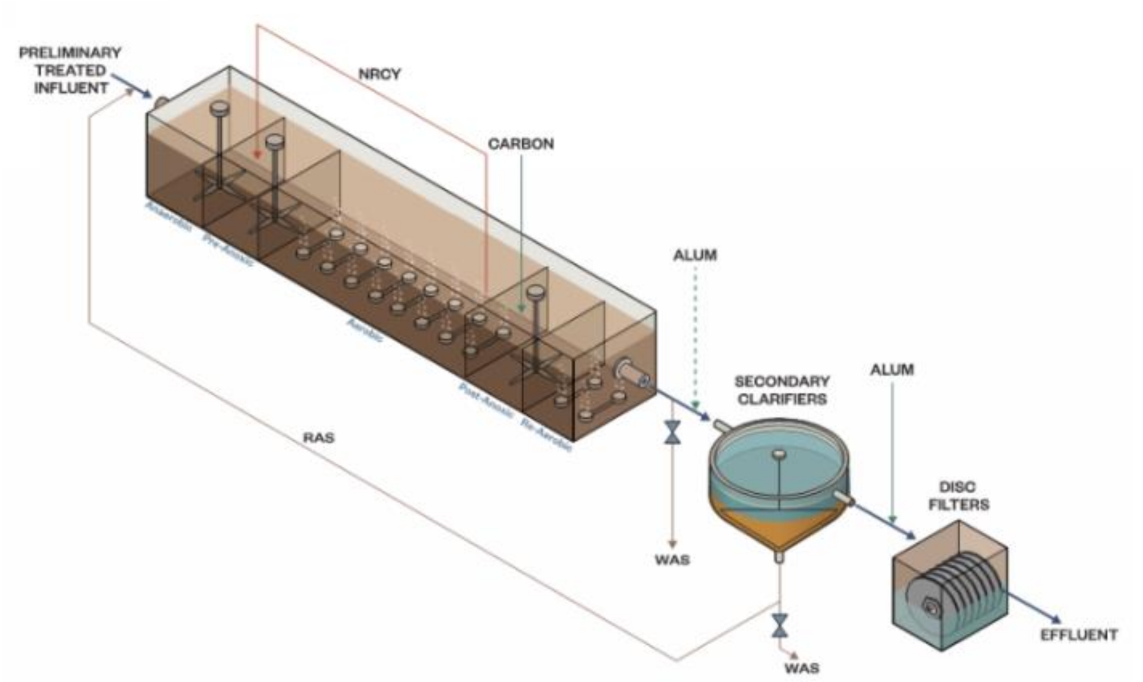


✗ SBR

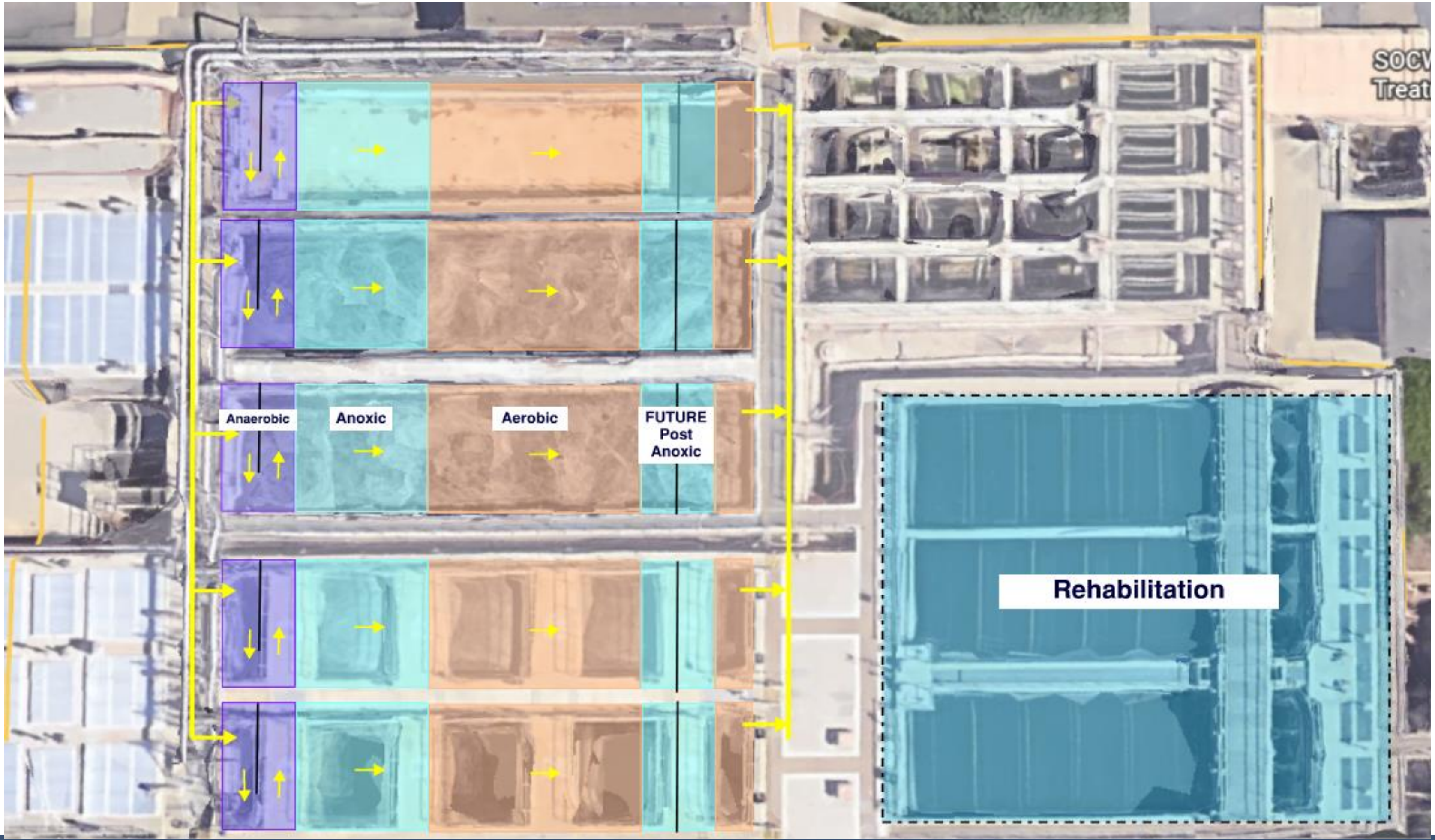
BNR Alternative

Biological Nutrient Removal (BNR)

- What?
  - Biological N and P removal through zone design to select specific organisms
- Why?
  - Proven approach with decades of implementation
  - Provides improved effluent quality (nutrients) compared to current operation
  - Consistent effluent quality
  - Improved settling



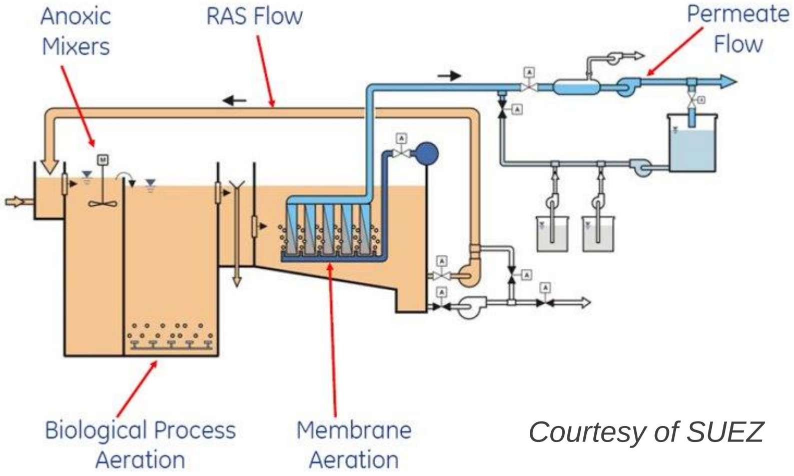
Layout of BNR Alternative at CTP



MBR Alternative

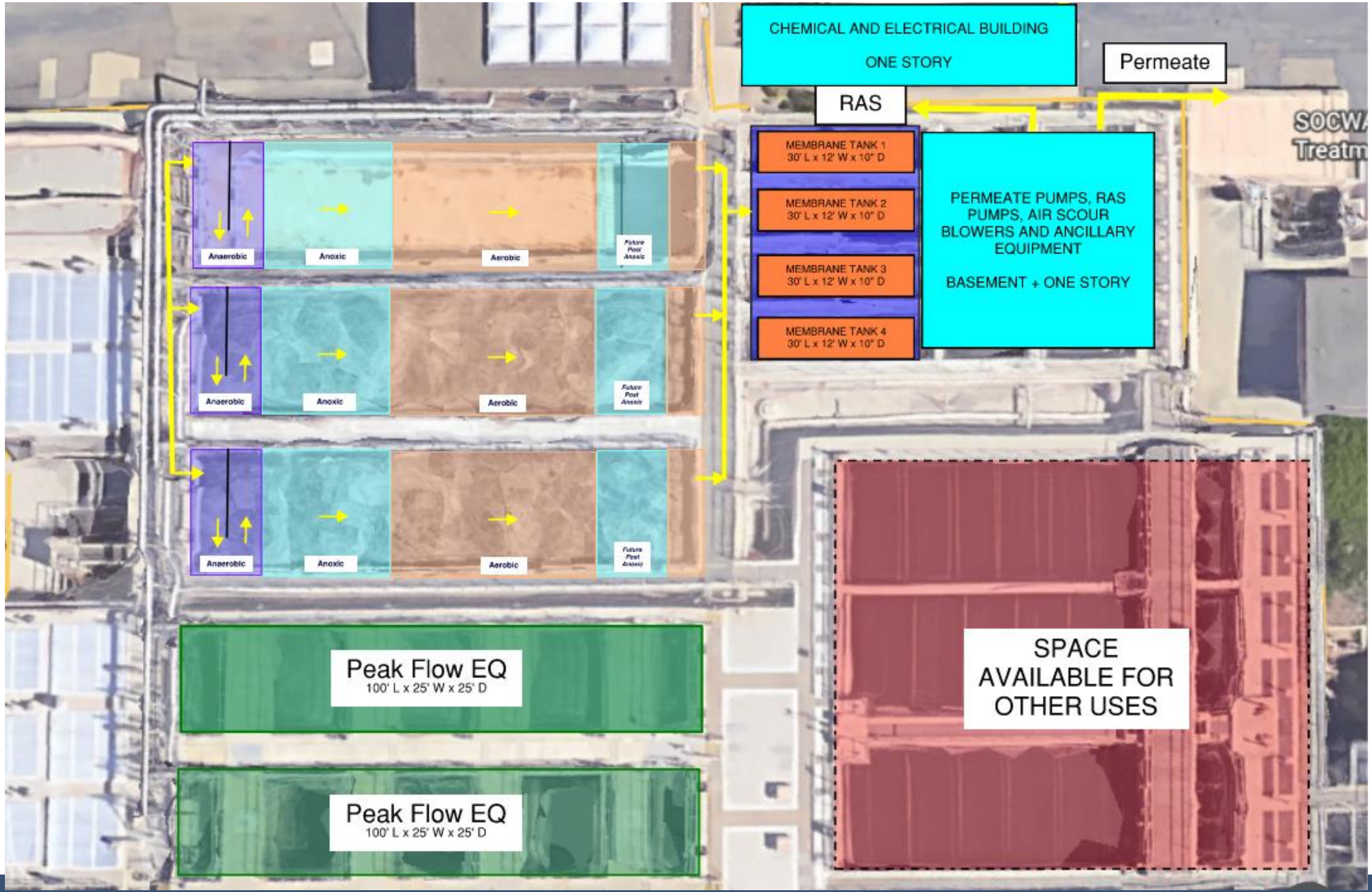
Membrane Bioreactor (MBR)

- What?
  - Secondary clarifiers replaced with membranes
  - Pump or gravity flow MLSS from aeration basins to membrane tank
  - Dedicated membrane tankage preferable for flexibility
  - Typical BNR configurations can be used
- Why?
  - Smaller footprint versus clarifier based secondary process
  - Enhanced effluent quality for reuse



Courtesy of SUEZ

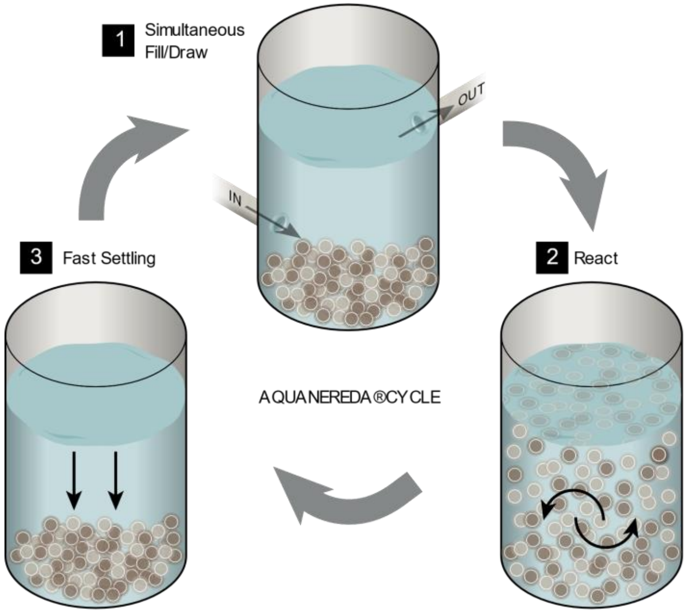
Layout of MBR Alternative at CTP

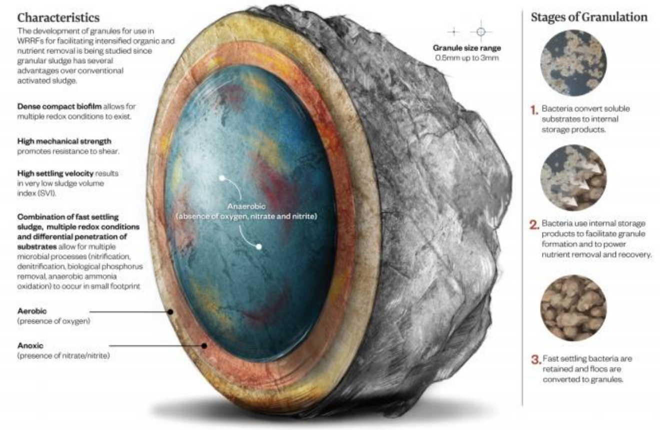


AGS Alternative

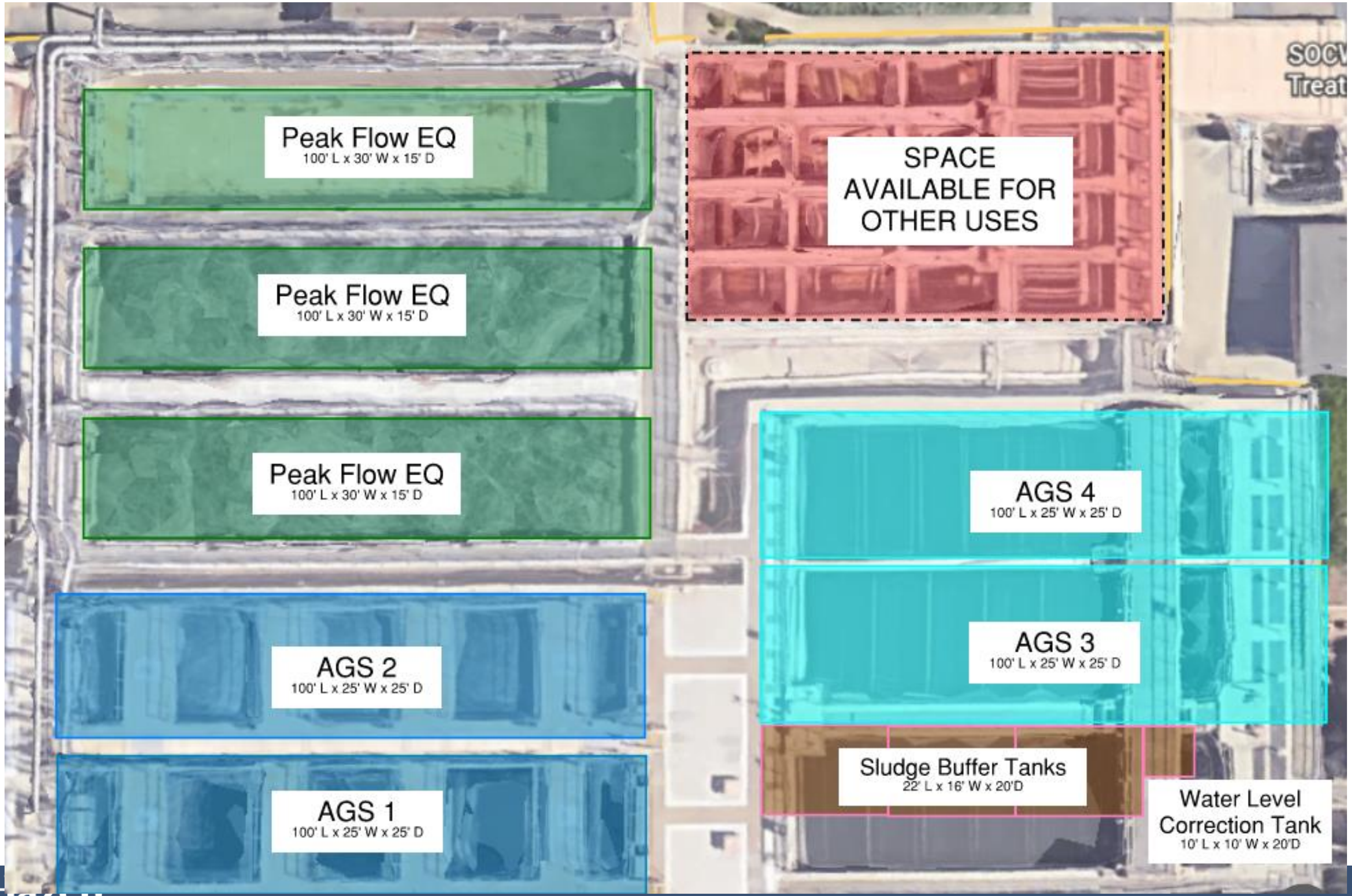
Aerobic Granular Sludge (AGS)

- What?
  - Simultaneous biological N and P removal through formation of granules typically in SBRs
- Why?
  - Smaller footprint, higher loading rates
  - Reduced energy
  - Good settling
  - Alternative to membrane bioreactors





Layout of AGS Alternative at CTP



New filter location and layout same as CAS BNR

Summary of Shortlisted Alternatives

- The shortlisted alternatives meet the same level of nutrient removal, providing an enhancement compared to the current facility operation
  - **Anticipating a >50% reduction in effluent TIN**

- MBR and CAS BNR alternatives provide the benefits of maximizing the existing basin infrastructure

- AGS requires extensive structural work (shoring, new foundations, etc.) for the 2 new reactors which increased the capital cost of that alternative

The following slides will summarize the cost estimate developed for the shortlisted alternatives

Cost Estimate Summary

Comparative Cost Estimate Assumptions

- Cost developed for alternative comparison purposes and do not include costs for improvements that are common between all alternatives
- American Association of Cost Estimators (AACE) Class 4 cost estimate with expected accuracy within -30%/+50%
- Unit process improvement exclusions: influent pumping, preliminary treatment, primary treatment, aeration blower improvements, solids handling, disinfection and outfall.
- Cost estimate markups:
  - **General Conditions = 10%**
  - **Contractor Profit = 18%**
  - **Bonds and Insurance = 3%**
  - **Contingency = 35%**
- Cost of engineering not included

Comparative Capital Cost Estimates

Alternative	Opinion of Probable Construction Cost[1,2]
1. CAS BNR	$16.5M
2. MBR	$25.6M
3. AGS	$32.3M

1. American Association of Cost Estimators (AACE) Class 4 cost estimate with expected accuracy within -30%/+50%
2. Cost estimates markups:
   - General Conditions = 10%
   - Contractor Profit = 18%
   - Bonds and Insurance = 3%
   - Contingency = 35%

These costs are for the secondary improvements only, not including the future advanced considerations to be discussed next…

Summary of Work Completed

- Evaluated and screened 5 alternatives down to the leading 3:

✓ **Biological Nutrient Removal (BNR)**
✓ **Membrane Bioreactor (MBR)**
✓ **Aerobic Granular Sludge (AGS)**

- Developed conceptual layouts and sizing for the 3 leading alternatives
- Developed high-level costs for the shortlisted concepts
- Considered potential Maintenance of Plant Operation (MOPO) approaches for each alternative

The above effort provides a completion of this project scope of work.

In a previous Engineering Committee Meeting, Hazen was asked about potential future considerations, drivers for reuse, potential technologies, etc. The following discussion is an added value to provide a starting point for future considerations...

CTP Future Advanced Water Treatment Considerations

Potential Advanced Treatment Drivers

Potential Near-Term and Long-Term Drivers

Near-Term Advanced Treatment Drivers

- Potential near-term drivers are considered applicable for removal of emerging contaminants

Near-Term Drivers:

Advanced Wastewater Treatment

Benefits:

•*Improve Water Quality Discharged to Ocean*
•*Reduced PFAS, 1,4-Dioxane, CECs, Microplastics, pathogens*
•*Recycled water capacity*
•*Meeting more stringent reuse requirements*

Long-Term Advanced Treatment Drivers

- Potential long-term is considered applicable if/when there is a driver to expand reuse options including implementing potable reuse

Long-Term Drivers:

Potable Reuse

Benefits

•*Improve Water Quality Discharged to Ocean*
•*High Level of Treatment*
•*Reduced Discharge to Ocean*
•*Multiple-Barrier Treatment*

These are example drivers in-line with the current industry. There are synergies with considering long-term drivers during near-term improvements planning (space considerations, technology selection, etc.)

Envisioning a Potential Future AWT at CTP

Hazen

Site Layout: Membrane-Based Future AWT (CAS, AGS)

Site Layout: Membrane-Based Future AWT (MBR)

Site Layout Assumes Demonstration work Proves MF is not needed downstream of MBR

Water Reuse Considerations for CTP

- **Addressing near-term treatment drivers allows for consideration of long-term reuse goals**
- **Further studies needed to identify best path forward for advanced water treatment**

Hazen

Next Steps for the CTP

Potential Next Steps

- Select one treatment alternative to progress into preliminary design
- Incorporate costs in the Ten-Year Plan to implement one treatment alternative
- Other suggested next steps from PC 15?

Hazen *Technical Memorandum*

South Orange County Wastewater Authority

Coastal Treatment Plant Future Alternatives Feasibility Study

October 14, 2021

FINAL

Job no

Hazen

Table of Contents

Executive Summary

The South Orange County Wastewater Authority (SOCWA) contracted Hazen and Sawyer (Hazen) to perform a planning level assessment of future upgrades and treatment alternatives for the Coastal Treatment Plant (CTP). The purpose of this assessment is to analyze treatment alternatives that prepare SOCWA for potential future considerations including regulations for enhanced effluent quality as well as impacts to the potential future Advanced Water Treatment Plant (AWTP) – [see section 7 for details] for the production of recycled water.

The alternative process configurations considered are newer treatment approaches that are currently not utilized at CTP. The approaches considered would improve effluent quality and increase operational flexibility to treat an average flow of 4 mgd (established in the 2014 CTP Facility Plan). These treatment approaches provide biological nutrient removal (BNR) to prepare CTP for the potential future effluent criteria summarized below.

Table ES-1. Potential Future Effluent Water Quality Objectives

Parameter	Units	Value
BOD_5	mg/L	< 10
TSS	mg/L	< 10
TN[1]	mg/L	< 10
NH_3-N[2]	mg/L	< 1

1. *Total Nitrogen*
2. *Ammoniacal Nitrogen*

The alternatives considered to meet these treatment objectives include:

- Conventional Activated Sludge (CAS) with Biological Nutrient Removal (i.e. 5-Stage BNR)
- Membrane Bioreactor (MBR)
- Membrane Aerated Biofilm Reactors (MABR)
- Aerobic Granular Sludge (AGS)
- Sequencing Batch Reactors (SBR)

A qualitative scoring approach was utilized to select three alternatives for a more detailed cost assessment to inform SOCWA's planning decisions. The scoring criteria included:

1. Relative capital costs.
2. Relative estimated energy and chemical requirements.
3. Compatibility with water quality goals for recycled water and flexibility in accommodating potential future discharge limits.
4. Compatibility to be incorporated into existing infrastructure while maintaining operations.

The preliminary screening identified three preferred secondary treatment processes: BNR, MBR, and AGS. MABR did not make the final shortlist due to limited full-scale installation history at the time of the feasibility study. MABR can be considered in the future as an add-on to the BNR or MBR alternatives once it has a longer operational history. The SBR did not offer treatment or infrastructure benefits over the AGS alternative, which uses a similar batch process to SBR.

Each short-listed alternative was further developed with site-specific comparative capital costs, operation and maintenance cost impacts, site layouts, and construction sequencing challenges. CTP has observed significant peak flows during severe wet weather events; therefore, alternatives were sized to manage up to 14.1 mgd (the previously established peak hydraulic capacity). The BNR alternative will utilize step feed flexibility while the MBR and AGS alternatives will utilize peak flow storage to accommodate high flows. Each alternative was configured to meet the treatment objectives described above and Title 14 California Code of Regulations for beneficial reuse flexibility. Site layouts for each shortlisted alternative are shown in the figures below.

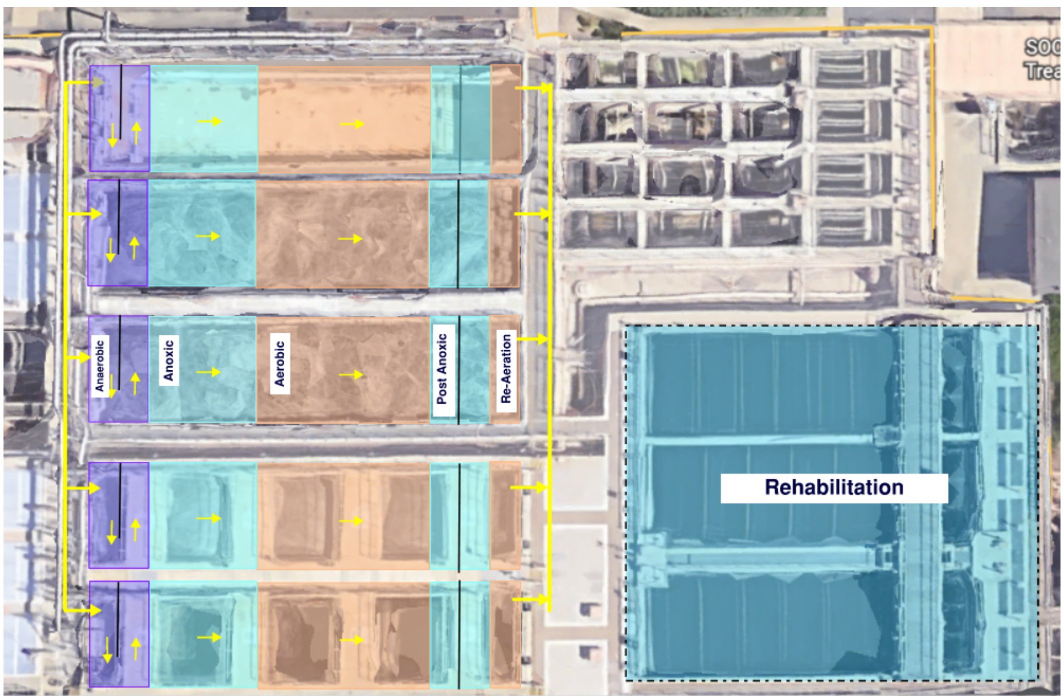


Figure ES-1. Five-Stage BNR Alternative Conceptual Layout (New disc filters for advanced water treatment not shown)

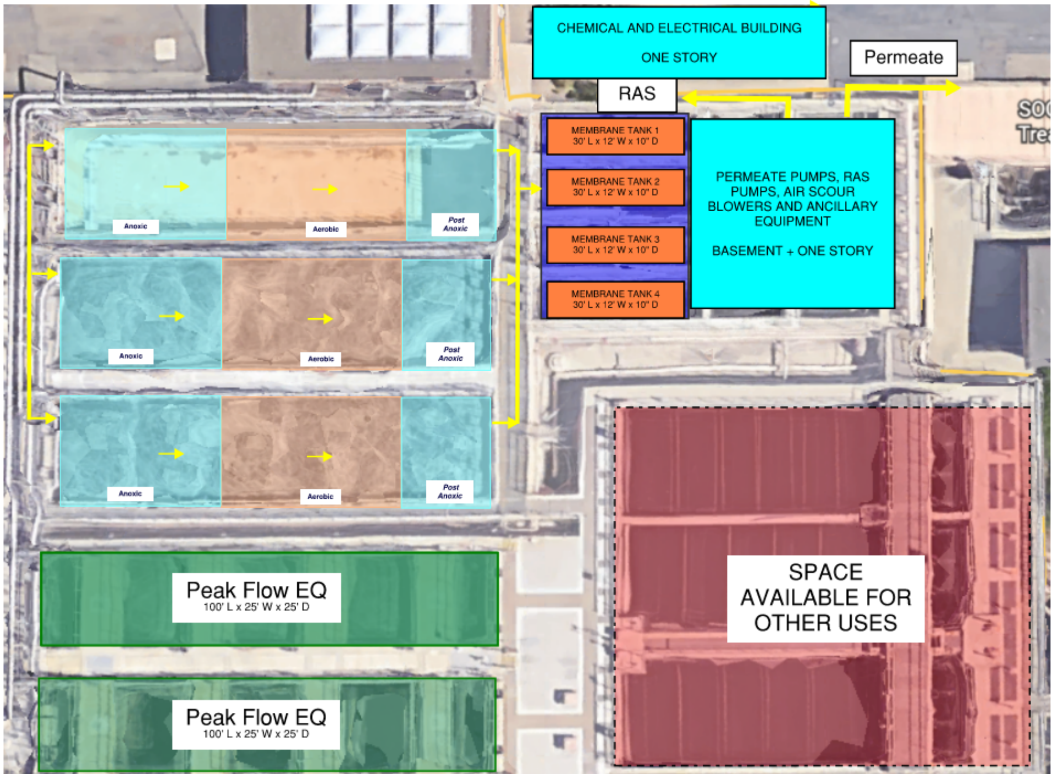


Figure ES-2. MBR Alternative Conceptual Layout

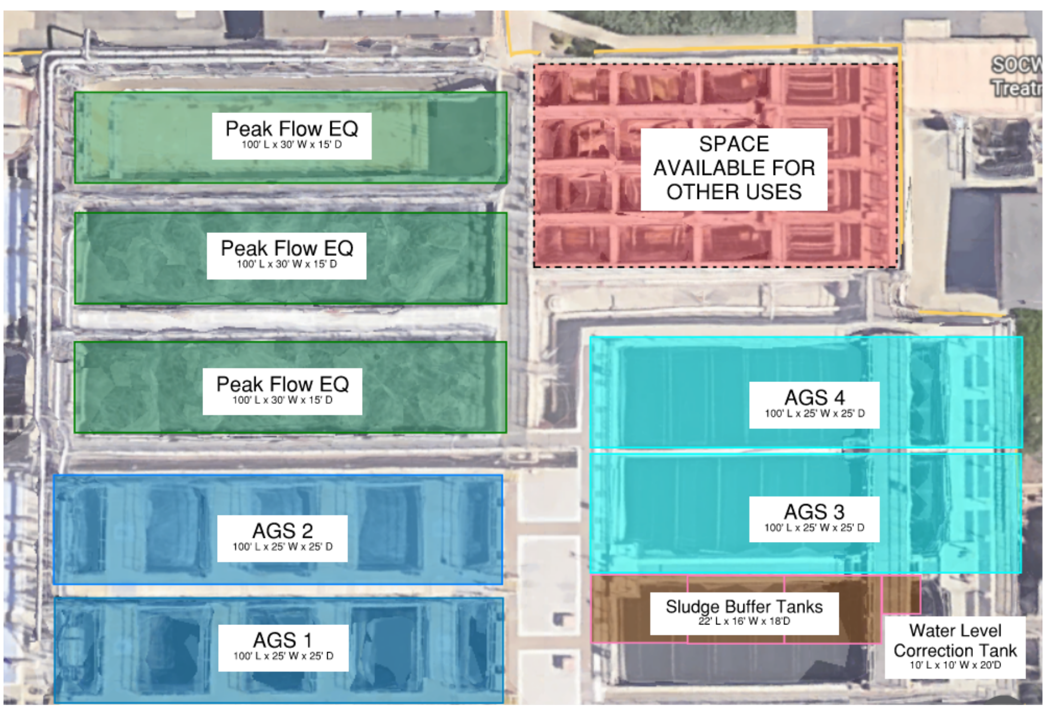


Figure ES-3. AGS Alternative Conceptual Layout (New disc filters for advanced water treatment not shown)

Table ES-2 below summarizes the capital, operations and maintenance (O&M), and 20-year net present value (NPV) by alternative. The BNR alternative leverages more existing infrastructure than the MBR and AGS alternatives resulting in lower initial capital investment. The existing site constraints, soil conditions and site accessibility have significant cost impacts to the MBR and AGS alternatives.

Table ES-2. Annual O&M and 20-Year NPV Cost Summary

Parameter	BNR	MBR	AGS
Comparative Capital Cost	$17,500,000	$28,800,000	$36,900,000
Annualized O&M Cost w/material cost escalation	$5,300,000	$9,300,000	$4,000,000
Total 20-year NPV	$22,800,000	$38,100,000	$40,900,000

All three alternatives are feasible and can be constructed while maintaining operation of the existing facility detailed in Section 6.3. The existing site conditions pose a more significant challenge to the construction of the MBR and AGS alternatives. For example, both alternatives will increase truck traffic during construction for removal of excavated material and demolition debris. In addition, vertical excavation will be required for the MBR and AGS alternatives resulting in increased complexity and safety measures.

Lastly, SOCWA and member agencies are interested in how the secondary treatment alternatives may be synergistic with near-term and long-term drivers for reuse in the region. A high-level evaluation of future considerations for the CTP including potential future regulatory drivers, industry trends, and/or synergies with advanced water treatment for reuse was completed. In general, the proposed alternatives would be synergistic with potential reuse drivers in the future. Additionally, high-level layouts were developed to provide initial understanding of space requirements advanced water treatment approaches with each secondary treatment alternative. Further details can be found in Section 7.

1. Introduction and Purpose

The South Orange County Wastewater Authority (SOCWA) contracted Hazen and Sawyer (Hazen) to perform a planning level assessment of future upgrades and treatment alternatives for the Coastal Treatment Plant (CTP). The purpose of this assessment is to analyze treatment alternatives that prepare SOCWA for future regulations related to ocean discharge as well as impacts to the potential future Advanced Water Treatment Plant (AWTP) – [see section 7 for details] for the production of recycled water. The alternatives analysis includes capital and operation and maintenance (O&M) cost estimates to assist SOCWA with funding considerations and capital planning.

The alternative process configurations considered are newer treatment approaches that are currently not utilized at CTP to improve effluent quality and increase operation flexibility. These treatment approaches provide biological nutrient removal to prepare CTP for the potential of more stringent limitations related to ocean discharge and expand opportunities to increase water reuse. The alternatives considered include:

- Conventional Activated Sludge (CAS) with Biological Nutrient Removal (BNR) (i.e. 5-Stage BNR)
- Membrane Bioreactor (MBR)
- Membrane Aerated Biofilm Reactors (MABR)
- Aerobic Granular Sludge (AGS)
- Sequencing Batch Reactors (SBR)

In addition, long-term considerations were considered for the AWT facility including potential for direct potable reuse applications and the advanced treatment processes required to meet current drinking water standards and potential future contaminants of concern.

2. Historical Data Review

Flows and loads summarized in this section are based on data analysis completed in September 2020 and reported in the September 29, 2020 meeting presentation (Appendix A). **Table 2-1** summarizes the observed influent characteristics from January 2016 through July 2020, and **Table 2-2** summarizes the primary effluent characteristics observed during the same period.

Table 2-1: CTP Influent Flow and Loads – January 2016 through July 2020

Parameters	Units	Current	
		Average Annual	Maximum 30-Day
Flow	mgd	2.68	2.93
	Peak Factor (PF)	1.0	1.10
BOD_5	mg/L	292	350
	lbs/d	6,600	8,600
	load PF	1.0	1.30
TSS	mg/L	364	461
	lbs/d	8,100	11,300
	load PF	1.0	1.40
VSS	mg/L	325	398
	lbs/d	7,300	9,700
	Load PF[1]	1.0	1.32

1. PF = Peak factor

Table 2-2: CTP Primary Effluent Loads[1] – January 2016 through July 2020

Parameters	Units	Current	
		Average Annual	Maximum 30-Day
BOD_5	mg/L	145	180
	lbs/d	3,250	4,240
	load PF	1.0	1.30
TSS	mg/L	103	126
	lbs/d	2,310	3,160
	load PF	1.0	1.37
VSS	mg/L	81	106
	lbs/d	1,810	2,400
	Load PF	1.0	1.32
NH_3-N	mg/L	32	37
	lbs/d	730	900
	Load PF[2]	1.0	1.22

1. Primary influent and effluent assumed to be equal for this evaluation

2. PF= Peak Factor

Table 2-3 compares the reported secondary effluent water quality to current limits.

Table 2-3. Reported Average Secondary Effluent Water Quality – January 2016 – July 2020

Parameter	Units	Observed Concentration	Average Monthly Discharge Permit Limitation	Average Weekly Discharge Permit Limitation
$cBOD_5$	mg/L	6.0	25	40
TSS	mg/L	7.2	30	45

SOCWA provided flow data for three significant rain events in the last five years (January 2017, February 2017, and December 2019). The observed peak hour flow during these events ranged from approximately 8 to 15 mgd. The observed hydrographs showed a rapid rise in flow and sharp reduction over a period of about four hours. These peak flow event observations informed the basis of evaluation described below.

3. Basis of Evaluation Criteria Summary

The CTP was constructed in two phases: in 1967 (east), and 1983 (west). The CTP was designed and permitted to treat an average flow of 6.7 mgd and 12-mgd peak hour flow. SOCWA is considering derating the plant capacity to an average flow of 4.0 mgd in the future and contracted Hazen to evaluate potential process alternatives to meet more stringent effluent limitations at the reduced flow.

The 2014 CTP Facility Plan concluded that the maximum hydraulic capacity is 14.1 mgd. For this evaluation, the alternatives were designed to process a peak flow of 14.1 mgd for a sustained duration of four hours. CTP observed an estimated 15-mgd instantaneous peak flow during a severe wet weather event on January 22, 2017. A more detailed hydraulic analysis is recommended to assess CTP's capability to pass flows up to 15 mgd before adopting the higher flow as the basis of design.

Historical influent and primary effluent loads were evaluated to develop the secondary process design loading criteria for this evaluation. Design loads and concentrations were developed for the anticipated 4.0-mgd flow. The primary effluent concentration assumed 40% BOD_5 removal and 70% TSS removal to match historical performance. **Table 3-1** and **Table 3-2** summarize the 4.0-mgd design flows, concentrations, and loads. The evaluations assumed a minimum wastewater temperature of 18^{o}C and an average wastewater temperature of 23^{o}C.

Table 3-1: Influent Characteristics

Parameters	Units	Current		Design	
		Average Annual	Maximum 30-Day	Average Annual	Maximum 30-Day
Flow	mgd	2.7	2.9	4.0	4.4
BOD_5	mg/L	292	350	292	350
	lbs/d	6,600	8,600	9,800	12,900
TSS	mg/L	364	461	364	461
	lbs/d	8,100	11,300	12,200	16,900
VSS	mg/L	325	398	325	398
	lbs/d	7,300	9,700	10,900	14,600

Table 3-2. Primary Effluent Design Loads at 4.0 mgd

Parameters	Units	Current		Design	
		Average Annual	Maximum 30-Day	Annual Average	Maximum 30-Day
Flow	mgd	2.7	2.9	4.0	4.4
TSS	mg/L	103	126	103	126
	lbs/day	2,330	3,090	3,440	4,620
BOD_5	mg/L	145	180	145	180
	lbs/day	3,270	4,410	4,850	6,600
NH_3-N	mg/L	32	37	32	37
	lbs/day	730	900	1,070	1,360

The objective of this evaluation is to determine improvements necessary to meet more stringent future effluent discharge limitations for an ocean discharge. **Table 3-3** summarizes the assumed future effluent water quality objectives for the alternative evaluation. These values are based on those that can be achieved with BNR and in-line with other BNR facilities in the region.

Table 3-3. Potential Future vs Current Effluent Water Quality Objectives

Parameter	Units	Future Value	Current Value
BOD_5	mg/L	< 10	25
TSS	mg/L	< 10	30
TN	mg/L	< 10	--
NH_3-N	mg/L	< 1	--
pH	-	6.0 - 9.0	6.0 – 9.0

This evaluation considered approaches to leverage the existing infrastructure where possible to reduce the overall capital cost to SOCWA. **Table 3-4** summarizes the existing secondary process dimensional criteria.

Table 3-4: Existing Aeration Basins and Secondary Clarifiers Dimensions

Parameters	Unit	East Plant	West Plant
Aeration Basins[1]			
Number of Aeration Basins		3	2
Basin Dimensions, L x W, each	ft x ft	100 x 30	100 x 25
Sidewater Depth	ft	15	25
Aeration Basin Volume, each	gallons	336,600	467,500
Secondary Clarifiers[1]			
Number of Secondary Clarifiers		4	3
Basin Dimensions, L x W, each	ft x ft	85 x 12	92 x 25
Sidewater Depth	ft	10	12
Secondary Clarifiers Area, each	ft^2	1,020	2,300

4. Initial Alternatives Development and Shortlist

This section provides process descriptions for each alternative considered and the methodology to short-list most feasible alternatives for further analysis.

4.1 Conventional Activated Sludge with Nutrient Removal (Five-Stage BNR Process)

This secondary treatment option provides five-stage BNR to meet more stringent nutrient limitations while maintaining the existing secondary clarifiers for solids removal. **Figure 4-1** shows a typical five-stage BNR process schematic. Each BNR basin is divided into multiple zones as follows.

- **Stage 1 - Anaerobic selector zone** – The anaerobic selector zone is beneficial for maintaining a well-settling sludge. An ancillary benefit of the anaerobic selector zone is to provide conditions for growth of phosphorus accumulating organisms (PAOs) that perform biological phosphorus removal.
- **Stage 2 – Pre-anoxic selector zone -** The pre-anoxic zone utilizes influent carbon for denitrification of nitrate that is returned from the end of the aerobic zone via the nitrified recycle (NRCY) pumps.
- **Stage 3 - Aerobic zone** - Performs nitrification and carbon oxidation using oxygen supplied by the blowers through diffused air.
- **Stage 4 – Post-anoxic selector zone -** The post-anoxic zone provides additional denitrification endogenously (through carbon generated by biomass decay) or with the addition of supplemental carbon.

- **Stage 5 - Reaeration zone** - The reaeration zone provides polishing of any residual ammonia in the post-anoxic zone effluent.

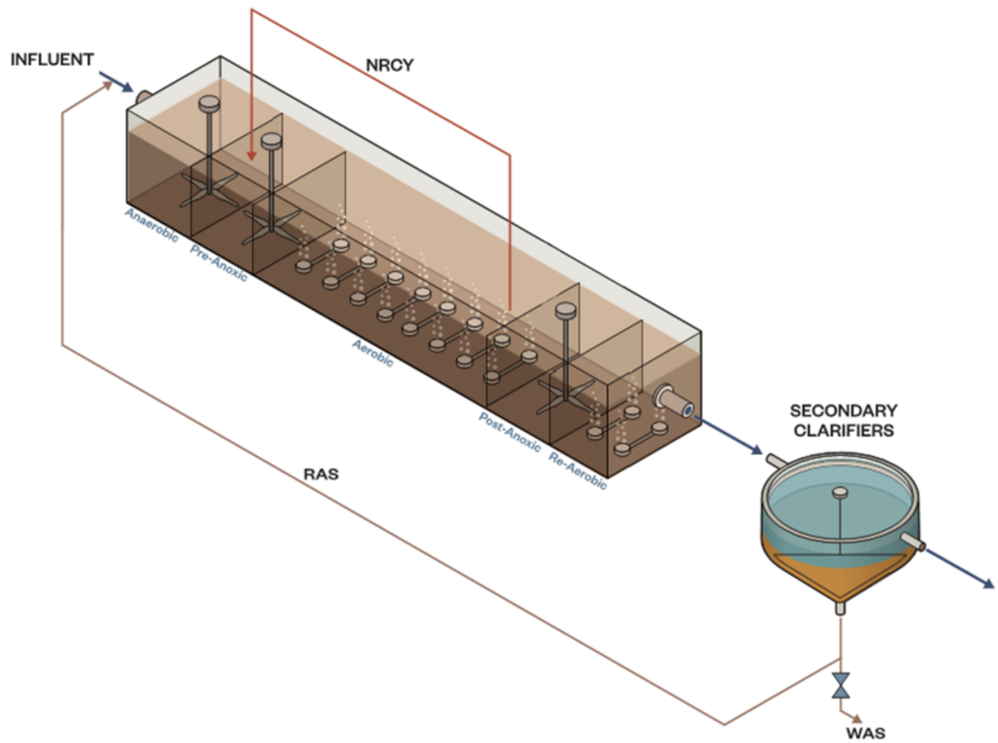


Figure 4-1. Five-Stage BNR Process Schematic

The existing secondary clarifiers will be utilized for settling of the mixed liquor from the five-stage BNR process. Secondary effluent will continue to the tertiary treatment and disinfection processes. Existing RAS pumps will return mixed liquor back to the head of the BNR tanks.

4.2 Membrane Biological Reactors (MBR) Nutrient Removal Process

The MBR nutrient removal process includes staged anoxic and aerobic zones similar to the five-stage BNR option coupled with ultrafiltration membranes for solids separation. A membrane filtration system provides a physical barrier for separation of solids and replaces the secondary clarifiers and tertiary filters used in the CTP.

Figure 4-2 shows a typical MBR BNR process schematic. Note that the re-aeration zone shown for the five-stage BNR process with conventional clarifiers is replaced with the MBR tanks, which are aerated to limit biofilm growth on the membranes (air scour). Since there are no secondary clarifiers, the improved settling associated with an anaerobic zone provides limited benefit. This process could also be configured with an upfront anaerobic zone (similar to the five-stage BNR option) if an effluent total phosphorus (TP) limit needs to be met in the future.

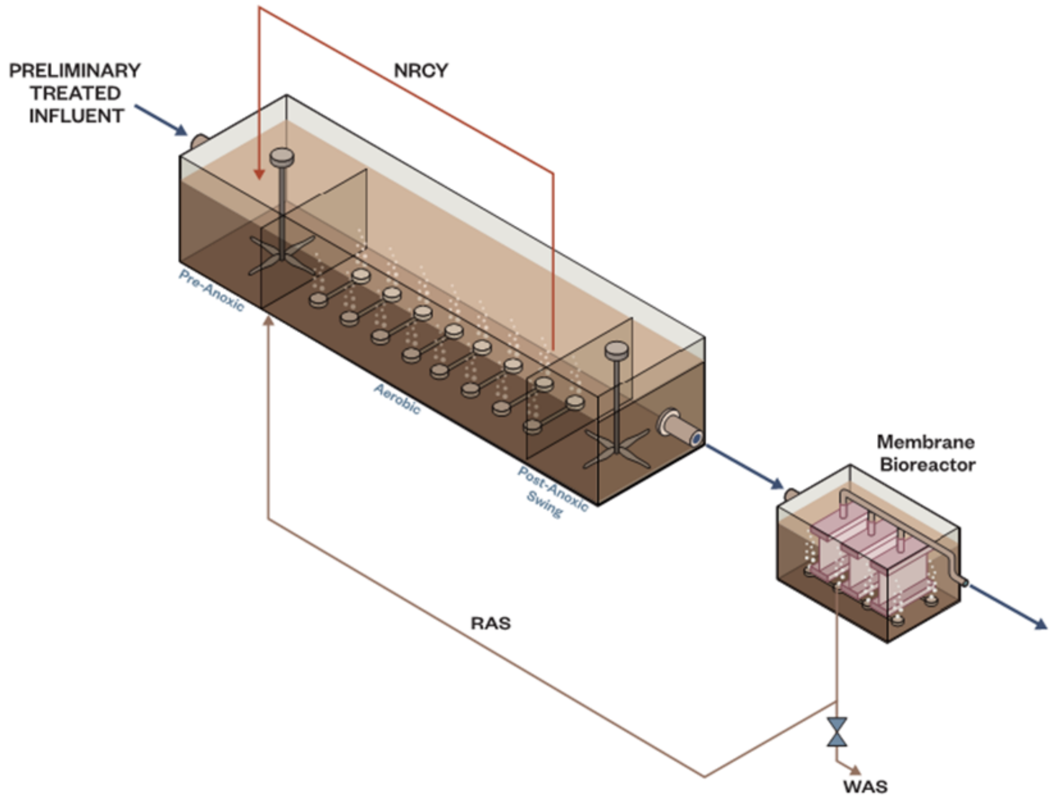


Figure 4-2. MBR BNR Process Schematic

MBR effluent, known as permeate, is sent directly to disinfection, and tertiary filters are not necessary. RAS from the MBR is returned to the BNR basins at a flow rate of approximately 300 to 400% of influent flow. MBR membranes are maintained through air scour, backwashing, maintenance cleaning (low concentration chemical cleaning), and recovery cleaning (extended duration chemical cleaning). Membrane organic and inorganic fouling is typically addressed by soaking the membranes in a solution of an oxidant (sodium hypochlorite) and acid (citric acid) respectively. Additional supporting systems such as pumps, chemical systems, and air scour blowers are required to perform these maintenance tasks and must be accounted for in consideration of the footprint of an MBR system.

MBR systems provide the following benefits:

- MBR systems are typically operated at a high MLSS concentration (8,000-10,000 mg/L) compared to conventional activated sludge, reducing the aeration basin volume required for a given load and SRT.
- Membrane pore sizes range from 0.1 to 0.4 µm and replace the need for secondary clarifiers and filtration, resulting in a consistent effluent quality.

The following considerations must be made for the implementation of MBR systems:

- Fine screens are one of the most important components of a MBR system and are required to protect membranes from debris that can damage the membranes. Coordination with the membrane vendor is required to ensure the fine screen size (typically 2 mm) is compliant with their membrane warranty requirements. Equalization basins and fine screens should be considered as part of MBR system requirements. The CTP currently has 2.5-mm fine screens, which was acceptable to the membrane manufacturer (SUEZ) contacted during this evaluation. If this alternative were selected a more detailed screening assessment is recommended including the potential for converting the existing screens to 2-mm screens.

- Membrane system sizing is typically limited to a maximum peak flow of twice the annual average flow to provide an economical system. Flow equalization is generally provided to store flows exceeding two times the design flow.
- MBRs generally require more energy to operate than conventional technologies due to permeate pumping, high RAS rates, and membrane air scour.
- Peak flows can drive the construction and operating costs of a MBR and can be managed through addition of an equalization basin.
- Membrane replacement may be required approximately every ten years.

4.3 Membrane Aerated Biofilm Reactor (MABR)

MABR utilizes a gas-permeable membrane to deliver oxygen to a nitrifying biofilm for ammonia removal. The MABR consists of membrane cassettes typically placed in the pre-anoxic zone of a BNR reactor. Air is introduced into the inside of the membrane (lumen), and oxygen diffuses out to the membrane surface, where nitrifying biomass create a biofilm and remove ammonia. Denitrification occurs in the same volume since no dissolved oxygen is introduced to the bulk liquid. Secondary clarifiers are still included in this process as final effluent is not drawn through the membrane. **Figure 4-3** shows a typical MABR conceptual layout.

The oxygen diffusion through the biofilm creates dissolved oxygen (DO) and organic carbon gradients. The low-pressure, diffusive air transfer through the biofilm can reduce aeration costs and potentially pumping costs associated with more conventional denitrification. MABR cassettes can also increase the aerobic SRT through fixed-film growth without increasing MLSS concentrations, increasing nitrification capacity within a given footprint.

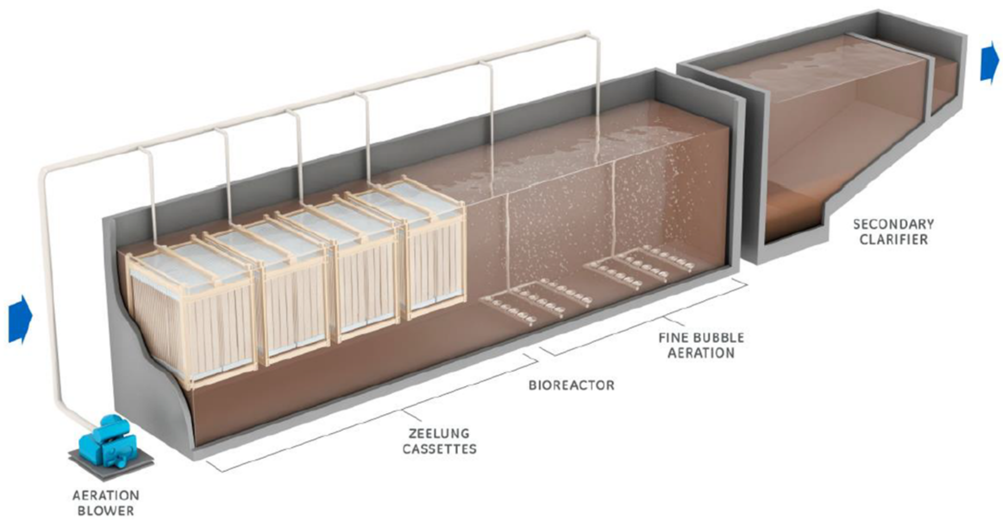


Figure 4-3. MABR Conceptual Layout (Zeelung® by Suez)

4.4 Aerobic Granular Sludge (AGS)

Aerobic Granular Sludge (AGS) processes utilize operating strategies to cultivate and retain AGS granules for the purpose of achieving BNR and increasing settleability. AGS granules display excellent settling characteristics, which facilitates operation at high MLSS concentrations (similar to MBR). AGS can achieve nutrient removal within a more compact footprint when compared to conventional activated sludge processes.

Aqua Aerobics Systems, Inc. (Aqua-Aerobic) is an AGS process provider in North America and licenses the AquaNereda® technology, which is an AGS process that utilizes proprietary equipment and operating strategies within sequential batch reactors (SBRs) to retain AGS granules. The use of SBRs consolidates infrastructure by performing BNR and solids separation in the same tankage. Considerations for this process include instrumentation reliance to successfully perform BNR in SBRs.

One key challenge of implementing AGS at the CTP is converting the current constant flow configuration to an SBR. AGS technology utilizes multiple SBRs, and flow distribution must be precisely monitored as the basins undergo draw and fill cycles at the same time. Equalization basins are recommended to maintain redundancy and manage both low and high flows. **Figure 4-4** shows a typical AGS process schematic.

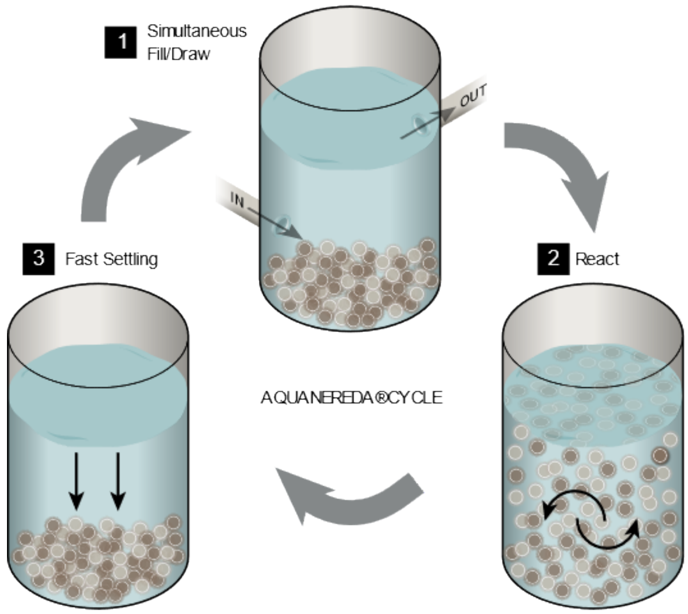


Figure 4-4. Aerobic Granular Sludge Process Schematic (AquaNereda®)

4.5 Sequencing Batch Reactors (SBR)

SBR achieves BNR through sequenced operation and intermittent aeration. The SBR process involves a fill-and-draw, complete mix reactor in which both aeration and clarification occur in a single reactor. The advantages of SBR include reduced complexity, eliminates need for clarifiers and RAS pumping systems, and increased tolerance for short-duration peak flows and shock loadings.

Figure 4-5 shows a typical SBR conceptual layout. The phases of each cycle include:

- **Fill** - Raw or settled wastewater is fed to the reactor during unaerated operation (for BNR applications) so anaerobic/anoxic conditions are provided.
- **React** – Intermittent aeration and mixing of the reactor contents to provide nitrification and denitrification.
- **Settle** - Quiescent setting and separation of MLSS from secondary effluent.
- **Draw and Decant**- Withdrawal of secondary effluent from the reactor
- **Idle** – Delay period before beginning the next cycle and might include removal of waste sludge from the reactor bottom.

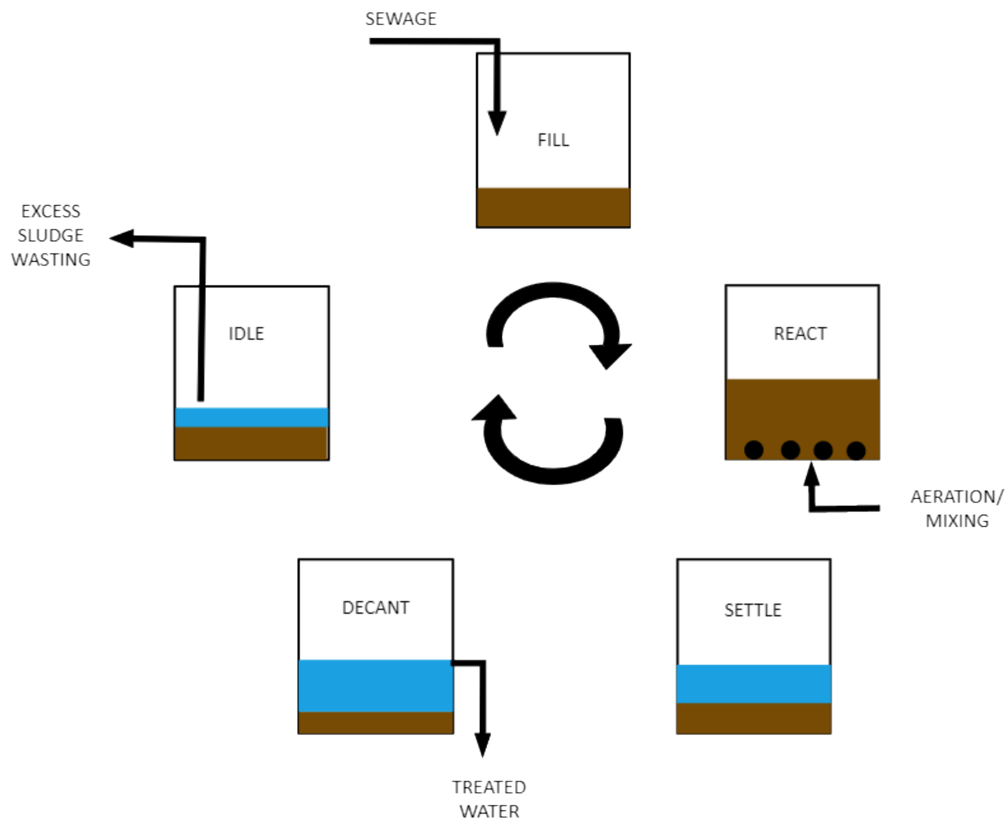


Figure 4-5. SBR Conceptual Layout

4.6 2014 CTP Facility Plan

Additional alternatives were considered as part of the 2014 CTP Facility Plan but were not evaluated further as part of this assessment. These alternatives included the following:

4.6.1 Maintain CTP Capacity of 6.7 mgd

SOCWA conducted a hydraulic analysis of the CTP to identify process bottlenecks and determine peak hydraulic capacity. The hydraulic analysis findings are summarized in the 2014 CTP Facility Plan, TM 2-1 Hydraulic Analysis. The study reported that the CTP hydraulic capacity was 14 mgd (PF of 2.1) with one unit out of service, achieving approximately 50/50 flow distribution between the East and the West plants.

The current aeration diffusers and blowers would need to be modified and replaced to efficiently treat 6.7-mgd. Based on current conservation, member agency historical discharges, and anticipated growth, the likelihood of average flows to the CTP reaching 6.7 mgd is unlikely. SOCWA is interested in facility upgrades that are flexible and sized for more realistic flows based on the currently available information. Additionally, peak flow events were bottlenecks for treatment operations limited by secondary clarifiers.

4.6.2 Relocation of the Plant Capacity

The 2014 CTP Facility Plan, TM 2-8 Relocation of the Plant Capacity (Jacobs, 2014) explored the option to partially and fully transfer the capacity of CTP to the Regional Treatment Plant (RTP). Full relocation of CTP capacity to RTP would require the following expansion:

- A separate sewer line to deliver the flows to RTP.
- Harvest recycled water from the Effluent Transmissions Main (ETM) tied to the ocean outfall to the CTP AWT facility to meet recycled water demands in the CTP service area.
- RTP expansion to treat an additional 6.7 mgd.

The estimated planning level cost to relocate capacity and ETM flow harvesting was $105 million. The cost to construct new sewer lines to deliver flow to RTP was not included in the cost estimate. The alternative was eliminated as a feasible option due to cost and complexity to construct.

4.7 Preliminary Screening

4.7.1 Initial Screening Methodology

The following criteria were selected for the initial screening of alternatives. These criteria were initially developed by Hazen and then finalized in collaboration with SOCWA. The following four main categories were used for technology evaluations:

1. Relative capital costs
2. Relative estimated energy and chemical requirements.
3. Compatibility with water quality goals for recycled water and flexibility in accommodating potential future discharge limits.
4. Compatibility of selected process to be incorporated into existing infrastructure while maintaining operations.

4.7.2 Summary of Initial Screening Results

The benefits and challenges of each alternative considered are summarized in **Table 4-1**.

Table 4-1: Technology Benefits and Challenges Overview

Alternative	Five-Stage BNR	MBR	MABR	Aqua Nereda AGS	Aqua SBR
Benefits	Utilizes existing treatment volume and familiar process	Enhanced effluent quality and no secondary clarifiers or filters required	Reduce aeration energy and potentially increase capacity	Smaller footprint, reduced equipment and potentially O&M costs, no separate clarifiers, and West Basins can be utilized	Reduced equipment and no separate clarifiers
Challenges	Requires all basins to be modified and operated to meet future standards	Requires substantial modifications to the secondary clarifiers, new equipment associated with MBR, and increased operational costs	Emerging technology, only **one** full scale installation in the United States	Existing east basins are too shallow to accommodate technology requiring addition of new basins and proprietary technology	Substantially more basin volume required and limited ability to retrofit existing tankage

The facility impacts of each alternative considered are summarized in **Table 4-2**.

Table 4-2: Facility Impacts Summary

Parameter	Five-Stage BNR	MBR	MABR	Aqua Nereda AGS	Aqua SBR
Reuse CTP Primary Clarifiers	Y	Y	Y	Y	Y
Repurpose CTP Aeration Basins	Y (all)	Y (East or West)	Y	Y (West Only)	Y (West Only)
Require Tertiary Facilities	Y	N	Y	Y	Y
Sludge Export PS Compatibility	Y	Y	Y	Y	Y
RTP Gas Generation	Decrease	Decrease	Decrease	Decrease	Decrease

The technologies evaluated are compared to one another based on a 1 to 5 scale for each of the four criteria evaluated, with 5 being the most favorable and 1 being the least favorable. Table 4-3 compares the scores for each alternative. **Based on the preliminary screening of the alternatives considered, the assessment identified three preferred secondary treatment processes: Five-Stage BNR, MBR, and AGS.** SOCWA and member agencies expressed interested in progressing the AGS alternative further to better understand cost, facility impacts, and compatibility with future objectives even through it scored lower than MABR. MABR did not make the final shortlist due to limited full scale installation history at the time of the feasibility study. MABR can be considered in the future with the five-stage BNR or MBR alternatives once it has a longer operational history.

The shortlisted alternatives meet the same level of nutrient removal, providing an enhancement compared to the current facility operation. The anticipated effluent total nitrogen (TN) can each meet the standards shown Table 3-3.

The MBR and five-stage BNR alternatives provide the benefits of maximizing the existing basin infrastructure. The AGS alternative requires extensive structural work (shoring, new foundations, etc.) for the 2 new reactors, which increases the capital cost of that alternative.

Table 4-3: Preliminary Alternatives Scoring

Criteria	BNR	MBR	MABR	AGS	SBR
Relative Capital Cost	5	4	3	2	1
Relative Energy and Chemical Costs	3	2	4	4	3
Compatibility with Water Quality Objectives	3	5	3	3	3
Compatibility with Existing Infrastructure	5	3	4	2	1
Total Score	**16**	**14**	**14**	**11**	**8**

5. Shortlisted Alternatives Analysis

The shortlisted alternatives, **Five-Stage BNR, MBR, and AGS**, were analyzed in further detail specific to implementation at CTP. This section summarizes the approach to peak flow management, process sizing, and CTP layout by alternative.

5.1 Peak Flow Management

The 2014 CTP Facility Plan concluded that the overall hydraulic capacity is 14.1 mgd. Therefore, this is the basis of hydraulic capacity for this alternative evaluation. Impacts of increased wet weather flows on the short-listed alternatives are described below.

5.1.1 BNR – Step-feed Mode

The East and West Aeration Basins were originally designed with step feed channels. The goal of the step feed process configuration is to retain the biomass inventory in the activated sludge process during wet weather operation. In a step feed configuration, a portion of the primary effluent is fed further down the aeration basin while RAS is still returned to the upstream end of the basin. Step feed reduces solids loading to the secondary clarifiers by diluting the aeration basin effluent MLSS and utilizing the upstream portions of the basins for storage of solids. Gate replacement and re-installation of gates are required for step-feed operational flexibility to be returned to CTP and are accounted for in the cost estimate.

5.1.2 MBR and AGS

The MBR and AGS alternatives were evaluated at an average day capacity of 4.0 mgd and were limited to an instantaneous peak flow of 8 mgd (2.0 peaking factor). Peak flow equalization is included under these alternatives to manage an instantaneous peak of 14.1 mgd. For this assessment, the peak flow was assumed to be sustained for three hours. **Table 5-1** summarizes the equalization volume required.

Table 5-1: Peak Flow Equalization for Shortlisted Alternatives

Parameter	Units	Assumptions
Instantaneous Peak Flow	mgd	14.1
Maximum Peak Flow to Secondary Treatment	mgd	8
Duration of Peak Flow	hours	3
Peak Flow Storage Volume Required	gallons	762,000

For the MBR alternative, the abandoned west aeration basins would be converted to equalization (EQ) basins and provide a total of 935,000 gallons of storage.

For the AGS alternative, the abandoned east aeration basins would be converted to equalization and provide a total of 1,000,000 gallons of storage.

The EQ basins for each alternative include coarse bubble diffusers and dedicated positive displacement blowers to mitigate septicity and maintain solids suspension when draining. The EQ basins are assumed to be covered with odor control treatment provided to address potential odor generation.

5.2 Low Flow Management

The 2019 CTP Blower Alternatives Evaluation summarized current minimum diurnal flows to the CTP as approximately 0.3 mgd. The potential minimum diurnal flows during the future improvements summarized in this report could range from approximately 0.3 mgd to 0.5 mgd. Impacts of diurnal low flows on the short-listed alternatives are described below.

5.2.1 Five-Stage BNR

Each of the short-listed alternatives requires operation at an increased solids retention time (SRT) compared to the current carbon-only oxidation operation to meet future effluent quality objectives. The BNR alternative does not include upstream equalization, so the process will see the full diurnal flow variation. Processes operated at longer SRTs are more resilient to variability in diurnal flows. Good process control (stable SRT, dissolved oxygen control, etc.) will help minimize the impacts from the diurnal low flows.

One common risk of treating low flows/loads without equalization is the potential for excess dissolved oxygen (DO) return to the anoxic zones, which will adversely impact total nitrogen removal. Blower and diffuser systems have a finite range of turndown to meet low flow/load periods while still providing sufficient air for average and peak load conditions. Additional flexibility to address low flow/load periods to decrease excess DO operation include using a blow-off with silencer to bleed excess air off of the main header and programming to allow diffuser operation below the minimum mixing setpoint, with intermittent increases in airflow to provide for resuspension and mixing.

5.2.2 MBR and AGS

The MBR and AGS alternatives include conversion of existing aeration basins to EQ volume to limit peak flows to 8 mgd. The equalization basins would also be designed to allow for diurnal equalization under normal dry-weather flows to provide a more consistent flow throughout the day. Operation of the EQ basins for diurnal equalization includes diverting flow to the EQ basins during high diurnal flows and returning flow to the secondary process during low flow periods. Diurnal equalization using ammonia load can also be considered to provide more consistent aeration control.

For the MBR alternative, membrane train design including filtrate pumping would incorporate the anticipated minimum flows to provide flexibility in operation

For the AGS alternative, the reactor feed cycles may need to be adjusted to accommodate low flow periods and should be carefully coordinated with the technology supplier. Flow consistency provided through diurnal equalization benefits the AGS process by providing more flexibility in reactor feeding and maintaining target food to mass (F:M) ratios to support granule formation.

5.3 Preliminary Process Sizing and Conceptual Layouts

5.3.1 Alternative 1: Five-Stage BNR

Table 5-2 summarizes the preliminary sizing for a the five-stage BNR alternative. An uncalibrated BioWin process model of the CTP was used to determine the size and capacity of the BNR tanks recommended for the 4.0-mgd reduced CTP capacity. The proposed BNR tanks can operate as a three-stage process with an anaerobic and pre-anoxic zone, with flexibility to shift aerobic volume to a post-anoxic zone followed by re-aeration zone to meet a range of future potential effluent nitrogen limits.

Table 5-2. CAS BNR Preliminary Sizing

Parameter	Units	3-Stage BNR	5-Stage BNR
No. of Basins	-	3 East, 2 West	3 East, 2 West
Total Bioreactor Volume	MG	1.9	1.9
Anaerobic Volume	MG	0.28	0.28
Pre-Anoxic Volume	MG	0.45	0.45
Aerobic Volume	MG	1.18	0.75
Post-Anoxic Volume	MG	-	0.29
Re-aeration Volume	MG	-	0.14
Design Aerobic SRT	days	6 to 8	6 to 8
Design MLSS	mg/L	3,000	3,000

Modifications to the east and west aeration basins include additional baffle walls, mixers for anaerobic and anoxic volume, and diffuser replacement. Rehabilitation to the west secondary clarifiers include chain and flight equipment replacement. Tertiary cloth media disc filters would provide effluent quality consistent with MBRs and therefore are included in the cost to provide equal comparison. The conceptual site layout for the BNR alternative is provided in **Figure 5-1** and **Figure 5-2**.

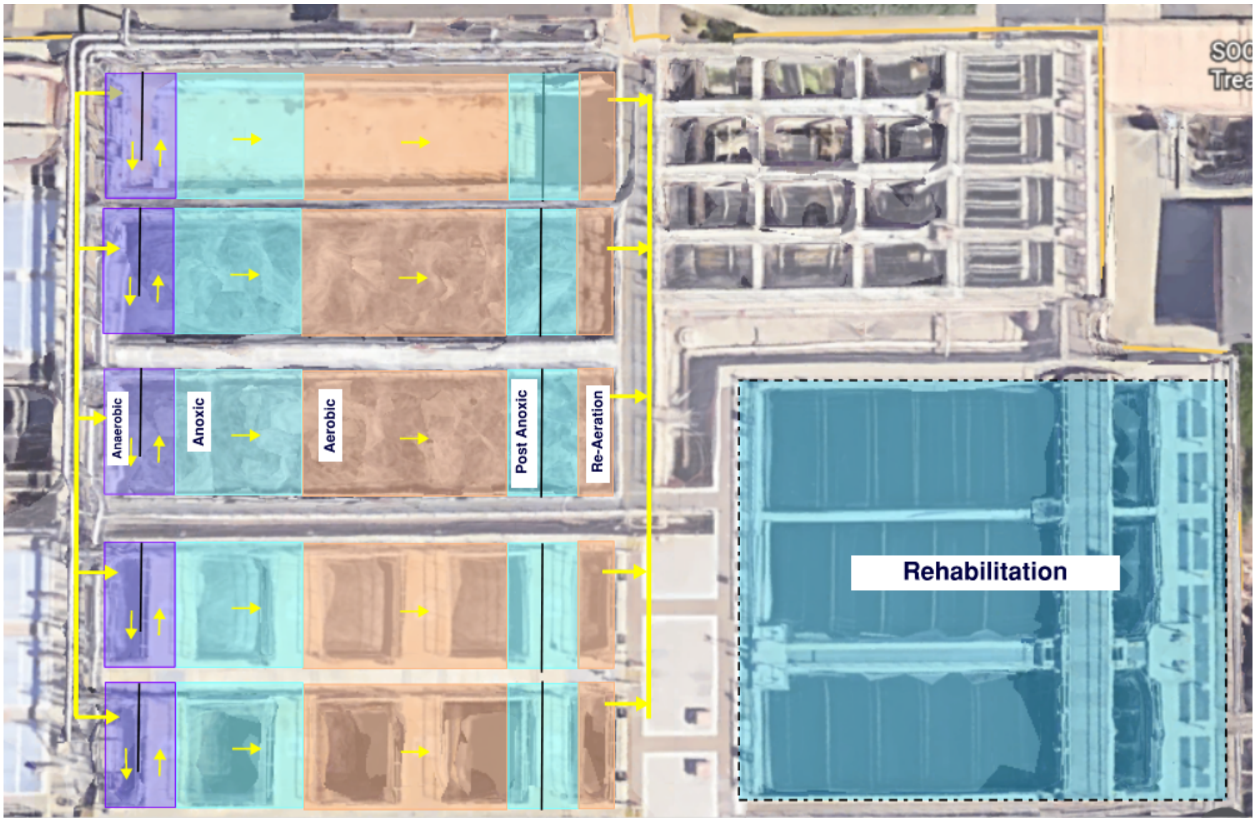


Figure 5-1. Five-Stage BNR Alternative Conceptual Layout

Figure 5-2. Disc Filters Conceptual Layout

5.3.2 Alternative 2: MBR MBR effluent quality will be suitable for reuse (irrigation for example) without additional filtration.

Table 5-3 summarizes the preliminary sizing for the MBR alternative proposed by Suez based on CTP specific flows, loads, and effluent goals. The proposed BNR tanks will operate as a two or four-stage process with a pre-anoxic zone and flexibility to operate the end of the aerobic zone as a post-anoxic zone. Re-aeration is provided in the membrane tanks when operating the post-anoxic zone. MBR effluent quality will be suitable for reuse (irrigation for example) without additional filtration.

Table 5-3. Preliminary MBR Process Sizing

Parameter	Units	Proposed Design
Proposed Anoxic Volume	MG	0.34
Proposed Aerobic Volume[1]	MG	0.94
Proposed Total Bioreactor Volume[1]	MG	1.27
Aerobic SRT[1]	days	8
Waste Sludge Volume	gal/d	100,000
RAS Flow	mgd	18
Design MLSS Concentration in Membrane Tank	mg/L	10,000
Design MLSS Concentration in BNR Basins	mg/L	8,000
Number of Membrane Tanks (trains)Updated	-	4
Type of Cassettes	-	52M
No of Cassettes Installed Per Train	-	4
Total Number of Modules Installed Per Train	-	168
Total Number of Modules Installed Per Plant	-	672
Total Number of Cassettes Installed Per Plant	-	16
Spare Space	%	19%
Membrane Tank Internal Dimensions	(L x W x H) ft	30x12x10

1. *Excluding membrane tanks*

Modifications to the east aeration basins are similar to the five-stage BNR alternative and include new baffle walls, mixers, and diffuser replacement. The east secondary clarifiers would be converted to new MBR tanks and to house the MBR equipment. The west aeration basins would be converted to EQ basins to manage peak flow. The west secondary clarifier tanks would be available for other uses. **Figure 5-3** show the conceptual site layout for the MBR alternative.

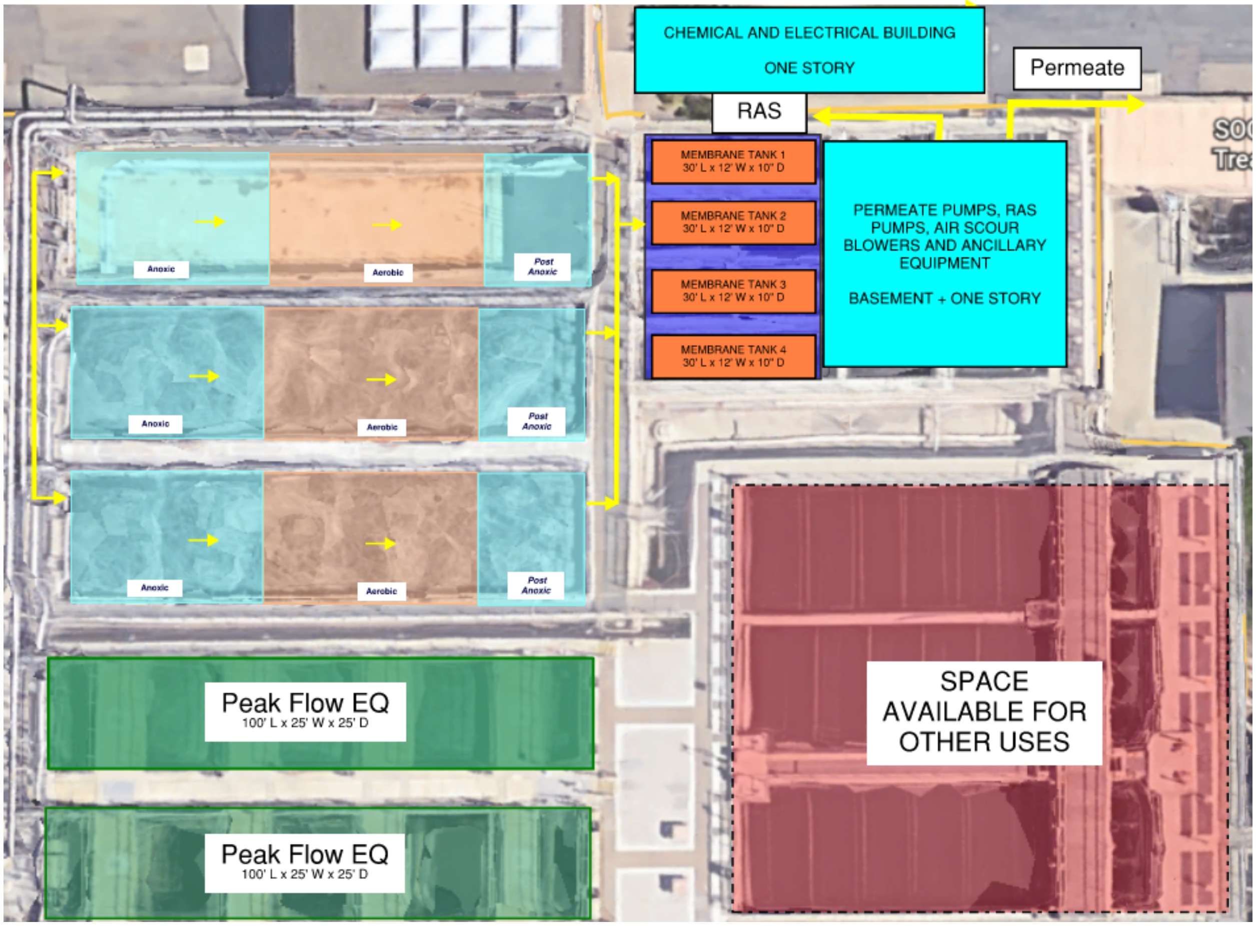


Figure 5-3. MBR Alternative Conceptual Layout

5.3.3 Alternative 3: AGS

Table 5-4 summarizes the preliminary design criteria for the AGS alternative based on coordination with Aqua-Aerobics. Sludge buffer tanks would be constructed to thicken AGS waste activated sludge to concentrations similar to that of the other alternatives. Thickened sludge from the sludge buffer tanks will be pumped to the DAF system or potentially to the CTP sludge holding tank. Supernatant from the sludge buffer tanks will be pumped back to the head of the AGS SBRs. Water level correction tanks would be constructed to attenuate elevation adjustments as part of AGS cycling. Tertiary cloth media disc filters would provide effluent quality consistent with MBRs and therefore are included in the cost to provide equal comparison.

Table 5-4. AGS Preliminary Sizing

Parameters	Units	Design
Number of AGS Basins	-	4
Total AGS Basin Volume	MG	1.8
AGS Basin Dimensions	(L x W) ft	100 x 25
AGS Basin Depth	ft	25
Solids Retention Time	days	8
MLSS	mg/L	8,000
Airflow/Basin, scfm	scfm	2,300
Sludge Buffer Volume	gallons	50,000
Sludge Buffer Dimensions	(L x W x H) ft	22 x 16 x 18
Water Level Correction Tank Volume	gallons	15,000
Water Level Correction Tank Dimensions	(L x W x H) ft	10 x 10 x 20

Aqua-Aerobics proposed converting the west aeration basins to two AquaNereda® reactors and building two new reactors in the footprint of the west secondary clarifiers, which requires significant structural modifications. The east aeration basins would be converted to an EQ basin to manage peak flow, and east secondary clarifier tanks would be available for other uses. One of the west secondary clarifiers will be converted to a sludge buffer and water level correction tank. **Figure 5-4** show the conceptual site layout for the AGS alternative.

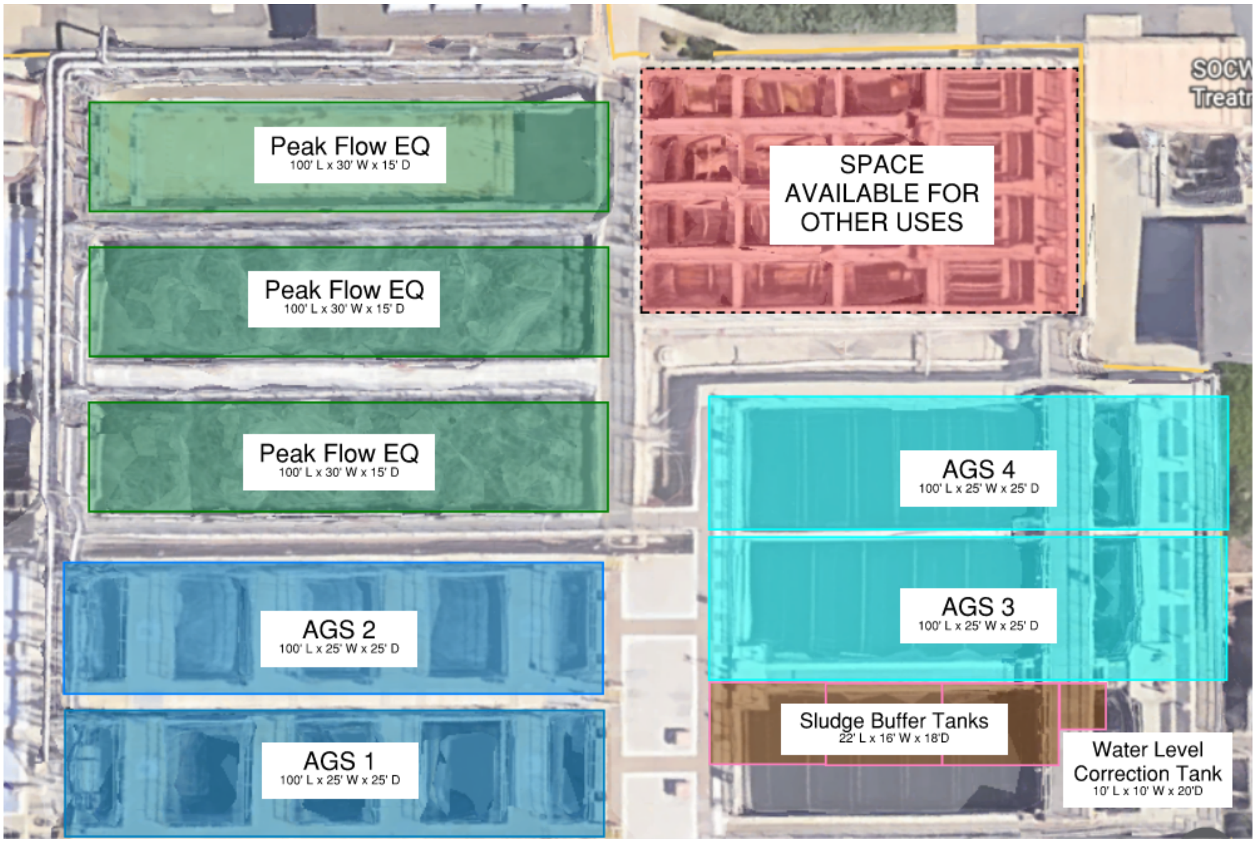


Figure 5-4. AGS Alternative Conceptual Layout

6. Cost Estimate and Implementation

This section summarizes the comparative Opinion of Probable Construction Cost (OPCC), operation and maintenance cost, and approach to construction while maintaining operation.

6.1 Comparative Capital Cost Estimate

The OPCCs were developed for alternative comparison purposes and do not include costs for improvements that are common between all alternatives. The estimate serves for alternative comparative analysis and aligns with the American Association of Cost Estimators (AACE) Class 4 definition for planning purposes. Class 4 has a typical accuracy range of -30% on the low side and +50% on the high side. The unit process improvements excluded from the estimate include the following: influent pumping, preliminary treatment, primary treatment, aeration blower improvements, solids handling, disinfection, and outfall. Improvements to these unit processes are expected to be comparatively similar between alternatives and are not expected to influence the decision. The following assumptions were made for markups and contingency:

- OPCC completed in 2021 dollars
- General Conditions = 10%

- Contractor Overhead and Profit = 18%
- Bonds and Insurance = 3%
- Contingency = 35% (based on status of the design, nature of the project, and the estimate classification)
- OPCCs do not include cost of engineering, administration, legal, or environmental costs.

Table 6-1 summarizes the total OPCC for each alternative. Appendix B summarizes the cost breakdown by unit process.

Table 6-1. Comparative Capital Cost Estimates

Alternative	Opinion of Probable Construction Cost
Five-Stage BNR	$17,500,000
MBR	$28,800,000
AGS	$36,900,000

6.2 Annual Operations and Maintenance Cost

The comparative O&M)costs were estimated to develop NPV of costs over a 20-year period. **Table 6-2** presents the assumptions for the annual O&M and NPV cost estimate.

Table 6-2. Annual O&M and NPV Cost Assumptions

Parameter	Units	Value
Electricity Cost	$/Kw-H	$ 0.17
Interest Rate	%	5%
Material Cost Escalation	%	3%
Time Period for NPV Calculation	Years	20
O&M Flow Basis	mgd	4.0

The estimated operating costs were divided into three categories: 1) energy, 2) maintenance parts and labor, and 3) chemical usage. The annual O&M and NPV costs are presented in **Table 6-3**.

Table 6-3. Annual O&M and 20-Year NPV Cost Summary

Parameter	Five-Stage BNR	MBR	AGS
Energy	$289,000	$450,000	$218,000
Maintenance Parts and Labor	$32,000	$84,300	$ 22,300
Chemical	$ -	$29,800	$ -
Total Annual O&M	$321,000	$563,000	$240,000
20-year O&M Cost	**$5,300,000**	**$9,300,000**	**$4,000,000**
Capital Cost	$17,500,000	$28,800,000	$36,900,000
Total 20-year NPV	**$22,800,000**	**$38,100,000**	**$40,900,000**

6.3 Maintaining Plant Operation During Construction

Consideration was given to constructing each alternative while maintaining plant operation. **Table 6-4** summarizes the general sequence of construction for each alternative including units that are offline and the anticipated constructability challenges.

Table 6-4. Potential Construction Sequencing and Challenges

Alternative	General Sequence	Challenges
Five-Stage BNR	Construct improvements in one AB and West SC at a time.	Coordination of basin operation
MBR	1. Offline: East Plant Online: West Plant Demo East SCs / Construct MBR Construct BNR Improvements in East ABs 2. Offline: West ABs Online: East ABs and West SCs Construct Peak Flow EQ Basin in West ABs 3. MBR and Peak Flow EQ basin online	Reliability of West SCs Demolition of East SCs Construction within constraints of East SC footprint Increased truck traffic to haul debris and spoils
AGS	1. Offline: West ABs and One West SC Online: East ABs, East SCs and Two West SCs Construct: AGS 1&2 in West ABs and Buffer Tanks in one West SC 2. Offline: West SCs Online: East ABs, East SCs and AGS 1 & 2 Construct: AGS 3&4 in West Secondary Clarifiers 3. Offline: East ABs and SCs Online: AGS 1 through 4 4. Construct: Peak Flow EQ Basins in East ABs	Staged demolition of West SCs Deep vertical excavation Geotechnical and groundwater impacts Increased truck traffic to haul debris and spoils

7. Future Considerations

SOCWA and member agencies are interested in gaining a high-level understanding of how the secondary treatment alternatives may be synergistic with near-term and long-term drivers for reuse in the region. This section summarizes the future considerations for the CTP including potential future regulatory drivers, industry trends, and/or synergies with advanced water treatment for reuse. The facilities and costing in the previous sections do not include the advanced water treatment elements described in Section 7. As discussed with SOCWA during this project, a follow-on study to better define drivers, goals, demands for reuse, etc. should be considered prior to capital improvements programming.

7.1 Potential Future Advanced Treatment Considerations

The preceding sections provide a summary of the different alternatives being considered for the CTP. There is benefit in identifying and considering potential synergies which may exist between these different alternatives and potential future drivers and considerations. This section summarizes the potential drivers that SOCWA may want to consider and explore further on a future phase of this project, and potential ways to integrate those considerations with the shortlisted treatment alternatives.

7.1.1 Potential Future Drivers

Figure 7-1 summarizes potential near-term and long-term drivers for advanced treatment based on current industry trends.

Figure 7-1. Example Near-Term and Long-Term Drivers

Near-term drivers may include improved effluent quality for ocean discharge. From a nutrient perspective, the alternatives developed in this study will reduce effluent total inorganic nitrogen. It should be noted that the CTP has a successful record of meeting current regulatory requirements for effluent quality and that nutrient removal is not currently required. Details on contaminants of concern (CECs) are shown as examples that may be considered for future projects. Additionally, quantifying the presence of CECs and addressing them per future regulatory requirements may be considered in the near-term. Additionally, increased demand for recycled water may be a near-term driver.

Long-term drivers may include enhancement of effluent quality (nutrients, CECs, etc.), reducing ocean discharge, and requirements for high level of treatment. Additionally, increased facility resiliency an reduced dependance on traditional water supplies might support potable reuse in the future at the CTP.

7.1.2 Potential Planning Approach

Considerations including water demand, indirect and direct reuse, access to local tie-in locations, cost of treating and conveying, and evolving regulatory requirements should all be considered and evaluated in a "Holistic Approach" follow-on study to this project. **Figure 7-2** summarizes the potential regulatory outlook associated with the near- and long-term drivers and a potential approach for future planning.

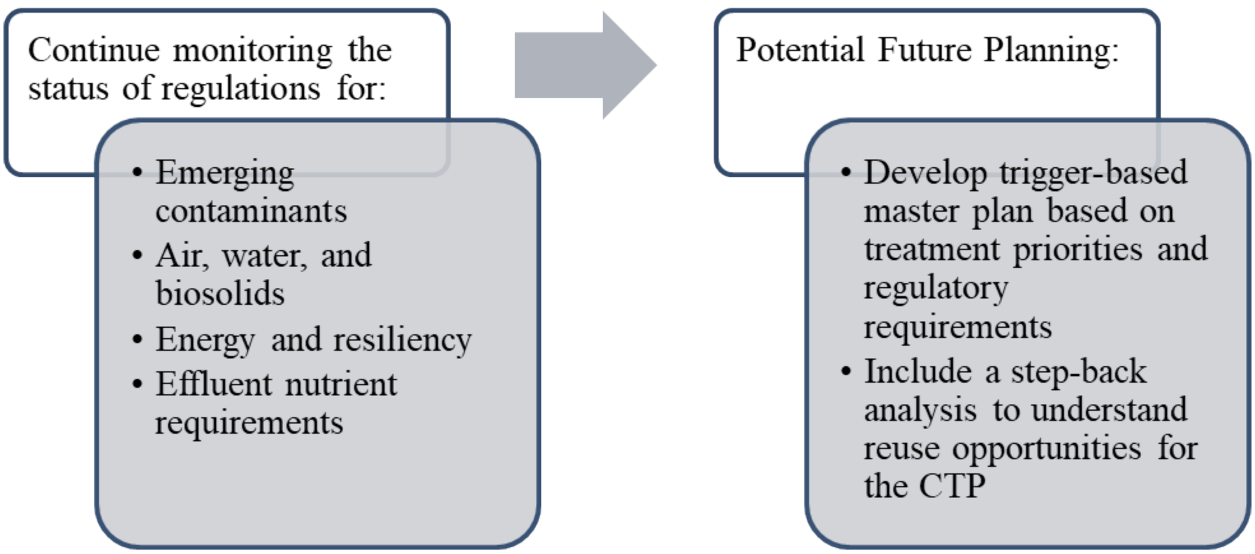


Figure 7-2. Potential Regulatory Outlook and Future Planning Approach

7.1.3 High-level Advanced Treatment Layouts

Hazen completed a high-level evaluation of synergies that may exist between addressing CECs or potential reuse in the future with the secondary treatment processes described in Section 5. Since space at the CTP site is restricted, identifying potential space requirements during the future secondary upgrades should be considered to enable potential future reuse improvements. **Figure 7-3** identifies what additional footprint may be available with the corresponding shortlisted alternatives. It should be noted, for this high-level evaluation, the existing AWT (media filtration, disinfection, and potentially the current membrane facility) may be replaced by the concepts discussed in this section. Components of the AWT that could remain and be enhanced could be refined as long-term drivers for advanced treatment at the CTP develop.

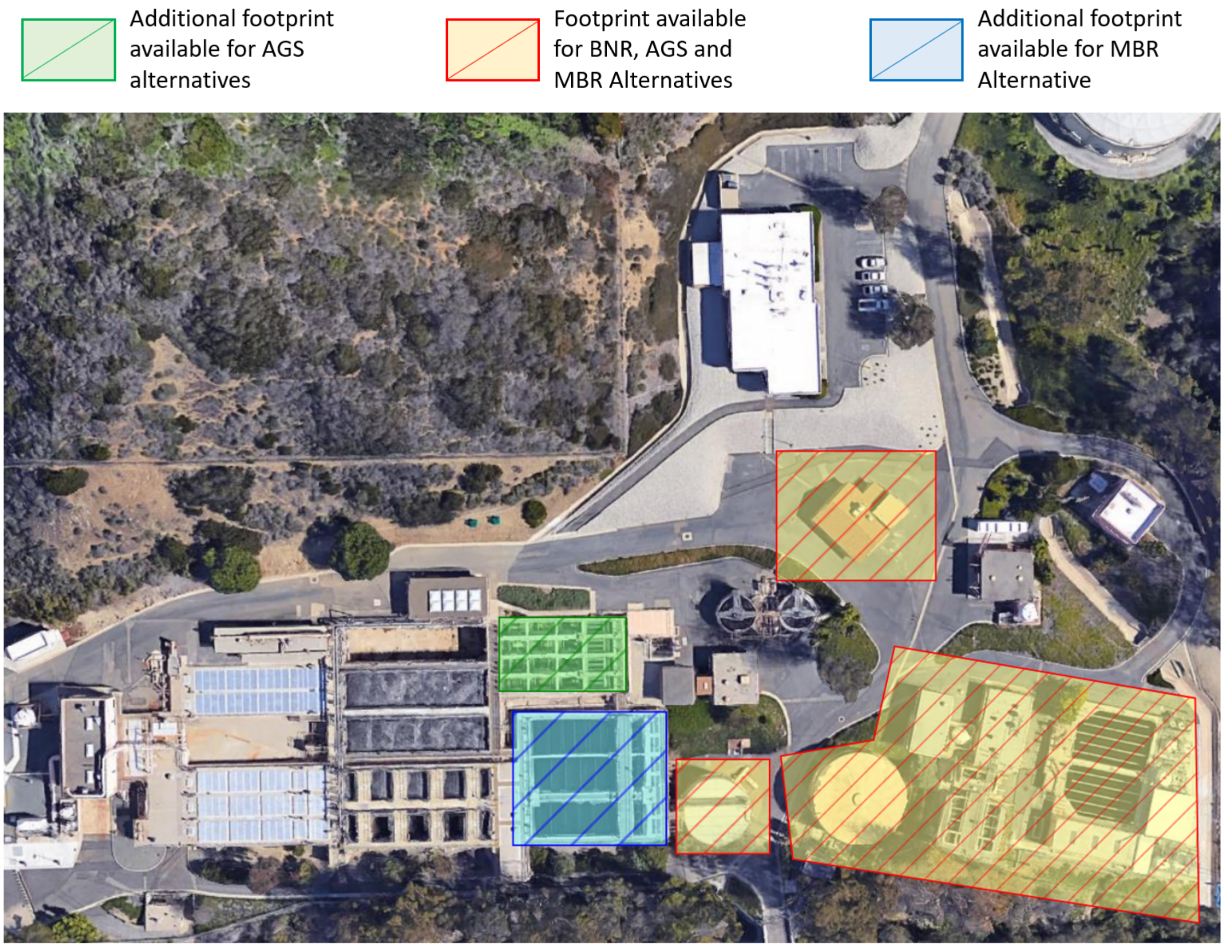


Figure 7-3. Available Footprint for Future Advanced Treatment Facilities

Figures 7-4 and **7-5** are example high-level conceptual layouts of a membrane-based advanced water facility that could address future drivers including reduction of CECs, expansion of reuse capacity, and/or preparing for potable reuse. **Figure 7-4** was developed for the five-stage BNR or AGS approach. **Figure 7-5** applies to the MBR alternative and assumes successful demonstration of MBR for pathogen removal to eliminate an additional MF membrane system. Further development of these concepts can be considered in a follow-on study.

Figure 7-4. Example Site Layout of Advanced Water Treatment Facility for BNR or AGS Alternatives

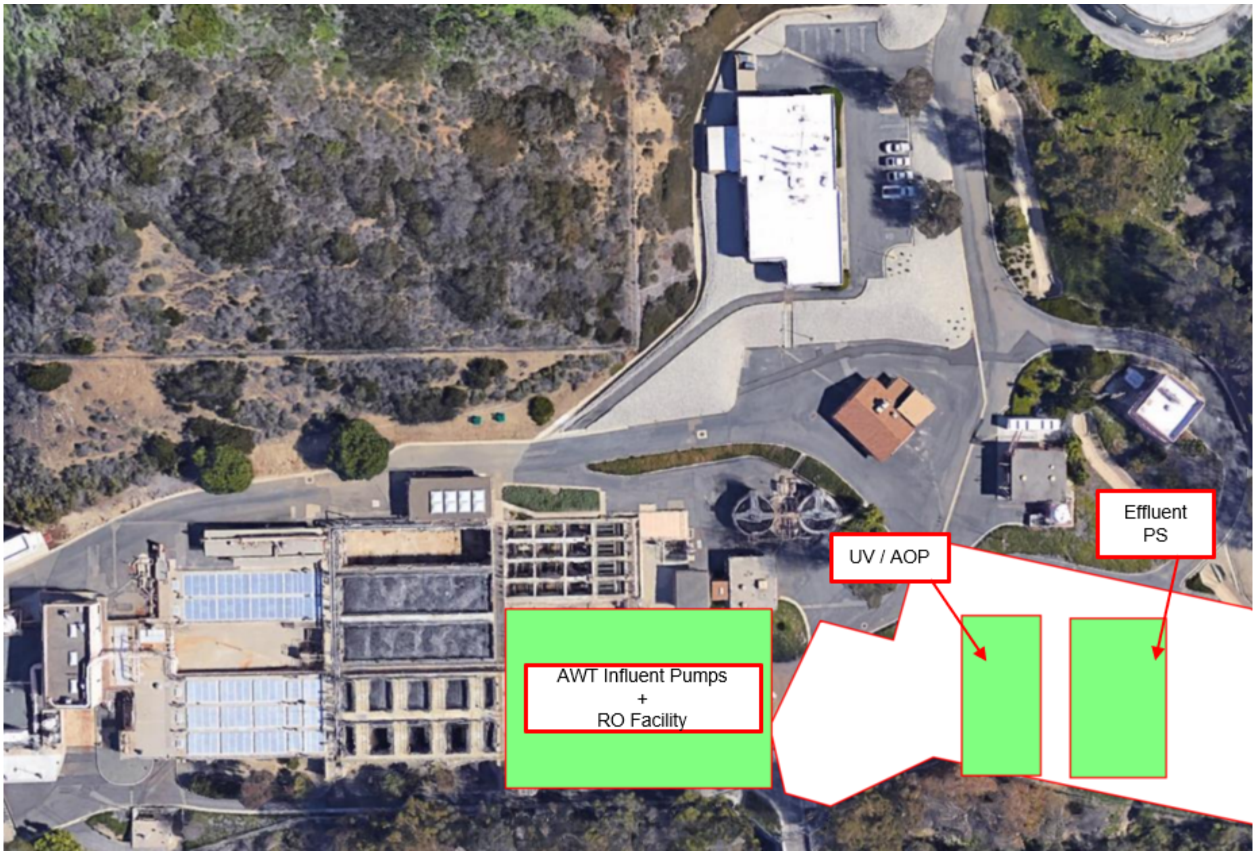


Figure 7-5. Example Site Layout of Advanced Water Treatment Facility for MBR Alternative

8. Summary of Alternatives

The five-stage BNR, MBR, and AGS alternatives are all compatible with and can prepare SOCWA for potential future regulations for enhanced effluent quality and increased production of recycled water. All three alternatives are feasible and can be constructed while maintaining operation of the existing facility detailed in Section 6.3. The five-stage BNR alternative leverages more existing infrastructure than the MBR and AGS alternatives resulting in lower initial capital investment and a lower 20-year net present value cost.

The existing site conditions (site constraints, soils, and accessibility) pose a more significant challenge to the construction of the MBR and AGS alternative, increasing capital costs. The MBR alternative provides a potential advantage for future reuse as it may reduce the number of required unit processes (i.e. elimination of microfilters for potable reuse), which could reduce the cost and impacts of future advanced treatment.

Appendix A: September 2019 Update

Hazen

CTP Feasibility Study Update

SOCWA
South Orange County Wastewater Authority

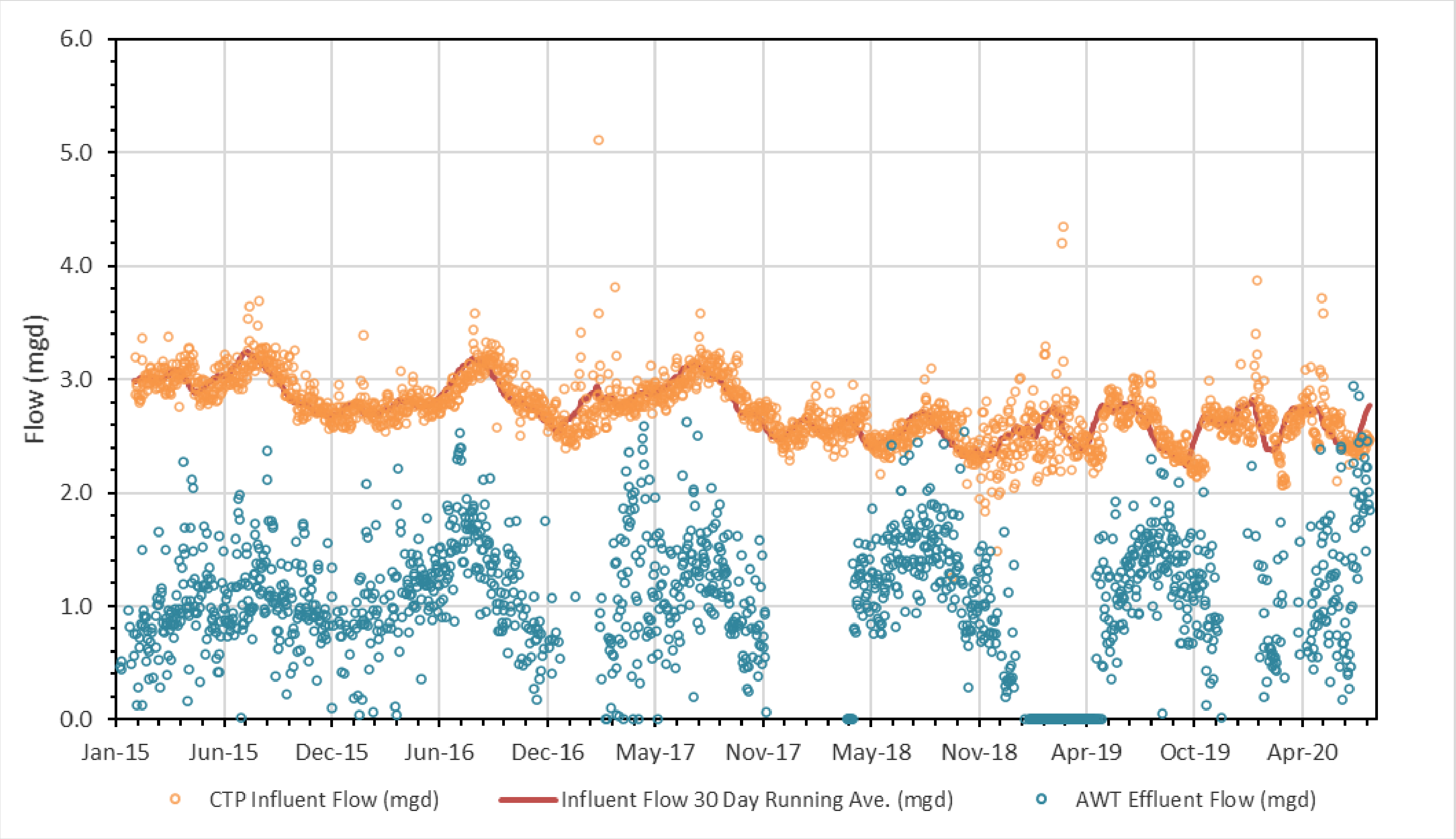
October 1, 2020

Agenda

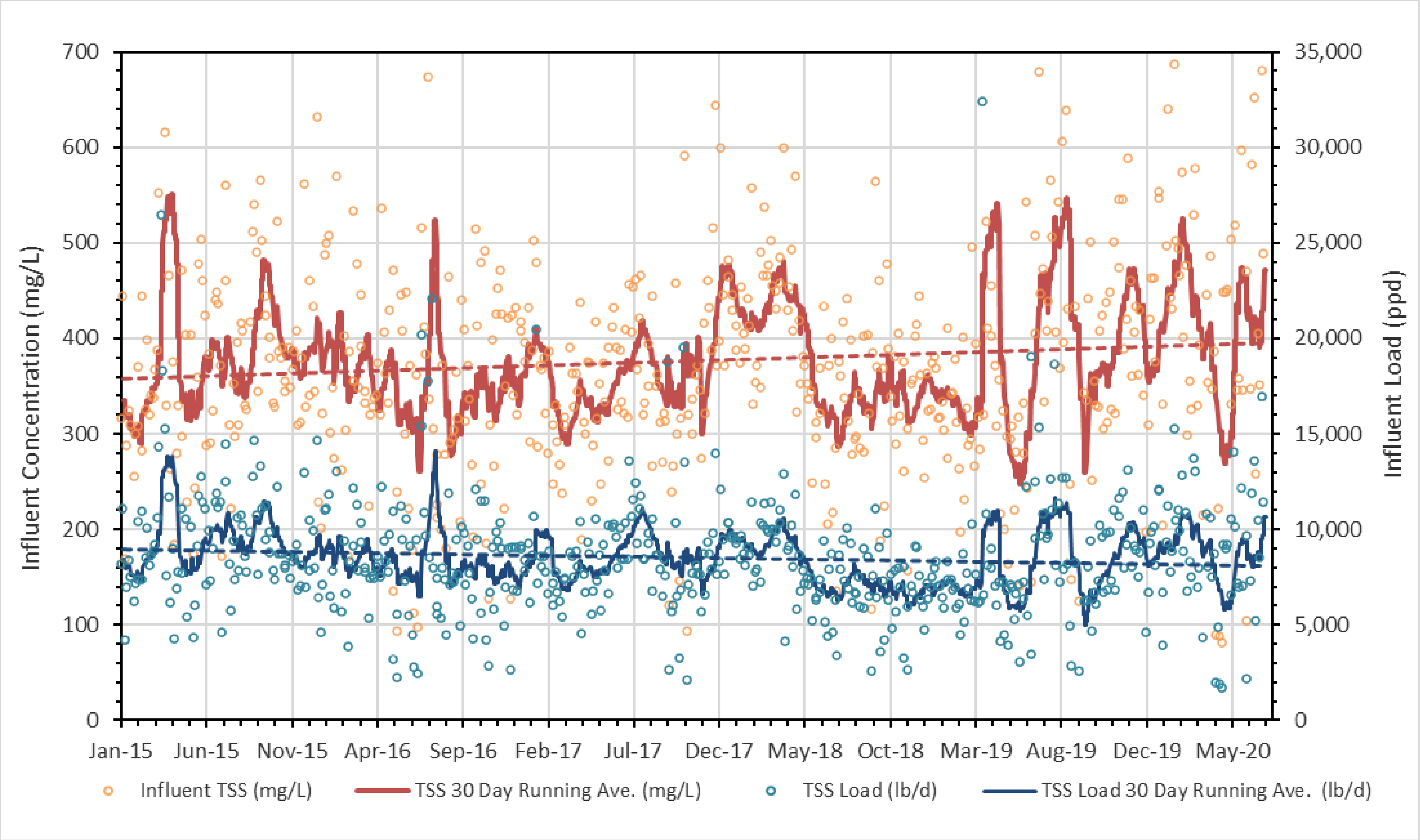
- Data Review Update
- Conceptual Design Basis
- Evaluation Approach
- Conceptual Layouts
- Preliminary Evaluation and Screening
- Next Steps

Data Review Update

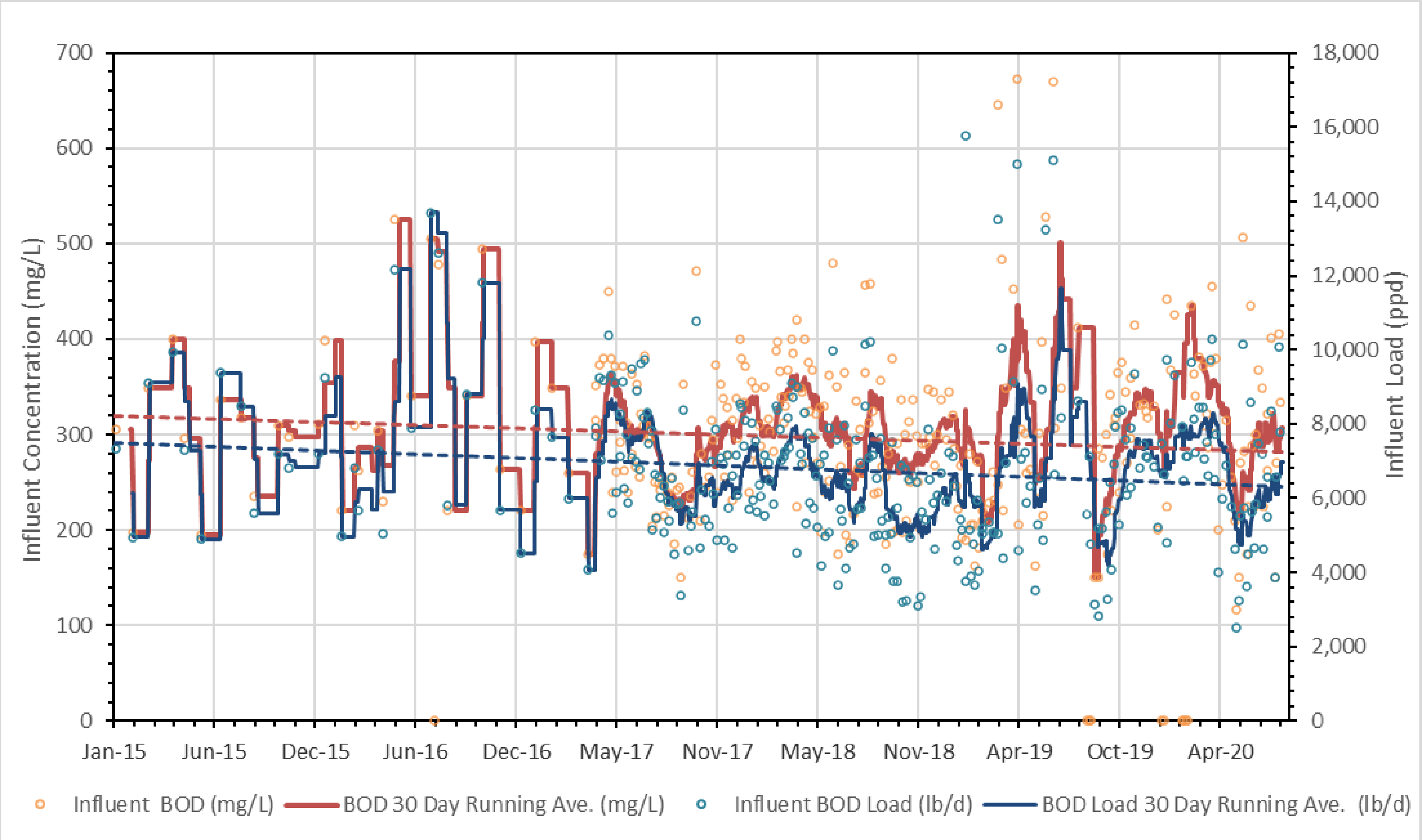
Influent Flow



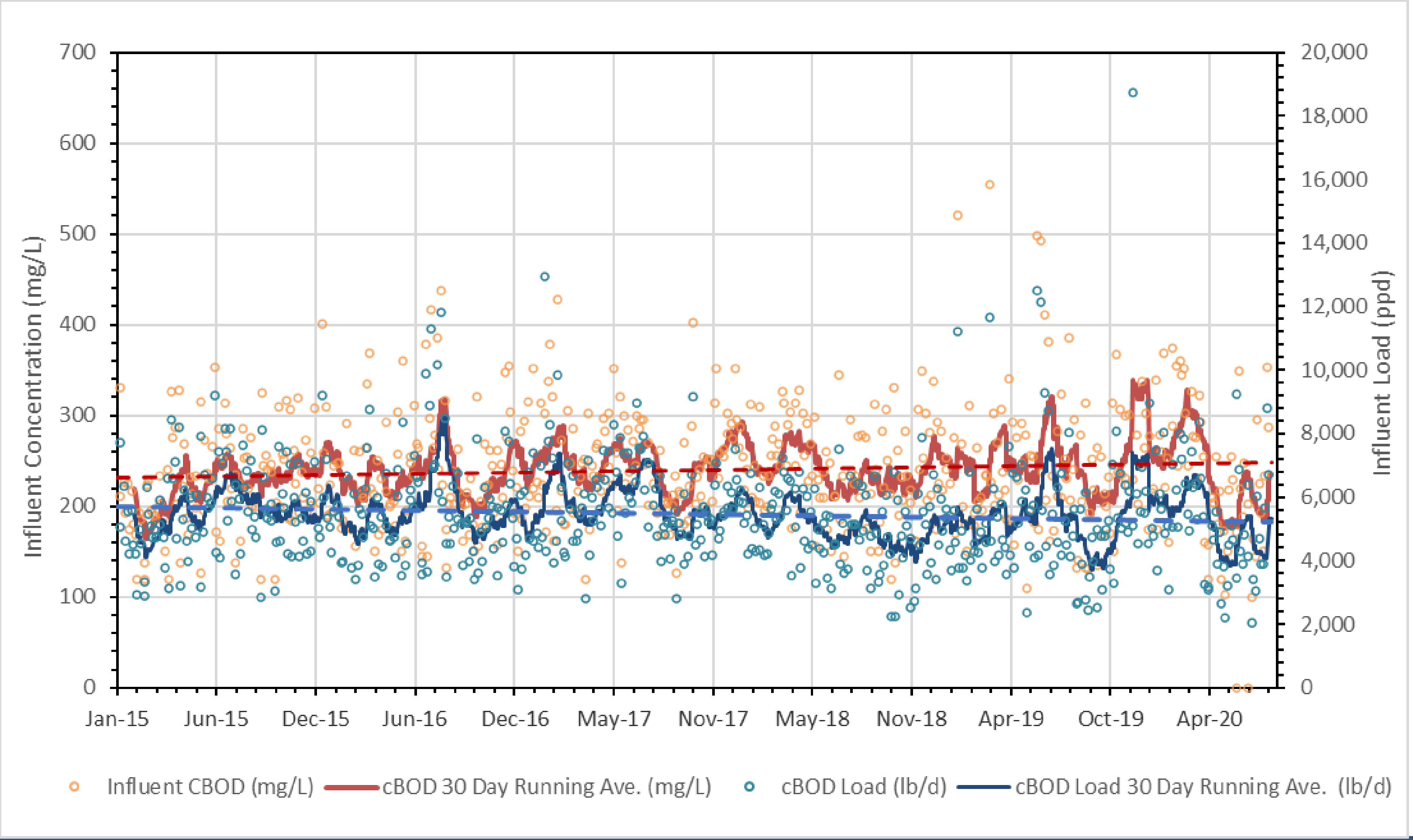
Influent TSS



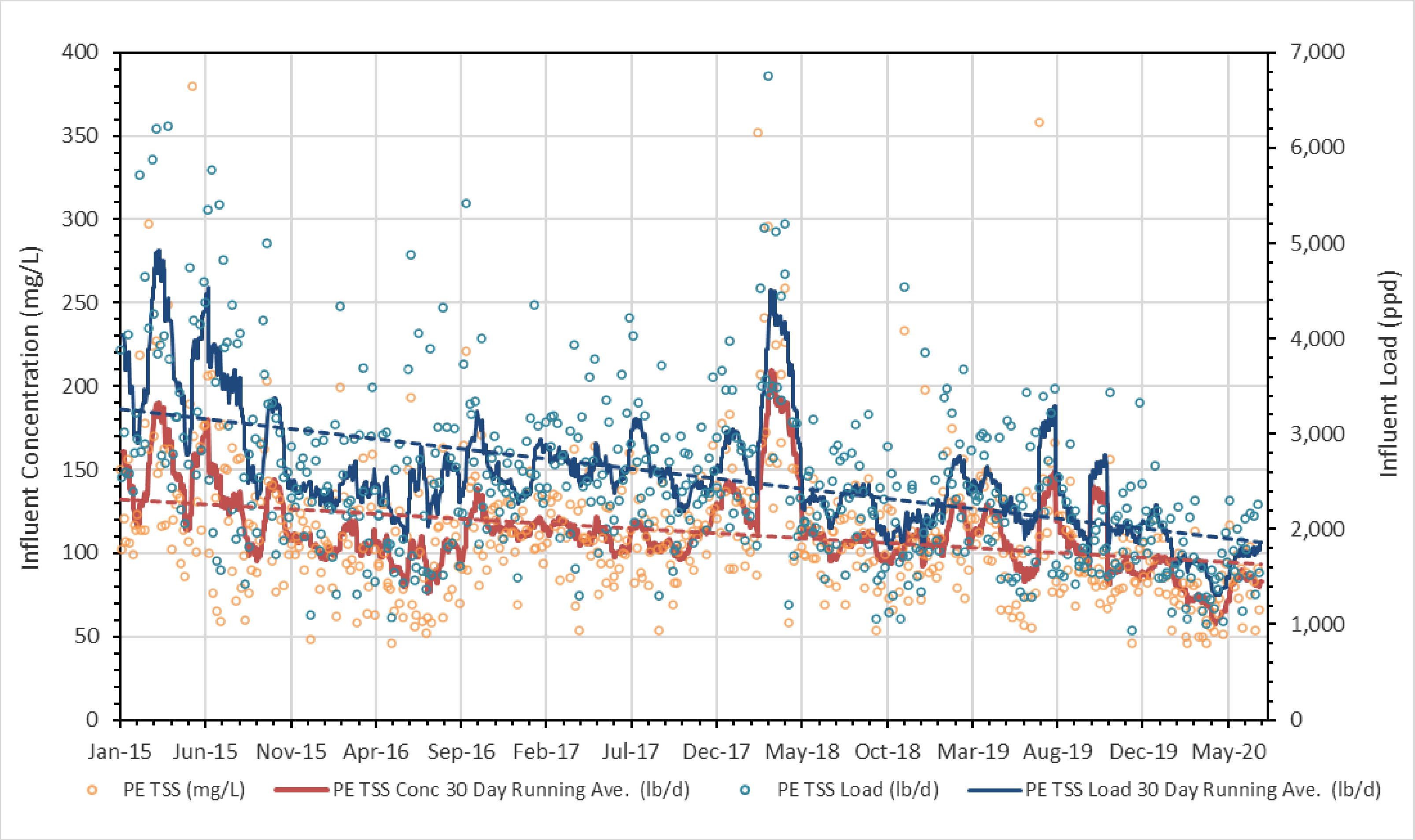
Influent BOD



Influent cBOD

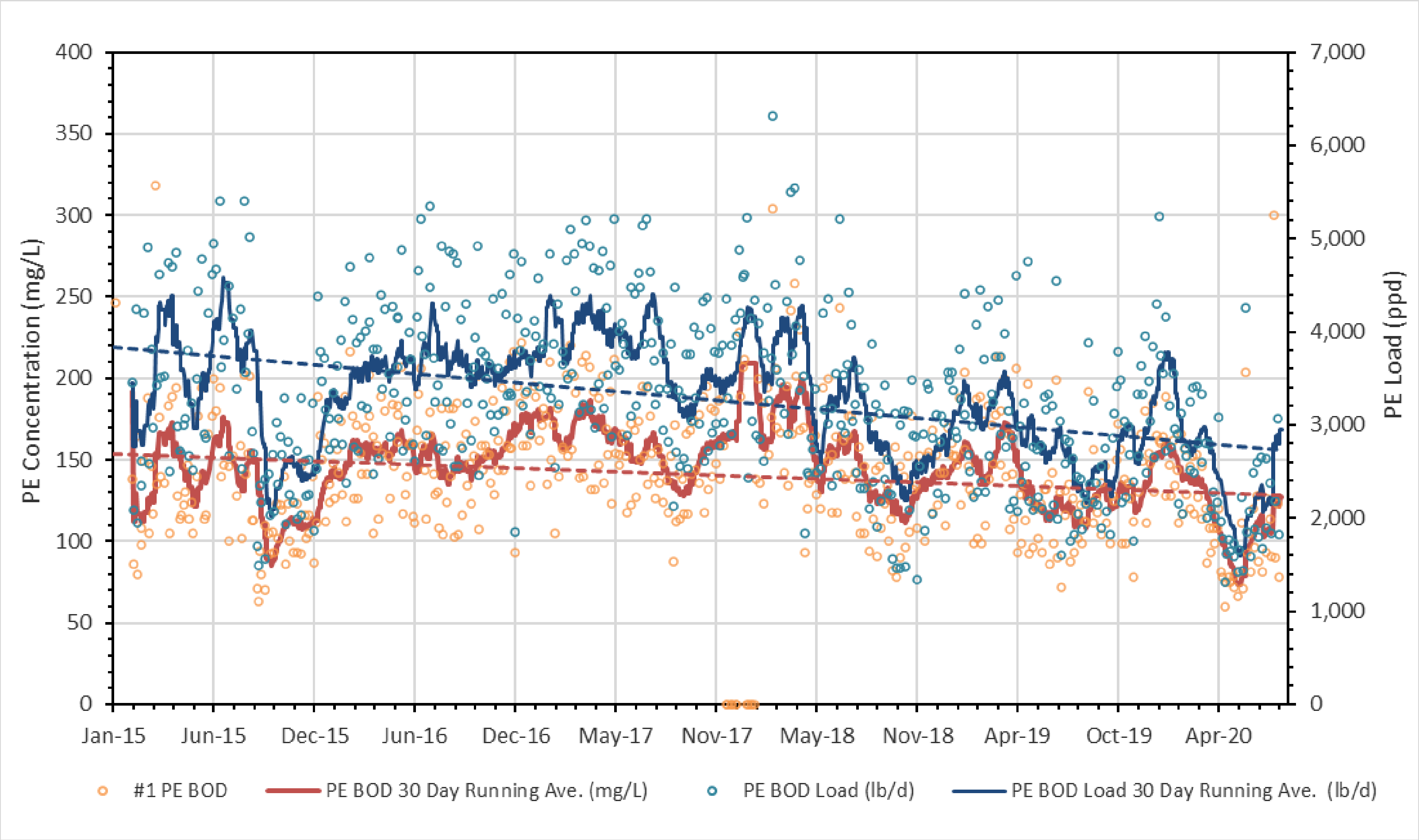


PE TSS



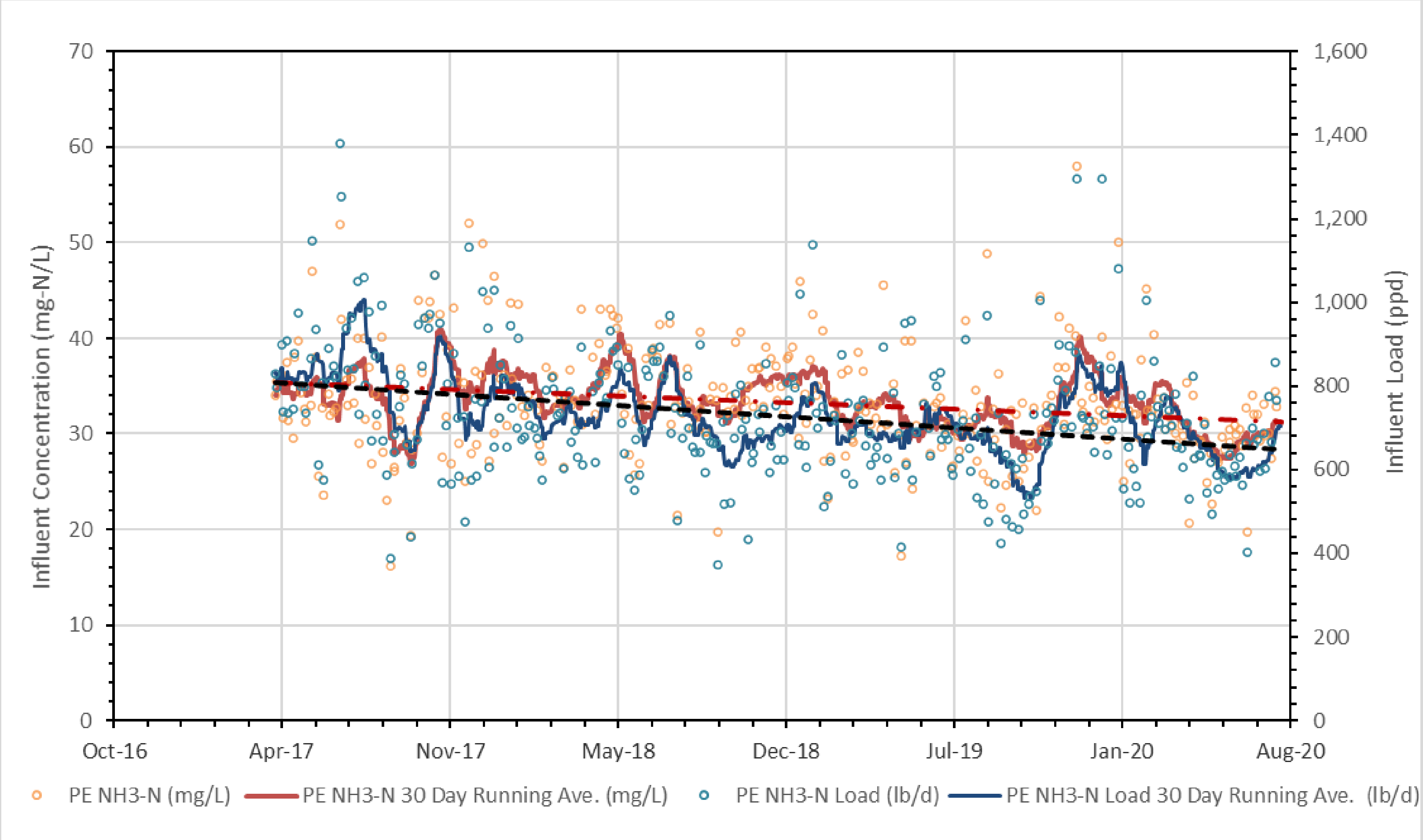
Influent Concentration (mg/L)
400
350
300
250
200
150
100
50
0
Influent Load (ppd)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-15
Jun-15
Nov-15
Apr-16
Sep-16
Feb-17
Jul-17
Dec-17
May-18
Oct-18
Mar-19
Aug-19
Dec-19
May-20
PE TSS (mg/L)
PE TSS Conc 30 Day Running Ave. (lb/d)
PE TSS Load (lb/d)
PE TSS Load 30 Day Running Ave. (lb/d)

PE BOD



PE Concentration (mg/L)
400
350
300
250
200
150
100
50
0
PE Load (ppd)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-15
Jun-15
Dec-15
Jun-16
Dec-16
May-17
Nov-17
May-18
Nov-18
Apr-19
Oct-19
Apr-20
#1 PE BOD
PE BOD 30 Day Running Ave. (mg/L)
PE BOD Load (lb/d)
PE BOD Load 30 Day Running Ave. (lb/d)

PE NH3



70
60
50
40
30
20
10
0
Influent Concentration (mg-N/L)
1,600
1,400
1,200
1,000
800
600
400
200
0
Influent Load (ppd)
Oct-16
Apr-17
Nov-17
May-18
Dec-18
Jul-19
Jan-20
Aug-20
PE NH3-N (mg/L)
PE NH3-N 30 Day Running Ave. (mg/L)
PE NH3-N Load (lb/d)
PE NH3-N Load 30 Day Running Ave. (lb/d)

Conceptual Design Basis

Influent Characteristics

Parameters	Units	Current		Future	
		Average Annual	Maximum 30-Day	Average Annual	Maximum 30-Day
Flow	MGD	2.68	2.93	4.00	4.39
BOD_5	mg/L	292	350	292	350
	lbs/d	6,600	8,600	9,800	12,900
TSS	mg/L	364	461	364	461
	lbs/d	8,100	11,300	12,200	16,900
VSS	mg/L	325	398	325	398
	lbs/d	7,300	9,700	10,900	14,600
NH_3-N	mg/L	32	37	32	37
	lbs/d	730	900	1,100	1,400

Historical data based on plant operations data: Jan 2016 to July 2020

Primary Effluent

Criteria		BOD_5	NH_3-N
Current Annual Average 2.7 mgd	mg/L	145	32.3
	lb/d	3,300	730
Design Annual Average 4.0 mgd	mg/L	145	32
	lb/d	4,900	1,080
Design Maximum 30-Day 4.4 mgd	mg/L	187	39
	lb/d	6,900	1,440
Design Maximum 7-Day 4.7 mgd	mg/L	213	46
	lb/d	8,500	1,830
Design Maximum Day 5.9 mgd	mg/L	257	52
	lb/d	12,800	2,600

Evaluation Approach

Task 1 - Develop and Analyze Alternatives to Upgrade Treatment but De-rate the Plant Capacity to 4.0 mgd

High-level evaluation and screening to shortlist to 2 potential implementable solutions:

(will be a relative comparison (scoring 1 through 5, from lowest to highest) of the alternatives using the following criteria)

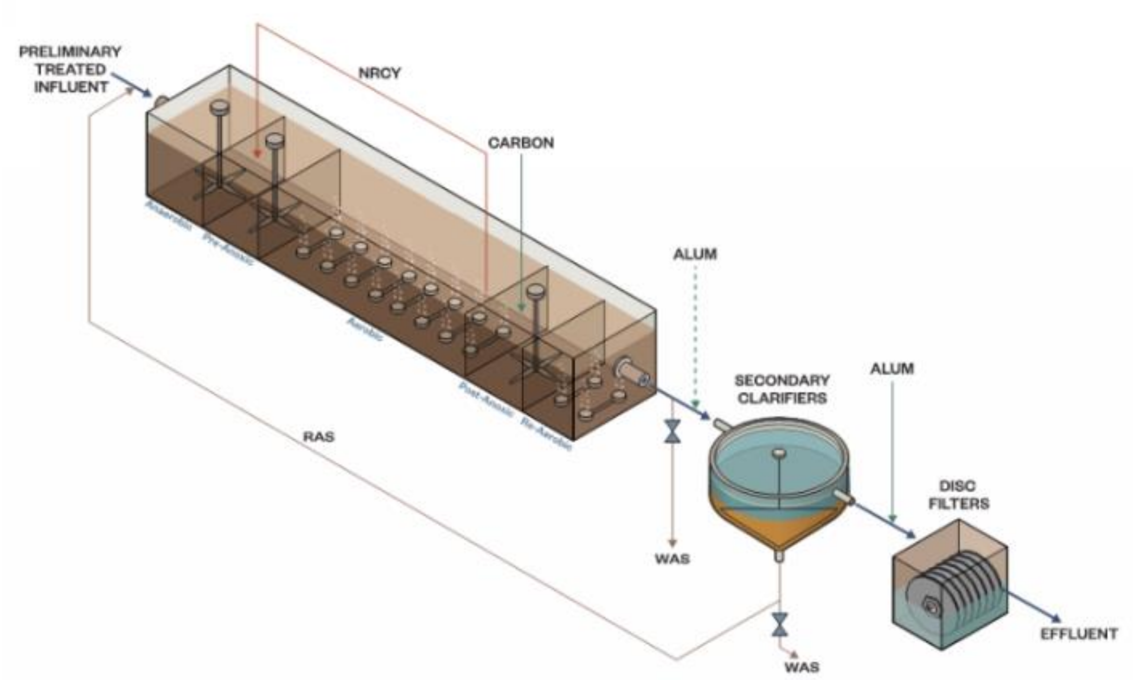
- Relative capital cost
- Relative estimated energy and chemical requirements
- Compatibility with water quality goals for recycled water and flexibility in accommodating potential future discharge limits
- Compatibility of selected process to be incorporated into existing infrastructure while maintaining operations

Future Alternatives For Consideration

- Conventional Activated Sludge **(CAS)** (selector/nutrient removal)
- Membrane Bioreactor **(MBR)**
- Membrane Aerated Biofilm Reactors **(MABR)**
- Aerobic Granular Sludge **(AGS)**
- Sequencing Batch Reactors **(SBR)**

Conventional Activated Sludge Biological Nutrient Removal (BNR)

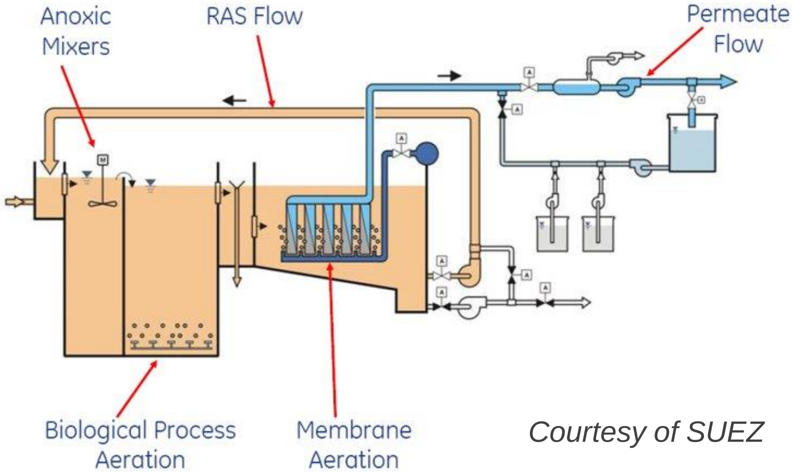
- What?
  - Biological N and P removal through zone design to select specific organisms
- Why?
  - Proven approach with decades of implementation
  - Consistent effluent quality
  - Improved settling



Parameter	Typical Effluent Range
TN (mg/L)	3 – 6
TP (mg/L)	0.5 – 2

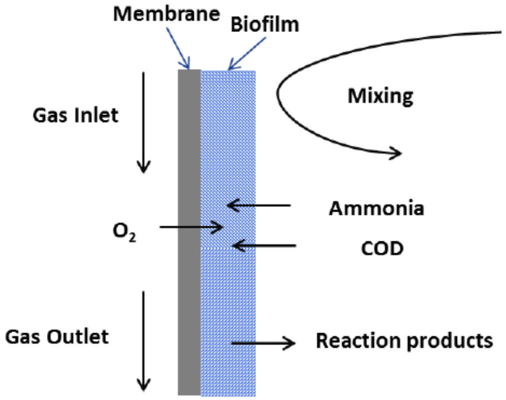
Membrane Bioreactor (MBR)

- What?
  - Secondary clarifiers replaced with membranes
  - Pump or gravity flow MLSS from aeration basins to membrane tank
  - Dedicated membrane tankage preferable for flexibility
  - Typical BNR configurations can be used
- Why?
  - Smaller footprint versus clarifier based secondary process
  - Enhanced effluent quality for reuse



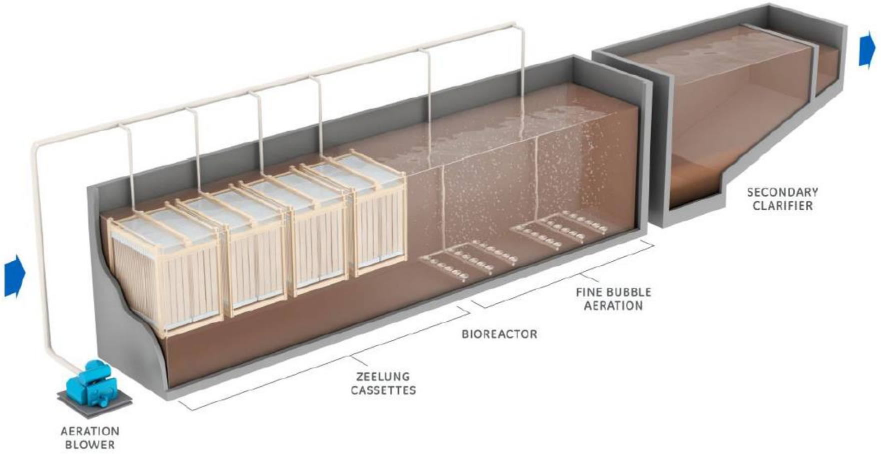
Courtesy of SUEZ

Membrane Aerated Biofilm Reactor (MABR)



- What?
  - Uses gas-permeable membrane for biofilm growth
  - O_2 transfer directly to nitrifying biofilm

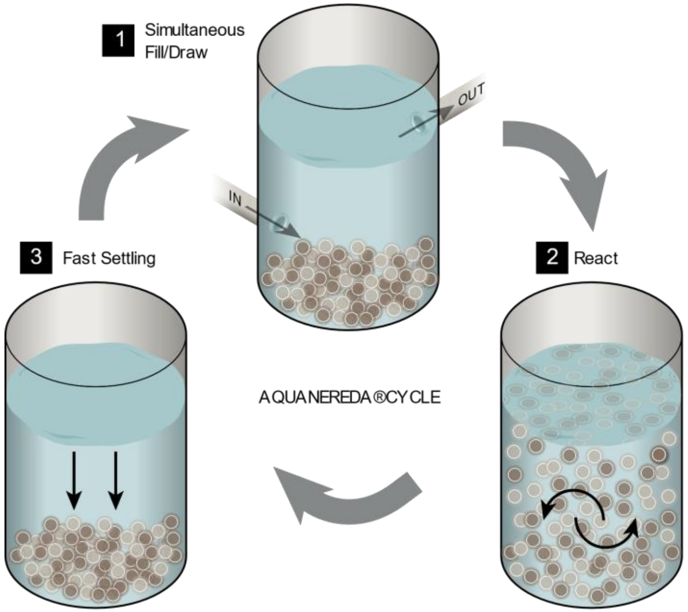
- Why?
  - Increased capacity due to fixed film growth
  - Reduced O_2 requirements
  - Nitrification and denitrification in the same volume

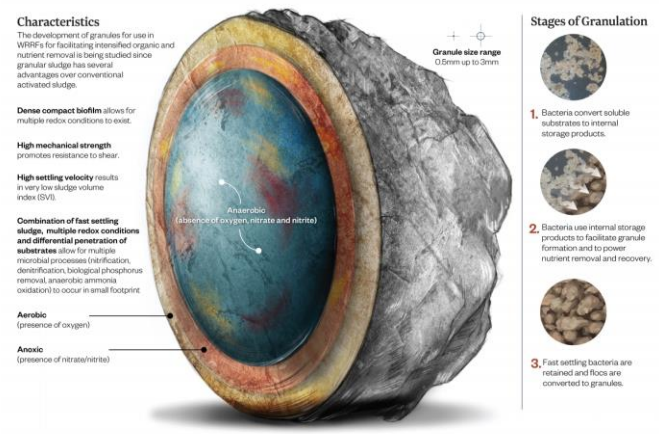


Courtesy of GE ZeeLung System

Aerobic Granular Sludge (AGS)

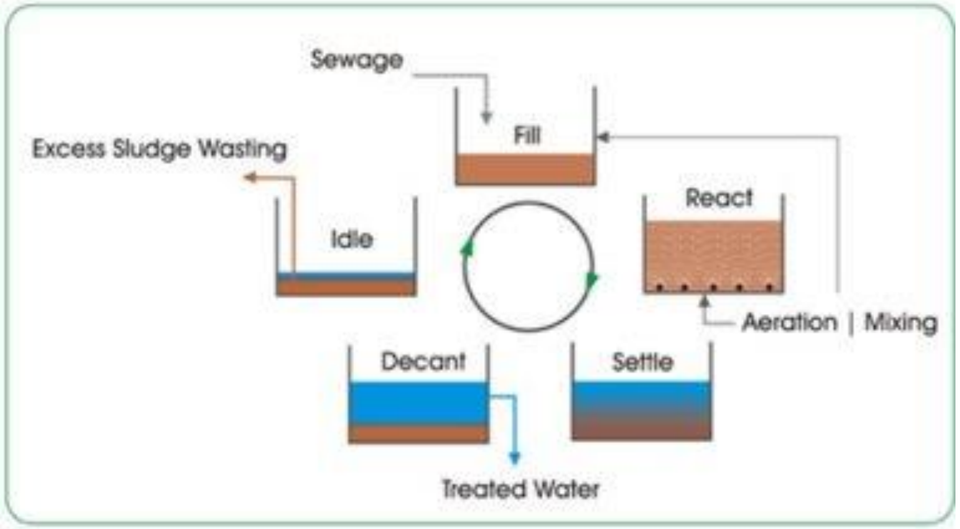
- What?
  - Simultaneous biological N and P removal through formation of granules typically in SBRs
- Why?
  - Smaller footprint, higher loading rates
  - Reduced energy
  - Good settling
  - Alternative to membrane bioreactors





Sequencing Batch Reactor

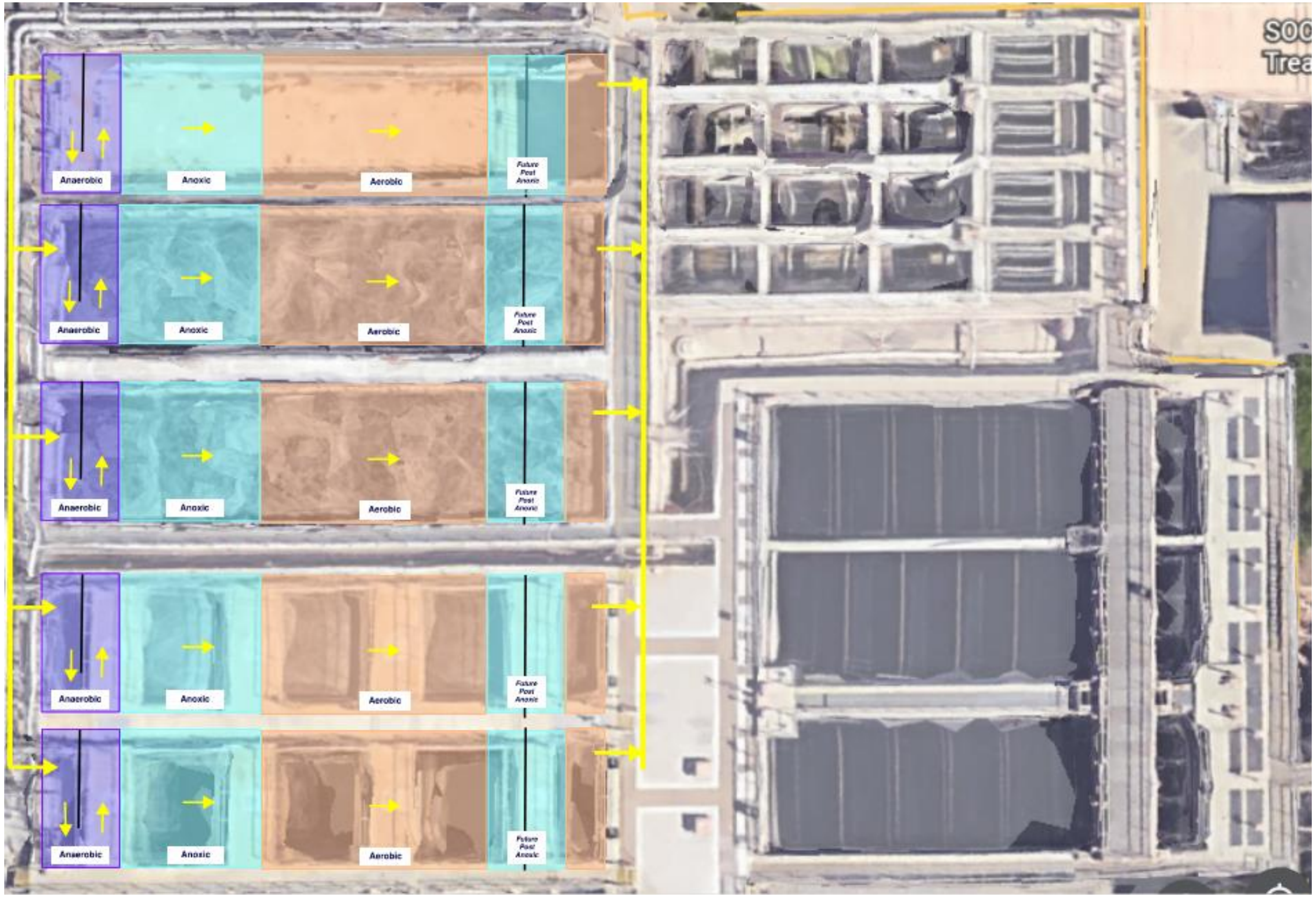
- What?
  - Biological N and P removal through sequenced operation
- Why?
  - Reduced complexity
  - Settling in tank eliminates need for clarifiers



Conceptual Layouts

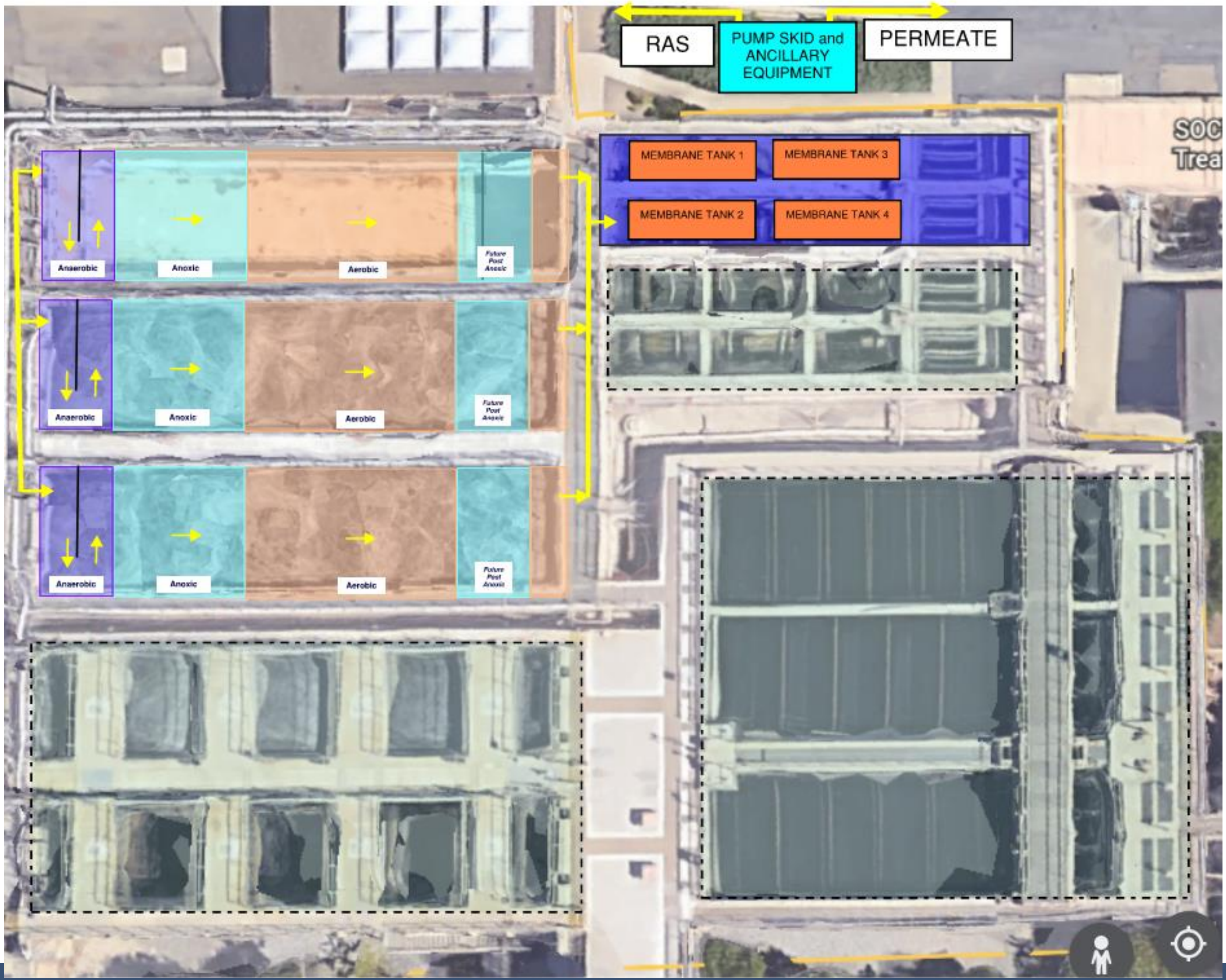
CAS Layout

- Utilizes the East and West Aeration Basins
- Secondary clarifiers remain



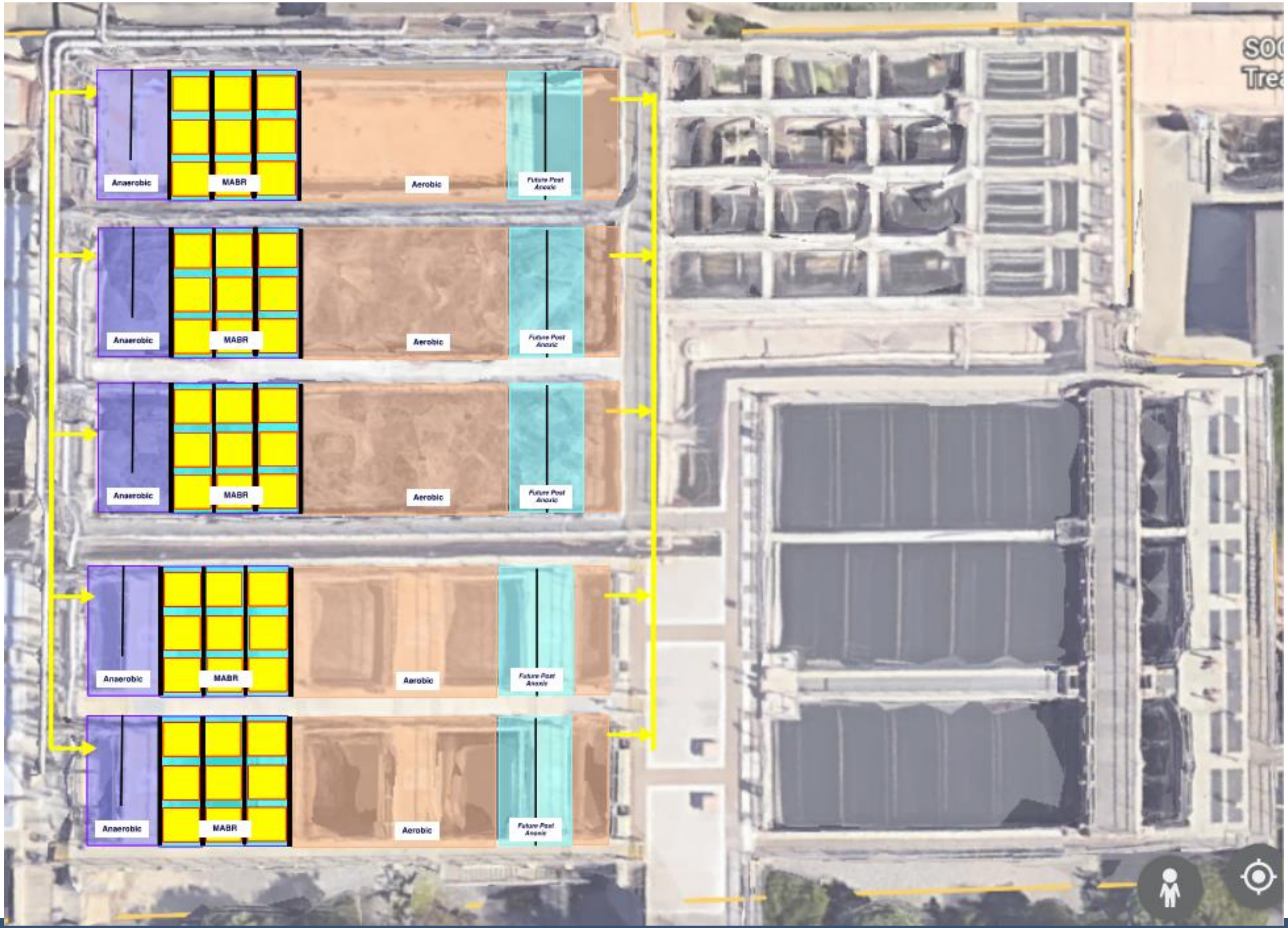
MBR Layout

- Utilizes the East Aeration Basins
- Reduced volume compared to other alternatives
- West basins could be utilized for equalization volume



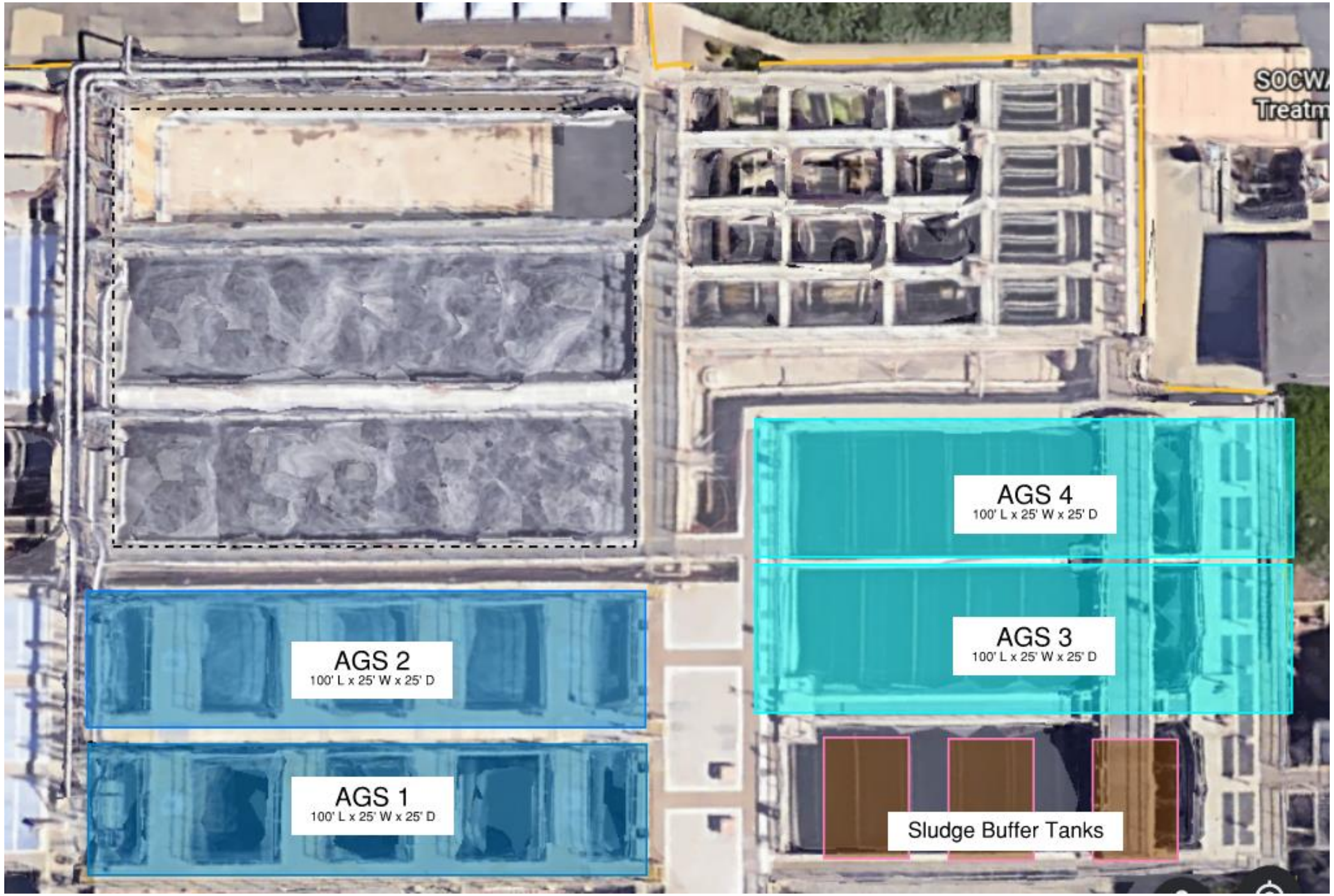
Membrane Aerated Biofilm Reactors

- Similar to conventional layout
- MABR cassettes located in the anoxic zone to improve total nitrogen removal and reduce energy



AquaNereda Aerobic Granular Sludge

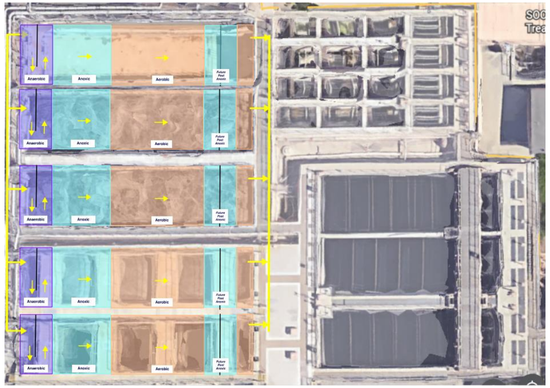
- Requires deep tanks (>18ft)
- Sludge buffer tanks located in existing West clarifier



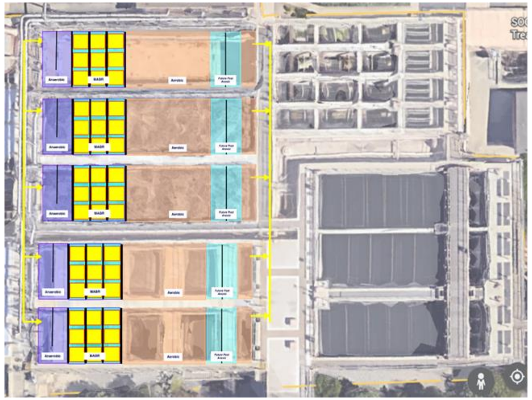
AquaSBR Sequencing Batch Reactor

- Requires the footprint of the existing aeration basins and secondary clarifiers

Facility Comparisons

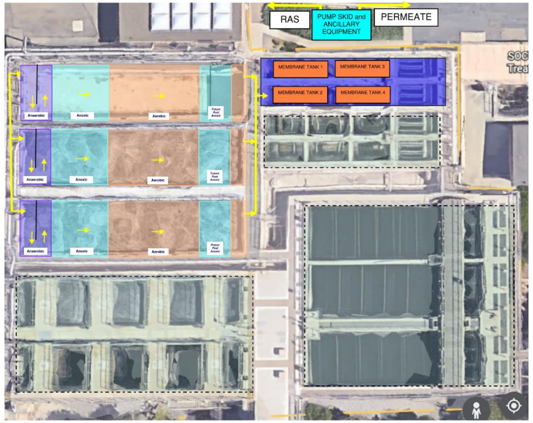


CAS BNR



MABR

SBR



MBR

AGS

Summary

Parameter	CAS	MBR	MABR	Aqua Nereda AGS	Aqua Nereda SBR
Existing Basin Volumes, MG	2.0	1.1	2.0	0.93	-
New Basin Volume, MG	-	-	-	**0.935**	**5.0**
Total Process Volume, MG	2.0	1.1	2.0	1.9	5.0
SRT	6-8 (Aer)	7.5 (Aer)	6.0	8.2	11.6
MLSS	3,000	<8,000 mg/L	2,800	8,000	4,500
Effluent Total Nitrogen	<10	<10	<10	<10	<10
Effluent NH_3	<1.0	<1.0	<1.0	<1.0	<1.0

Facility Impacts Summary

Parameter	CAS	MBR	MABR	Aqua Nereda AGS	Aqua Nereda SBR
CTP Primary Clarifiers	+	+	+	?	?
Repurpose CTP Aeration Basins	+	+	+	+/-	-
Require Tertiary Facilities	Y	N	Y	Y	Y
Sludge Export PS Compatibility	Y	Y	Y	Y	Y
RTP Gas Generation	↓	↓	↓	↓	↓

Preliminary Evaluation and Screening

Screening Evaluation Insights

	CAS	MBR	MABR	AGS	SBR
Relative Capital Cost	$$	$$	$$$	$$$	$$$
Relative Energy and Chemical Costs	$$	$$$	$	$	$$
Compatibility with WQ Objectives	++	+++	++	++	++
Compatibility with Existing Infrastructure	+++	++	+++	+	-

Preliminary Scoring

	CAS	MBR	MABR	AGS	SBR
Relative Capital Cost	5	4	3	2	1
Relative Energy and Chemical Costs	3	2	4	4	3
Compatibility with WQ Objectives	3	5	3	3	3
Compatibility with Existing Infrastructure	5	3	4	2	1
Total Score	**16**	**14**	**14**	**11**	**8**

Next Steps

Task 1 - Develop and Analyze Alternatives to Upgrade Treatment but De-rate the Plant Capacity to 4.0 mgd

- Progress the two (2) leading potential alternatives through:
  - Preliminary sizing and conceptual layout
  - Comparative advantages and disadvantages
  - Relative complexity
  - Conceptual level costs (Task 2)

Task 2 - Develop Cost Estimates

Hazen will develop estimated capital and operation and maintenance (O&M) costs for the two (2) screened alternatives evaluated in Task 1.

- The capital cost estimates will be Class 5 Level
- Hazen will develop the estimated capital costs with O&M costs (chemical, energy and sludge disposal).

Task 3 – Presentation and Findings

Hazen will prepare a table summarizing estimated costs and other non-economic factors considered in the comparative evaluation of the alternatives analyzed in Task 1. The presentation will include the following:

- Table comparing alternatives
- Brief discussion of other alternatives not analyzed including abandoning the CTP (conveying wastewater to the Regional Treatment Plant or JB Latham Treatment Plant) and maintaining the CTP at its current 6.7 mgd capacity.
- Estimate of the overall time frame to implement the alternatives
- Regulatory and permitting issues to be considered
- Future potential trends and concerns for potential potable reuse.

Project Schedule and Deliverables

- Project will be substantially completed 6 months from NTP
- (July 2020 – December 2020)

- Deliverables:
  - Draft and final TM summarizing the evaluation
  - Presentation of the work to SOCWA

Appendix B: Cost Estimate

Comparative Opinion of Probable Cost Summary by Alternative

Improvement	OPCC	
Alternative 1 - CAS BNR		
East Basin BNR Modifications	$	4,830,000
West Basin BNR Modifications	$	3,820,000
West Secondary Clarifier R&R	$	2,180,000
New Disc Filters	$	5,670,000
Site Yard Piping	$	1,000,000
Total CAS BNR	**$**	**17,500,000**
Alternative 2 -MBR		
East Basin BNR Modifications	$	5,030,000
West Basin EQ Modifications	$	4,880,000
MBR Basins in East Filters	$	17,800,000
Site Yard Piping	$	1,000,000
Total Alt 1	**$**	**28,800,000**
Alternative 3 - AGS		
East Basin Conversion to Peak Flow EQ	$	6,560,000
West Basin Conversion to AGS Basins	$	8,280,000
New AGS Basins	$	15,800,000
New Disc Filters	$	5,620,000
Site Yard Piping	$	600,000
Total Alt 2	**$**	**36,900,000**

American Association of Cost Estimators (AACE) Class 4 (-30%/+50%)
OPCC completed in 2021 dollars
General Conditions = 10%
Contractor Overhead and Profit = 18%
Bonds and Insurance = 3%
Contingency = 35%
OPCCs do not include cost of engineering, administration, legal, or environmental costs