Montecito Sanitary District & Montecito Water District
Enhanced Recycled Water Feasibility Analysis

Technical Memorandum 6
COST FOR MBR CONSTRUCTION AND 30-YEAR OPERATIONS

DRAFT | August 2022

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This document is released for the purpose of information exchange review and planning only under the authority of Andrew Thomas Salveson, August 29, 2022, California C-56902.

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Abbreviations

AWPF	advanced water purification facility
BOD	biochemical oxygen demand
BOD_5	5-day BOD test
Carollo	Carollo Engineers, Inc.
DDW	Division of Drinking Water
DPR	direct potable reuse
EQ	equalization
gal	gallons
gpd/sf	gallons per day per square foot
gpm	gallons per minute
LRV	log removal value
MBR	membrane bioreactor
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
MLSS	mixed liquor suspended solids
mm	millimeter
MSD	Montecito Sanitary District
MWD	Montecito Water District
NPDES	National Pollutant Discharge Elimination System
NPR	non-potable reuse
NPV	net present value
NTU	nephelometric turbidity unit
O&M	operations and maintenance
PDT	pressure decay testing
Q	flow
RAS	return activated sludge
SC	secondary clarifiers
scfm	standard cubic feet per minute
SRT	solids retention time
TM	technical memorandum
TSS	total suspended solids
WAS	waste activated sludge
WRF	Water Research Foundation
WWTP	wastewater treatment plant

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Technical Memorandum 6

COST FOR MBR CONSTRUCTION AND 30-YEAR OPERATIONS

6.1 Introduction and Background

This project will provide guidance to Montecito Water District (MWD) and Montecito Sanitary District (MSD) for implementation of recycled water and the beneficial use of treated wastewater from the community of Montecito. The project seeks to identify the best method of maximizing wastewater reuse capabilities thus producing a new local drought proof water supply for the community and reducing the discharge of treated wastewater to the ocean. The analysis considers local and regional partnerships, non-potable and potable reuse alternatives, and various treatment methods and technologies.

This technical memorandum (TM) builds upon work performed in prior TMs. Prior work leveraged and referenced in this TM includes the wastewater flow and load projections from TM 1, MSD Flow and National Pollutant Discharge Elimination System (NPDES) Permit Analysis, the cost and effort to rehabilitate existing facilities in TM 3, Condition Assessment, and the calibrated plant process model that was built for the performance and capacity assessment for TM 4, Evaluation of Performance and Capacity. This TM evaluates two alternatives to replacing the secondary treatment facilities. Alternative 1 consists of constructing a new membrane bioreactor (MBR) facility, while Alternative 2 consists of retrofitting the MBR facilities within the existing secondary process infrastructure (i.e., aeration tanks and clarifiers).

The evaluation includes process schematics, design criteria, layouts, capital, operations and maintenance (O&M) and life cycle costs, and various non-economic considerations.

6.2 Summary of Findings

Alternatives were compared over a 30-year planning horizon. The key findings are summarized below:

- Alternative 1: New MBR:
  - New MBR facilities would require several new structures that could be built in the open area to the western end of the treatment plant property.
  - Processes could be constructed all at once without disruption to existing treatment.
  - New treatment processes will not require replacement within the 30-year planning horizon.
- Alternative 2: Retrofit Wastewater Treatment Plant (WWTP) With MBR:
  - Two of the four existing secondary clarifiers (SCs) could be retrofit to fit the new membrane tanks. The condition assessment performed at the plant (see TM 3) found the structural condition of the clarifiers to be moderate to poor. Concrete repair will be required.

  - One of the two existing aeration tanks could be retrofit and reconfigured to house a two new bioreactor trains providing anoxic and aerobic treatment upstream of the membrane tanks. Concrete repair will be required.
  - Rehabilitation will extend the life of the existing aeration tanks and SCs, but replacement will still be needed likely within the 30-year planning period. The condition assessment performed at the plant (see TM 3) found the structural condition of the clarifiers to be moderate to poor.
- Comparison of Alternatives:
  - Estimated construction costs are similar between the two facilities.
  - Uncertainties in structural condition of the existing facilities to be utilized in Alternative 2 may lead to full replacement of assets within the next 15 to 20 years, increasing the costs of Alternative 2.
  - Construction sequencing, phasing, and space requirements will be constrained for both alternatives, but more complicated for Alternative 2.
  - Alternative 1 allows for existing plant tankage to be utilized for future recycled water storage, pending structural condition.

6.3 Basis of Evaluation

The flow and load criteria for this MBR analysis comes from TM 1 (Tables 1.1 and 1.2). Several items of note:

- Flow values focus upon existing and future flow and load concentrations as well as with the addition of septic to sewer conversions identified in TM 1.
- The MBR would treat the entire process flow, not a side stream. Because of uncertainty related to climate change and storm intensities and the fact that MBR systems have distinct maximum production capacity, conservatism in sizing equalization (EQ) (pre-MBR) and MBR systems is included in this analysis.

The following modeling and process assumptions for the MBR are included:

- MBR system is based on a 10-day total solids retention time (SRT).
- Sizing is based on meeting existing permit for biochemical oxygen demand (BOD) and total suspended solids (TSS) removal only. Although the proposed system will remove nutrients, it does not need to meet a numeric nutrient target.

6.4 Alternatives Description and Overview

Two alternatives were developed to replace the secondary treatment facilities with the MBR process. Both alternatives utilize the same process and approach; the primary difference being whether the MBR facilities are constructed as new or retrofitted within the existing secondary process.

MBR systems are similar to the existing secondary process in that it utilizes aeration and microorganisms to remove soluble pollutants such as BOD and nutrients. However, instead of using gravity for solids separation in SCs, membranes are used. Because of this difference, the aeration tanks can be operated at much higher mixed liquor suspended solids (MLSS) concentrations and therefore achieve the same treatment in a reduced volume. Membranes can accommodate solids concentrations up to 10,000 to 15,000 milligrams per liter (mg/L), depending on the membrane type and manufacturer. In an activated sludge process with conventional clarifiers, MLSS concentrations are limited the ability to settle mixed liquor, which is difficult to do above 4,000 to 5,000 mg/L.

For the MBR, mixed liquor from the aeration tanks would flow to new membrane tanks, where micro- or ultra-filtration membranes are used to produce high quality effluent that meets Title 22 standards for effluent turbidity, which is 0.2 nephelometric turbidity unit (NTU) 95 percent of the time and 0.5 NTU not to exceed at any time. MBRs also provide pathogen disinfection, as noted further on in this document.

MBRs come in both hollow fiber and flat plate types. The advantages and disadvantages of each type are shown in Table 6.1.

Table 6.1 MBR Hollow Fiber vs. Flat Plate

Membrane Type	Advantages	Disadvantages
Hollow Fiber	• Lower blower air scour demand. • Smaller membrane footprint, more easily retrofit into shallow clarifiers. • More flexibility for retrofits with other manufacturers.	• More complex O&M. • Membranes susceptible to debris.
Flat Plate	• Membranes less susceptible to debris buildup and damage. • Higher allowable solids concentration, subsequently smaller bioreactors. • Less frequent cleanings required.	• Larger footprint and volume for membrane tank. • At higher MLSS, lower oxygen transfer efficiency and more process air utilization. • Retrofits with other manufacturers retrofits are less "streamlined".

For the purposes of this evaluation, a Kubota flat plate MBR system was used. Kubota is the leading installer of flat plate membranes globally and has undergone extensive virus and protozoa removal validation following the Water Research Foundation (WRF) 4997 protocols, which have been approved by the State of California. Other systems, such as Suez or DuPont, are anticipated to be equally effective once they have completed their own validation testing.

Other key common elements of both alternatives are as follows:

- The existing influent pumps will be utilized to pump to a new, partially buried flow EQ tank.
- Wet weather flow EQ would be utilized to limit the wet weather flow peaking factor to 2.0. Industry experience is that with higher peaking factors, MBRs are not as cost effective. An analysis of historic storms performed in TM 1 indicates 2.1 million gallons (MG) would be needed to limit the wet weather equalized flow to 1.5 million gallons per day (mgd) at buildout[1]. Due to site space constraints, the EQ tank will be constructed

[1] Note: In the summer of 2022, Morro Bay was permitted by the RWQCB to have a PWWF bypass for their 1.88 mgd peak flow MBR. Flows above 1.88 mgd receive primary treatment through cloth disc filters before discharge to an ocean outfall. A similar approach could be taken for a future MSD project, the equalization ahead of MBR would be replaced by a primary treatment bypass system, significantly reducing footprint and cost. A cost reduction of ~$8M is anticipated.

partially below grade at an equal depth to the existing influent pump station. A small pump station is required to pump equalized flow from the EQ basins to downstream treatment. Although the EQ tank would only need to be used during wet weather when the wastewater is dilute, it is assumed the tank would be covered and have odor control.

- New screening facilities will be needed to protect the membranes from rags and debris. The max opening size of the screens should not exceed 2-millimeter (mm) to sufficiently protect the downstream MBR process and meet typical membrane warranty requirements. It is assumed that rotating drum screens would be used and that they would be located between the EQ tank and MBR train. Locating the screening downstream of EQ and the EQ pump station will minimize the required size of the screening facilities. The EQ basin will need to be cleaned to remove debris from the influent wastewater after each use. However, due to the seasonal, wet weather use of the EQ basin it is anticipated this cleaning will be infrequent and minimal. The screening facility will be located at grade adjacent to the EQ basin and pumping facility.
- The new membrane system includes membrane tanks, membranes, permeate pumps, membrane air scour blowers, chemical cleaning facilities, and return activated sludge (RAS)/waste activated sludge (WAS) pumping.
- While the existing process aeration blowers can continue to be used for process aeration, RAS pumping will be at a significantly higher flow rate, and new membrane air scour blowers may require new electrical and power distribution facilities.
- Although MBRs provide a measure of disinfection, for this analysis it is assumed that the existing chlorination system would remain in place, although efficiency (and cost) will improve.
- If disinfection is enhanced in the future, the MBR effluent (or permeate) would be suitable for Title 22 reuse. To maximize the capture and reuse of effluent, and minimize the sizing of recycled water distribution facilities, it is assumed that MBR permeate would be equalized. The amount of EQ needed after the MBR depends upon the maximum production rate of recycled water and the diurnal flow through the WWTP. Based on the average dry-weather flow of 0.7 mgd, prior work (2019 Montecito Recycled Water Facilities Plan) has determined that 100,000 gallons of storage is needed to maximize the capability for non-potable reuse (NPR) and 230,000 gallons is needed for direct potable reuse (DPR). The volume needed for DPR is driven by the draft regulations, which require a minimum 10:1 dilution of flow in the event of a potential 1-hour chemical spike. See TM 8, Recycled Water Treatment Options at MSD and TM 9, Infrastructure Analysis for a more detailed review of post MBR EQ.

Detailed design criteria for this MBR analysis are available in Appendix 6A. Figure 6.1 illustrates the proposed flow schematic for both alternatives.

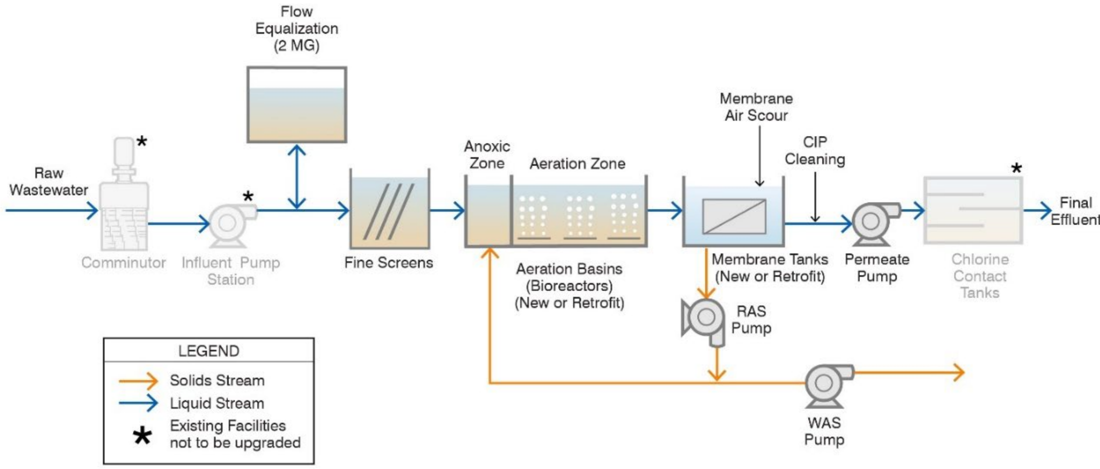

Figure 6.1 Proposed Treatment Schematic

6.4.1 Future NPR Considerations

MBR is an ideal treatment for NPR, providing an effluent with very low turbidity and very low bacterial counts. For NPR that does not require salt removal (see TM 8 and TM 9), disinfection with free chlorination using the existing chlorination system is proposed following MBR. Free chlorination is expected due to the reliable nitrification by an MBR system[2]. Ammonia could be added to the reclaimed water system to form chloramines if a long lasting residual is desired. In total , for NPR, no additional disinfection systems are needed to comply with regulations.

Should salt reduction be desired for NPR, MBR can be followed directly by reverse osmosis, then followed by a small ultraviolet disinfection system for final disinfection.

6.4.2 Future Potable Reuse Considerations

MBR treatment is a proven barrier to pathogens, including virus, protozoa, and bacteria and an integral component of potable reuse programs, should advanced treatment be implemented in the future.

With regard to pathogen removal by MBR, which is an important consideration for a potable reuse program, the following must be reinforced:

- Based upon WRF Project 4997, which was led by Carollo Engineers, Inc. (Carollo), the State of California Division of Drinking Water (DDW) will permit any MBR to receive 1 log removal value (LRV) for virus and 2.5 LRV for protozoa as long as turbidity values are 0.2 NTU (or lower) 95 percent of the time and do not exceed 0.5 NTU. These conservative credits are called “Tier 1”.
- The same WRF Project 4997 details how to obtain higher LRV credits, referred to as “Tier 2”. Industry progress on Tier 2 testing is summarized below:

[2] Disinfection credit under Title 22 of the California Code of Regulations would be based upon the Australian WaterVal process which allows for very short contact times for free chlorination.

- To date, only Kubota has finished their "Tier 2" work, documenting virus and protozoa LRVs in the 3 to 4 range. These "Tier 2" credits, once approved by DDW, would apply to any Kubota system used for potable reuse in California.
- Suez, DuPont, and Koch are each either working through Tier 2 efforts or Tier 2 efforts are in their near future.
- For Tier 2, turbidity remains a primary performance surrogate. Tier 2 also requires a secondary surrogate, which can be either total coliform monitoring in MBR permeate or pressure decay testing (PDT). Regarding PDT:
  - PDT is NOT required.
  - PDT testing of MBR is something that DuPont has pioneered, but has been included in the Metropolitan Water District and Hyperion MBR demonstration systems for Suez, DuPont, and Koch, all designed by Carollo.
  - Kubota cannot effectively perform PDT because of the flat sheet application, it is anticipated to be too destructive of a test. For Kubota, their Tier 2 monitoring would be turbidity and total coliform.

The Tier 2 validation will provide downstream benefits to the future advanced water purification facility (AWPF) processes. A full evaluation of MBR suppliers, such as DuPont-Memcor and Suez-Zenon, is recommended as part of the predesign effort, should this project move forward.

6.4.3 Alternative 1 – New MBR at WWTP

This alternative consists of constructing all new MBR facilities at the WWTP and includes three bioreactors and three membrane tanks to provide reliability and redundancy. The existing aeration tanks and SCs will not be used for the MBR facilities and can be used for recycled water storage if a recycled water program is implemented in the future. If desired, the existing aeration tanks and SCs could also be demolished if additional space is needed for other facilities, such as a future AWPF. TM 8 evaluates the space needed for a future AWPF.

A site layout of this alternative is provided on Figure 6.2.

6.4.4 Alternative 2 – Retrofit WWTP With MBR

This alternative consists of constructing new MBR facilities within the existing aeration tanks and SCs. One of the two aeration tanks would be modified with new diffusers, mixers, and partition walls so that the process includes two reactors. Two of the four SCs would be converted to membrane tanks. Unlike Alternative 1, this alternative includes two bioreactors and two membrane tanks because this configuration fit more logically into the existing infrastructure given the treatment capacity requirements. Plant staff will still have the ability to take one train out of service for maintenance activities if needed. Should additional redundancy be required, three bioreactors and membrane tanks could be considered, though this might require more significant retrofitting efforts and possible utilization of more aeration tanks and SCs. The remaining secondary infrastructure (one aeration tank and two SCs with this current configuration) can be used for recycled water storage if a recycled water program is implemented. To allow for the retrofit, the 2.1 MG of EQ would need to first be constructed, which then allows for operation of only two SCs during MBR system construction.

Alternative 2 does not include structure replacement. Condition assessment results, referenced in TM 3, indicate extensive cracking in both the existing aeration tanks and SCs. It is unknown at this time whether the cracking can be repaired and the tank rehabilitated to extend its useful life or if it is indicative of alkali-silica reaction, which would negate full structure replacement. It is recommended that a more detailed structural assessment be performed should retrofit be the preferred alternative.

A site layout of this alternative is provided on Figure 6.3.

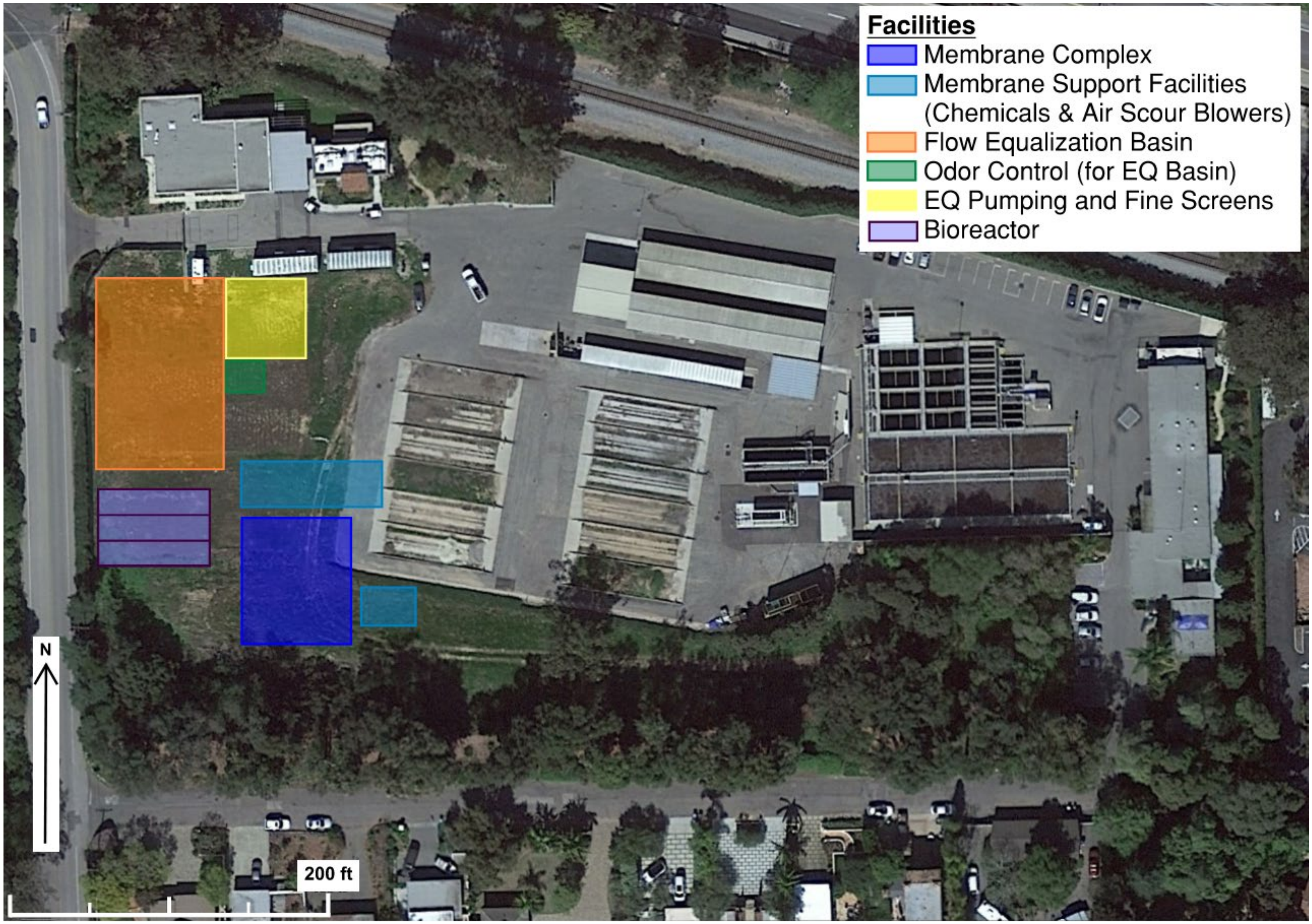

Figure 6.2 Alternative 1 New MBR Site Layout

Figure 6.3 Alternative 2 Retrofit WWTP Site Layout

6.5 Alternative Comparison

This section compares the costs and non-economic considerations, which assess the advantages and disadvantages for both alternatives.

6.5.1 Cost Comparison

The following section compares the capital costs, O&M costs, and life cycle costs for both alternatives. Detailed cost documentation is available in Appendix 6B.

6.5.1.1 Capital Cost Comparison

An AACE International Class 5 cost estimate was prepared for this each evaluated alternative. Per AACE International standards, a Class 5 cost estimate has an expected accuracy range of - 20 to - 50 percent and +30 to +100 percent for the low and high ranges, respectively.

The costs presented herein were developed using the Carollo Cost Estimation database, past similar projects, and vendor quotes.

Table 6.2 shows the anticipated capital costs for both alternatives. Note that these costs are developed for the purposes of alternative comparison and do not include mid-point escalation or bid market allowance. Current market conditions suggest large rates of cost escalation and high rates of variance in construction bidding. It is suggested that an escalation rate and bid market allowance be added to capital costing efforts as project development becomes more refined.

Costs presented include rehabilitation, but not full structure replacement, of the existing aeration tanks and SCs. Rehabilitation costs include repair to cracks and exposed aggregates, coating replacement, and repair to struts and walkways, as needed. Should results of subsequent structural studies indicate replacement of the aeration tanks and SCs is required in the near-term, the cost of Alternative 2 will increase substantially.

Table 6.2 Capital Cost Comparison (Presented in 2022 Dollars)[1,2]

Cost Item/Process Area	Description	Alternative 1 - New ($M)	Alternative 2 - Retrofit ($M)
Direct Costs			
Primary Treatment	Fine Screens	$1.30	$1.30
Flow EQ	EQ Basin and Pumping	$3.00	$3.00
	Odor Control System	$0.22	$0.22
Aeration Tanks	Structural Rehabilitation		$0.11
	New Aeration Basin (0.30 MG)	$0.71	
	Mechanical Equipment	$0.89	$0.89

Cost Item/Process Area	Description	Alternative 1 - New ($M)	Alternative 2 - Retrofit ($M)
MBR System	Secondary Clarifier Rehabilitation		$0.19
	Secondary Clarifier Retrofit		$0.04
	MBR System (Includes Membrane Complex and Equipment)	$2.56	$2.70
	Blower Building and Electrical Room	$0.74	$0.66
	Chemical Facility	$0.12	$0.12
Subtotal		**$9.60**	**$9.30**
Demolition			$0.50
Retrofit Contingency	5 percent of Subtotal		$0.47
Civil/Yard Piping	10 percent of Subtotal	$0.96	$0.93
Process Mechanical Allowance	10 percent of Subtotal	$0.96	$0.93
Electrical, Instrumentation & Controls	25 percent of Subtotal	$2.39	$2.31
Subtotal Direct Cost		**$13.91**	**$14.44**
Contingency	30 percent	$4.18	$4.33
Total Direct Costs	**Subtotal + Contingency**	**$18.09**	**$18.77**
Construction Costs			
General Conditions	12 percent of Total Direct Cost	$2.18	$2.26
Bond/Insurance	2.5 percent of Total Direct Cost	$0.46	$0.47
Contractor Overhead and Profit	12 percent of Total Direct Cost	$2.18	$2.26
Sales Tax	8 percent of Total Direct Cost	$0.73	$0.76
Total Construction Cost		**$23.64**	**$24.52**
Project Costs			
Engineering (Design and Construction Services)	20 percent of Total Construction Cost	$4.73	$4.91
Owner's Reserve for Change Orders	5 percent of Total Construction Cost	$1.19	$1.23
Total Project Cost		**$29.56**	**$30.66**

Notes:

(1) Expressed in 2021 dollars.

(2) Note that capital costs presented are for alternative comparison only. These costs do not include mid-point escalation or bid market allowance. Current market conditions suggest large rates of cost escalation and high rates of variance in construction bidding. It is suggested that an escalation rate and bid market allowance be added to capital costing efforts as project development becomes more refined.

(3) Permitting of a primary effluent bypass, similar to the Morro Bay MBR project, would minimize EQ needs and instead replace EQ with the primary bypass system, dropping the cost shown for EQ from $3M to $1.5M.

As noted earlier in this document, the recent approval of a primary effluent bypass for peak wet weather flow in Morro Bay presents a significant cost savings for the evaluated MBR project above. The 2022 construction costs for the Morro Bay primary bypass system was $1.46M. Applying that cost in lieu of the $3M cost for equalization results in a cost reduction of $4M for either MBR project, resulting in an estimated Total Project Cost for MBR in the range of $25M to $27M.

6.5.1.2 O&M Cost Comparison

Annual O&M costs were developed for each alternative. The following assumptions were made when developing these costs:

- $0.23 per kilowatt-hour for power costs.
- $2.75 per gallon for sodium hypochlorite (12.5 percent solution) based on the price MSD is currently paying.
- $7.00 per gallon for citric acid based on similar industry values.
- Additional labor and equipment maintenance were not included, as this is anticipated to be similar for both alternatives.

Table 6.3 shows the anticipated annual O&M costs for the MBR system and associated improvements. O&M costs are anticipated to be similar between the greenfield and retrofit alternatives.

Table 6.3 Annual O&M Costs (2022 Dollars)(1,2)

O&M Item	Annual Cost
Power	
EQ Pump Station	$33,000
EQ Odor Control	$18,000
Aeration Tanks	$124,000
MBR System	$150,000
Chemicals	
Sodium Hypochlorite (12.5 percent solution)	$5,000
Citric Acid (50 percent solution)	$2,000
Additional Annual Running Costs	
Diffuser Replacement	$3,000
MBR Membrane Replacement(3)	$40,000 to $55,000
Total	**~$400,000**

Notes:
(1) Expressed in 2021 dollars.
(2) Note that costs presented are for alternative comparison only. Current market conditions suggest large rates of cost escalation. Prices should be confirmed as project develops.
(3) Membrane replacement required approximately every ten years. New vs. retrofit membranes may range in replacement costs due to different configurations. Annualized membrane replacement for Alternative 1 (New) is anticipated to be approximately $40,000 while replacement for Alternative 2 (Retrofit) is anticipated to be approximately $53,000.

6.5.1.3 Life Cycle Cost Comparison

A comparison of construction, annual O&M, and net present value (NPV) costs are summarized in Table 6.4 for a 30-year life cycle. Equipment replacement and labor costs were not considered, as these are expected to be similar for both alternatives. The following assumptions were made when developing the life cycle costs:

- Two years of design.
- Three years of construction.
- Annual O&M for the remainder of the 30-year life cycle period.
- No replacement of structures will be required within the life cycle. Note that this is contingent on further structural assessment for existing concrete tanks.

Table 6.4 Cost Comparison(4)

Cost Item	Total Cost ($M)	
	Alt. 1 - New	Alt. 2 - Retrofit
Total Project Cost(1)	$29.56	$30.66
Escalated Capital Cost(2)	$31.94	$33.13
Annual O&M Cost(1)	$0.37	$0.39
Total O&M(1)	$9.30	$9.63
Escalated Total O&M(2)	$15.72	$16.28
NPV(3)	$41.33	$42.84

Notes:
(1) Expressed in 2021 dollars.
(2) Over a 30-year lifespan using a 3 percent escalation rate.
(3) Analysis based on a 30-year lifecycle using a 3 percent escalation rate and 2 percent discount rate.
(4) Note that capital costs presented are for alternative comparison only. These costs do not include mid-point escalation or bid market allowance. Current market conditions suggest large rates of cost escalation and high rates of variance in construction bidding. It is suggested that an escalation rate and bid market allowance be added to capital costing efforts as project development becomes more refined.

6.5.2 Phasing and Scheduling

Estimated phasing for each alternative must accommodate uninterrupted operation at the WWTP as well as meet required NPDES permit stipulations.

6.5.2.1 Alternative 1 (New) Phasing and Scheduling

The new facilities will be constructed on the vacant space on the west end of the WWTP property. Construction phasing is likely to be fairly straightforward, as preliminary sizing and layouts suggest that the facility can be constructed in open space. Based on sizing of the MBR, it is crucial that the flow EQ be operational prior to MBR startup.

After the new facilities are constructed, the existing aeration tanks and SCs can be taken out of service and utilized for future recycled water storage.

6.5.2.2 Alternative 2 (Retrofit) Phasing and Scheduling

Implementation of Alternative 2 will require construction sequencing that considers maintaining existing treatment process capacity.

Rehabilitation Requirements

Significant concrete and liner repairs are required to repurpose the existing aeration tanks and SCs. A BioWin model of the existing plant processes was used to assess the ability to convert one of the two aeration tanks into a bioreactor and two of the four SCs into membrane tanks. At existing flows, it was found that the plant will not have the required capacity to operate reliably at this reduced capacity during wet weather events. However, modeling results indicate that if the new flow EQ (2.1 MG) is completed prior to rehabilitation work, there will be sufficient capacity to maintain existing treatment while rehabilitation is taking place.

Anticipated Schedule

The following sequence is recommended for proceeding with a retrofitted MBR process:

1. Step 1 – Demolish existing sludge drying beds:
   a. Clear new space by demolishing the existing sludge drying beds for siting the new flow EQ basin. Existing sludge drying beds are used for emergency sludge management only. Typically, solids are dewatered through an existing belt filter press. It is recommended that, should additional solids dewatering be required, sludge is hauled offsite for processing by a third party.
2. Step 2 – Construct new flow EQ and MBR support facilities:
   a. Build new 1 MG of wastewater EQ, including mixing and odor control.
   b. Build new MBR fine screens.
   c. Construction additional MBR components (e.g., additional blowers, electrical, chemical systems) in the location of the existing drying beds.
   d. Build new membrane tanks in the location of the existing drying beds.
3. Step 3 – Rehab Structures:
   a. Remove one aeration tank from service and perform rehabilitation of the concrete and prepare one aeration tank to be converted into two biological reactors for new MBR.
   b. Remove two SCs from service and upgrade each to a membrane tank.
4. Step 4 – Transition of Processes, take old plant out of service.

6.5.3 Non-Economic Considerations

Non-economic factors for consideration include constructability, space constraints, and treatment reliability/flexibility to meet current and potential future regulations. Advantages and disadvantages of both alternatives is shown in Table 6.5.

Table 6.5 Alternative Non-Economic Comparison

Alternative	Advantages	Disadvantages
Constructability		
Alt. 1 – New	• Simplifies construction. Use existing treatment processes until MBR is completed, then switch over.	• More process tanks and equipment to fit into available space.
Alt. 2 – Retrofit	• Utilizes existing infrastructure as much as possible.	• Complicated construction phasing. Must keep plant running while rehab is taking place. • Higher risk of delays in schedule and unforeseen costs during rehab (e.g., detailed structural analysis not yet performed).

Alternative	Advantages	Disadvantages
Reliability		
Alt. 1 – New	• Upgrades structures all at once, will not require future rehabilitation or unforeseen costs.	• Slightly higher infrastructure cost
Alt. 2 – Retrofit		• The old tanks are already ~40 years old. Even with rehab they will likely need replacement within the 30-year planning period. Rehab is likely delaying an inevitable expenditure.
Flexibility		
Alt. 1 – New	• Frees up existing aeration tanks and SCs for future recycled water storage.	• Site requirements for new structures reduces available land.
Alt. 2 – Retrofit	• Keeps western edge of the property free for siting future AWPF.	• Additional storage may need to be constructed for recycled water.

6.6 Summary

Construction of the greenfield MBR (Alternative 1) allows for the plant to operate safely and efficiently during MBR construction. Construction of greenfield MBR allows for existing concrete infrastructure to be reused for recycled water storage and EQ.

Construction of a retrofit MBR (Alternative 2), if tightly managed and controlled, can be done without significantly impacting safety and efficiency. Construction of retrofit MBR results in repurposing of all concrete assets with the exception of two SCs as well as needing new construction of two concrete basins, similar to the greenfield option.

Costs for both greenfield and retrofit are similar.

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Appendix 6A

DESIGN CRITERIA

Table 6A.1 Secondary Process Operation

Parameter	Unit	Alt. 1 – New	Alt 2. – Retrofit
Influent Flow			
Average Annual	mgd	0.70	
Maximum Month	mgd	1.2	
Peak Wet Weather Flow	mgd	8.76	
Influent Concentration			
Average Concentration at Average Flow			
BOD_5	mg/L	289	
TSS	mg/L	278	
Max Month Concentration at Average Flow			
BOD_5	mg/L	460	
TSS	mg/L	407	
EQ Basin			
Number	-	1	
Volume	MG	2.1	
Side Water Depth	feet	28	
Peak Equalized Flow	mgd	1.53	
Flow Control to Aeration Tanks	-	Gravity Flow through Modulating Gate or Valve	
EQ Pumping			
Number	-	2 + 1	
Capacity, each	gpm	0.77	
Firm Capacity	mgd	1.53	
Primary Effluent Screening			
Number (Duty + Standby)	-	2+1	
Type	-	Rotary Drum, 2-mm	
Capacity, each	mgd	1.53	
Bioreactors			
Number	-	3	2
Volume, each	gal	100,000	150,000
Anoxic Zone Volume, each	gal	16,700	25,000
Aerobic Zone Volume, each	gal	83,300	125,000
Total Volume	gal	300,000	
Max Month MLSS			
Aeration Tanks	mg/L	7,500 – 10,000	
Membrane Tanks	mg/L	10,000 – 12,000	
Process Air Usage			
Average	scfm	1,500	
Maximum Month	scfm	1,830	
Peak	scfm	3,000	

Parameter	Unit	Alt. 1 – New	Alt 2. – Retrofit
Membrane Flux (All Trains in Service)			
Average Annual	gpd/sf	8.0	6.0
Max Month	gpd/sf	13.6	10.2
Peak (24-hr sustained)	gpd/sf	17.6	13.2
Additional Secondary Process Operational Parameters			
Total SRT	Days	10	
RAS Flow, firm capacity	mgd	6	6
Typical RAS Flow	% of Q	300 to 500 percent	

Notes:
Abbreviations: BOD_5 - 5-day BOD test; gpm - gallons per minute; gal - gallons; gpd/sf - gallons per day per square foot; scfm - standard cubic feet per minute; Q - flow.

Table 6A.2 Secondary Process Equipment

Parameter	Unit	Alt. 1 – New	Alt 2. – Retrofit
Aeration Tank Diffusers			
Type	-	9-inch membrane disc	
Number per Aeration Tank	-	500	750
Total	-	1,500	
Process Aeration Blowers			
Number	-	2 + 1	
Capacity, each	scfm	1,500	
Firm Capacity	scfm	3,000	
Mixers			
Number per Anoxic Zone	-	1	
Total	-	3	2
RAS Pumping			
Number (Duty + Standby)	-	2 + 1	1 + 1
Capacity, each	gpm	2,083	4,167
Firm Capacity	mgd	2.8	2.8
Membrane Air Scour Blowers			
Number (Duty + Standby)	-	2 + 1	1 + 1
Capacity, each	scfm	426	1,365
Permeate Pumps			
Number (Duty + Standby)	-	2 + 1	1 + 1
Capacity, each	gpm	550	1,150
Firm Capacity	mgd	1.58	1.66

Appendix 6B

DETAILED COST DOCUMENTATION

COST SUMMARY

Project:	Enhanced Recycled Water Feasibility Analysis	Estimate Class:	5
Client:	City of Montecito	CSM:	A. Salveson
Location:	Montecito, CA	PM:	A. Salveson
Zip Code:	93108	Date:	May 9, 2022
Carollo Job #	12289A10	By:	M. Rasmus

Area or Spec Section	DESCRIPTION		Alt. 1 New	Alt. 2 Retrofit
Liquid Process				
Primary Treatment				
	Fine Screens		$1,300,000	$1,300,000
Flow Equalization				
	Equalization Basin and Pumping		$3,000,000	$3,000,000
	Odor Control System		$220,000	$220,000
Aeration Basins				
	Aeration Basin Structural Rehabilitation			$110,000
	New Aeration Basin (0.30 MG)		$710,000	
	Aeration Basin Mechanical Equipment		$890,000	$890,000
MBR System				
	Secondary Clarifier Rehabilitation			$190,000
	Secondary Clarifier Retrofit			$40,000
	MBR System (Includes Membrane Complex and Equipment)		$2,560,000	$2,700,000
	Blower Building and Electrical Room		$740,000	$660,000
	Chemical Facility		$120,000	$120,000
	SUBTOTAL		$9,600,000	$9,300,000
	Demolition			$500,000
	Retrofit Contingency	5.0%		$470,000
	Civil/Yard Piping	10.0%	$960,000	$930,000
	Process Mechanical Allowance	10.0%	$960,000	$930,000
	Electrical, Instrumentation & Controls	25.0%	$2,390,000	$2,310,000
Other Construction				
	SUBTOTAL DIRECT COST		$13,910,000	$14,440,000
	Contingency	30.0%	$4,180,000	$4,330,000
	TOTAL DIRECT COST		$18,090,000	$18,770,000
	INDIRECT COST			
	General Conditions/Requirements	12.0%	$2,180,000	$2,260,000
	Bond and Insurance	2.5%	$460,000	$470,000
	Contractor Overhead, Profit & Risk	12.0%	$2,180,000	$2,260,000
	Sales Tax (Based on 50% of direct cost)	8.0%	$730,000	$760,000
	TOTAL INDIRECT COST		$5,550,000	$5,750,000
	TOTAL ESTIMATED CONSTRUCTION COST		$23,640,000	$24,520,000
	Engineering, Administrative, and Legal	20.0%	$4,730,000	$4,910,000
	Owner's Reserve for Change Orders	5.0%	$1,190,000	$1,230,000
	TOTAL ESTIMATED PROJECT COST		$29,560,000	$30,660,000

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

Note that capital costs presented are for alternative comparison only. These costs do not include mid-point escalation or bid market allowance. Current market conditions suggest large rates of cost escalation and high rates of variance in construction bidding. It is suggested that an escalation rate and bid market allowance be added to capital costing efforts as project development becomes more refined.

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ANNUAL O&M COST SUMMARY

Project:	**Enhanced Recycled Water Feasibility Analysis**	**Estimate Class:**	**5**
Client:	**City of Montecito**	**CSM:**	**A. Salveson**
Location:	**Montecito, CA**	**PM:**	**A. Salveson**
Zip Code:	**93108**	**Date:**	**May 9, 2022**
Carollo Job #	**12289A10**	**By:**	**M. Rasmus**

O&M Item	Quantity	Quantity	Unit	Unit Cost	Annual Cost[1]	Annual Cost[1]
	Alt 1 - New	Alt 2 - Retrofit			Alt 1 - New	Alt 2 - Retrofit
Power						
EQ Pump Station	141,116	141,116	KW-hr/year	$0.23	$33,000	$33,000
EQ Odor Control	76,650	76,650	KW-hr/year	$0.23	$18,000	$18,000
Aeration Basins	537,661	537,661	KW-hr/year	$0.23	$124,000	$124,000
MBR System	648,447	648,447	KW-hr/year	$0.23	$150,000	$150,000
Chemicals						
Sodium hypochlorite (12.5% solution)	1,522	1,522	gallon	$1.00	$2,000	$2,000
Citric acid (50% solution)	152	152	gallon	$7.00	$2,000	$2,000
Annual Running Costs						
Aeration Basin Diffusers Replacement	300	300	diffuser	10	$3,000	$3,000
MBR Membrane Replacement	1	1	LS		$39,600	$52,800
					$372,000	$385,000

(1) Expressed in 2022 dollars