Stantec

Technical Memorandum

To:	Brett Dingman, P.E. Veronica Hurtado Las Virgenes Municipal Water District	From:	James Borchardt, PE Zakir Hirani, PE Tyler Hadacek, PE Kyleen Marcella, EIT
Title:	Compliance Method Study	Date:	May 9, 2018

1. INTRODUCTION

The Las Virgenes-Triunfo Joint Powers Authority (JPA) own and operate the Tapia Water Reclamation Facility (Tapia) that discharges its treated effluent for part of the year to Malibu Creek. Tapia currently treats approximately 7 million gallons per day (MGD) of wastewater, which is either reused or sent to the Los Angeles River (Outfall 005), Malibu Creek (Outfall 001, 002, 003), or to JPA-operated spray irrigation fields. Reuse of 60-70% of the tertiary effluent produced annually is achieved through an extensive recycled water system. Although the facility is permitted for a capacity of 16.1 MGD, planning efforts over the last 10 years related to nutrient management have considered 12 MGD as the maximum required capacity for the foreseeable future.

Discharge to Malibu Creek and the Los Angeles River are regulated under NPDES permit CA0056014 issued by the Los Angeles Regional Water Quality Control Board (RWQCB) in 2017. According to Tapia's NPDES permit, discharge of treated water to Malibu Creek is allowed from November 16th to April 14th each year, with the rest of the year referred to as the prohibition period. During the prohibition period, discharges are only allowed for emergency situations (where there is a pipe break or other malfunction in infrastructure), for extreme wet weather flows, or for the purpose of maintaining minimum flows in Malibu Creek as set forth in the NPDES guidelines (augmentation flows). From November 16th through April 14th, excess Tapia flows not consumed by the JPA's recycled water customers have been discharged to one of the three other outfalls, with the majority going to the Malibu Creek outfalls.

Past water quality requirements for discharge to Malibu Creek included monthly limitations for nitrogen compounds of 3.1 mg/L-N ammonia and 8 mg/L-N nitrate plus nitrite. Monthly limitations for total phosphorous was 3 mg/L. New, more stringent nutrient summertime requirements of 1.0 mg/L total nitrogen (TN) and 0.1 mg/L total phosphorus (TP) have been proposed as the Total Maximum Daily Loads for Nutrients in the Malibu Creek Watershed by the United States Environmental Protection Agency, Region 9.

1.1. BACKGROUND

The JPA Board is moving forward with the "Pure Water Project Las Virgenes – Triunfo" in order to maximize beneficial reuse of the Tapia WRF's effluent. This will decrease discharge to Malibu Creek during the wintertime and shoulder periods of the year. However, Tapia WRF will still be required to augment flows to Malibu Creek such that 2.5 cubic feet per second (cfs) of flow is maintained at gauging station F-130-R that meets the stringent TN and TP discharge limits during the summer season.

Due to the potential of low TN and TP limits being implemented for the Malibu Creek discharge, JPA requested Stantec in 2016 to prepare a technical memorandum (TM), *Treatment and Operations Scenarios for Meeting Lower Nutrient Discharge Limits for the Augmentation Flow to the Malibu Creek*, summarizing various options to meet these limits. Stantec evaluated two different treatment options and a potable water augmentation option. This Study expands on those three options and includes two additional treatment options for evaluation.

1.2. OBJECTIVES

The purpose of this TM is to evaluate five different options to meet TN and TP limits for the Malibu Creek augmentation flow of up to 2.5 cfs (1.6 MGD). Five different options with corresponding design criteria and cost estimates are discussed in this TM; four of these options include treating the Tapia WRF effluent (primary or secondary) to a higher standard while the fifth option analyzes use of imported potable water from Metropolitan Water District of Southern California (Metropolitan) for augmenting Malibu Creek flows. Evaluation criteria were defined to compare the results and determine the optimal option to meet LVMWD's goal.

2. APPROACH

Figure 1 presents the study approach for evaluation and selection of compliance alternatives for augmenting Malibu Creek flow. The evaluation and selection of process trains was conducted in five major steps. Each of these steps is discussed in detail in the following sections.

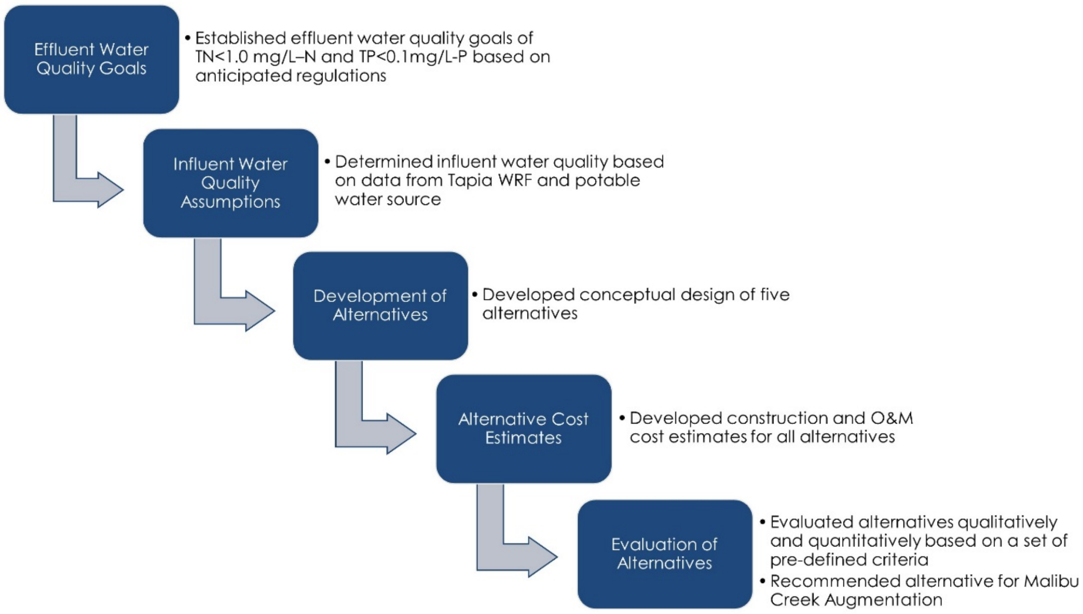


Figure 1 – Study Approach

2.1. EFFLUENT WATER QUALITY AND FLOW GOALS

The proposed TMDLs of 1.0 mg/L TN and 0.1 mg/L TP in the Malibu Creek Watershed were the basis for the development of process treatment train alternatives. The discharge permit requires a minimum of 2.5 cfs constant flow in the creek. If LVMWD has to supplement the entire creek for the entire permit period (April 15th – November 15th), this would result in a maximum volume of 345 MG for augmentation. However, historical records have not indicated that this is a realistic expectation for the near future. For the years 2007-2009, releases were under 10 MG. For the years 2010-2012 no releases were required. Between 2013 and 2017, LVMWD released much greater amounts of augmentation flow to Malibu Creek than in previous years due to drought in Southern California, but still below the total expected maximum. Since 2007, the maximum amount released in a single year to meet endangered species flow requirements was approximately 160 MG, which occurred in 2017. The maximum flow released in a single month during that period was in October 2016 at 42.4 MG. Historical augmentation flows to Malibu Creek are shown in **Table 1**.

Table 1 – Historical Augmentation Flow Released to Malibu Creek

	Augmentation Volume (MG)										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
April 15th-30th	0	0	0	0	0	0	0	0	0	0.84	0
May	0	0	0	0	0	0	2.0	0.0	0.0	0.0	0.0
June	0	0	0	0	0	0	6.3	5.9	3.5	0.0	0.1
July	0	0	0.92	0	0	0	15.4	13.3	11.7	0.0	26.6
August	0	0	0	0	0	0	14.7	16.8	17.2	0.1	37.8
September	0.55	0.58	5.67	0	0	0	23.5	17.7	17.5	18.0	40.5
October	0	0	2.58	0	0	0	15.9	17.0	18.4	42.4	41.7
November 1st-14th	0	0	0	0	0	0	6.2	8.3	8.2	19.2	12.7
Total Flow (MG)	**0.55**	**0.58**	**9.17**	**0**	**0**	**0**	**84.1**	**78.9**	**76.4**	**80.6**	**159.2**
							Average Augmented Volume (MG) 2007-2017				**44.5**

Based on maximum augmentation flows experienced from 2007 to 2017, this analysis assumed approximately 160 MG of water per year released to Malibu Creek for cost estimating purposes.

2.2. INFLUENT WATER QUALITY ASSUMPTIONS

Influent water quality parameters used in the development of treatment alternatives are based on data obtained from Tapia WRF and sampling of the nearby potable water source; these parameters are summarized in **Table 2**. All values are median values obtained from LVMWD provided data, except where noted otherwise. Historical data from Tapia WRF is from 2014 to 2017. Potable water quality is based on water quality from Jensen WTP for Ammonia and Nitrate from 2014 to 2015, and sampling from the distribution system at nearby locations to Tapia WRF for TN and TP from four samples (two taken in Jan and Feb 2016 and two taken in Feb 2018). Additional potable water sampling and analysis is currently taking place to provide more data for TN and TP.

Table 2 – Influent Water Quality for Various Treatment Alternatives

Parameter	Tapia WRF Primary Effluent	Tapia WRF Secondary Effluent	Metropolitan Potable Water
Ammonia (mg/L-N)	32.6	1.4	0.5
Nitrate (mg/L-N)	0	5.4[1]	0.7
Total Nitrogen (mg/L)	43.5[2]	7.8	1.2
Total P (mg/L)	6.8	2.6	<0.1

1. Secondary effluent median nitrate concentration is calculated as 5.4 mg/L-N based on median value of 7.8 mg/L TN, 1.4 mg/L NH_3-N, and an assumed 1.0 mg/L organic nitrogen. Nitrate concentration of 10 mg/L-N was used for modeling of tertiary biological processes for conservatism.

2. Primary effluent TN is estimated based on median ammonia and typical WW fraction of NH_3-N:TKN-N of 0.75:1.0

2.3. DEVELOPMENT OF ALTERNATIVES

Previous planning efforts had identified three alternatives for achieving seasonal compliance. These alternatives were evaluated in greater depth along with two additional alternatives (4 and 5), as follows:

1. Tertiary Membrane Bioreactor (MBR) + Reverse Osmosis (RO)
2. Microfiltration/Ultrafiltration (MF/UF) + RO + Ion Exchange (IX)
3. Breakpoint Chlorination of Potable Water (PW)
4. Secondary MBR + RO
5. Biologically Active Filtration (BAF) + MF/UF + RO

All alternatives were designed to produce treated water flow of 2.5 cfs (1,123 gpm/1.6 MGD) with treated water TN and TP concentrations of less than 1.0 and 0.1 mg/L, respectively. Each alternative is described in detail in **Section 3**.

2.4. ALTERNATIVE COST ESTIMATES

The initial step for determining the cost estimates for the various alternatives was the compilation of construction and O&M costs for each unit process. The cost estimates developed during this study are Class 5 estimates and have a confidence level of -50% to +100%. Cost estimates for each alternative are summarized in **Section 4**.

Construction costs were developed for each process alternative by accounting for the following items:

- Construction Costs
  - Site work
  - Canopy
  - Concrete
  - Pipeline
  - Process Equipment
- Electrical and I&C
- Mechanical Installation
- Overhead Costs
- Contingencies
- Engineering/Legal/Admin Fees

The principal components for the O&M costs were as follows:

- Equipment Power Consumption
- Chemicals including
  - membrane cleaning chemicals for MBR, MF/UF and RO,
  - acid and antiscalant for RO,
  - carbon source for biological processes
    (note that carbon addition required for denitrification was assumed to be the same for alternatives that use secondary or tertiary biological processes since theoretically overall carbon consumption i.e. wastewater carbon plus supplemental carbon, should be same to achieve the same RO feed water nitrate concentration for these alternatives)
  - sodium hypochlorite and sodium bisulfite for breakpoint chlorination
- Consumables including
  - replacement of membranes,
  - imported potable water for breakpoint chlorination, and
  - Salt cost for IX resin regeneration
- Maintenance – 1% of the total construction cost and adjusted for operation of 6 months per year.
- Water – since potable water is already purchased to supplement the recycled water system during summer months, there is no net change in potable water purchases, and no cost is assumed, for any of the alternatives.
- Secondary Treatment Cost Savings – Secondary MBR would provide similar secondary treatment to what Tapia WRF already produces and would not be an additional cost to current operations. Therefore, the secondary treatment cost was removed from the O&M costs of Alternative 4 so that all costs were compared for tertiary treatment and beyond.

For simplicity, all alternatives are assumed to be constructed at Tapia WRF and operated by existing Tapia WRF staff without the need for additional labor.

2.5. EVALUATION OF ALTERNATIVES

After conceptual design and cost development, each process alternative was comparatively assessed using a set of evaluation criteria including:

- Ease of Seasonal Operations
- Performable Reliability for Permit Compliance
- Operational Complexity/Familiarity
- Construction Cost
- Operations and Maintenance Cost
- Environmental and Community Impacts

Each alternative was assessed against established criterion and given a numeric score, allowing for a relative comparison of the trains. The alternatives were then ranked based upon the combined scores for each alternative. The highest ranking alternative represents the recommended approach for implementation and CEQA analysis.

3. DESCRIPTION OF ALTERNATIVES

This section describes the five process trains that were developed to meet the TN and TP goals for discharge to Malibu Creek. The flows and effluent quality used to design each process are summarized in **Table 3**.

Table 3 – Water Quality Projections for Unit Processes

	Alternative	Effluent (mg/L)	Secondary MBR	Tertiary MBR	BAF	MF/UF	RO	IX (blended effluent)	Breakpoint Chlorination
1	Tertiary MBR + RO	TN	--	<4.5	--	--	<1	--	--
		TP	--	2.2	--	--	<0.1	--	--
2	MF + RO + IX	TN	--	--	--	10.5	<4	<1	--
		TP	--	--	--	3.6	<0.1	<0.1	--
3	Breakpoint Chlorination	TN	--	--	--	--	--	--	<1
		TP	--	--	--	--	--	--	<0.1
4	Sec MBR + RO	TN	<4.5	--	--		<1	--	--
		TP	2.2	--	--		<0.1	--	--
5	BAF + MF + RO	TN	--	--	<4.5	<4.5	<1	--	--
		TP	--	--	2.2	2.2	<0.1	--	--

3.1. ALTERNATIVE 1 – TERTIARY MBR + RO

Alternative 1 uses tertiary MBR and RO processes to meet effluent water quality goals. Considering that the RO process will only achieve 80% removal of nitrogen species conservatively, a biological process upstream of the RO system will be necessary to achieve the TN limit of 1.0 mg/L. A two-stage tertiary MBR process consisting of pre-anoxic and aerobic/membrane basins, followed by RO, can be utilized to achieve the required TN and TP limits.

Figure 2 below shows the process schematic of the treatment train for Alternative 1. Since Tapia produces nitrified effluent, the secondary effluent will be fed to a pre-anoxic zone for denitrification. Due to absence of a biodegradable carbon in the secondary effluent, methanol (or an alternative carbon source) will be added to the pre-anoxic zone at a rate of 75 gpd to achieve effluent nitrate concentrations of <0.5 mg/L-N. A total of eight membrane cassettes will be required to treat a target influent flow-rate of 3.00 cfs (1.9 MGD), which will be required to achieve a product (RO permeate) flow-rate of 2.50 cfs (1.6 MGD).

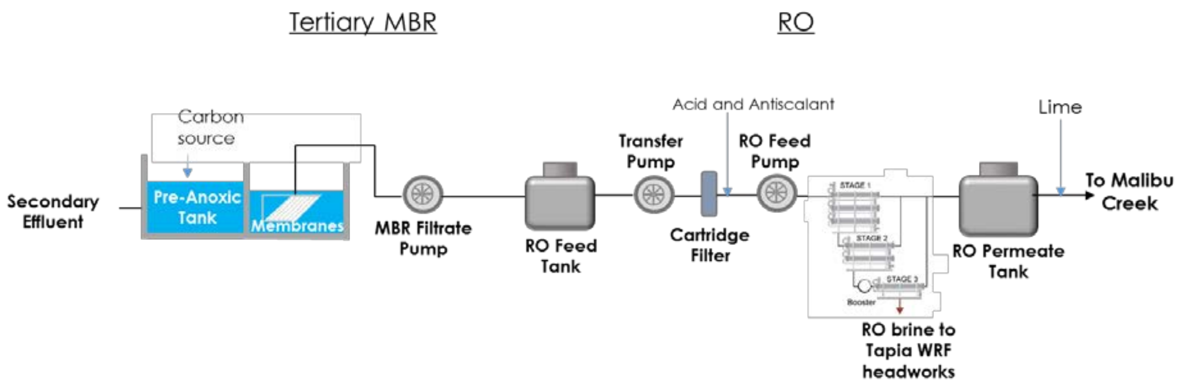


Figure 2 – Process Schematic for Alternative 1

The MBR effluent will be fed to the RO system which will achieve a high degree of phosphorus removal (<0.1 mg/L-P) and lower the effluent TN concentration to <1 mg/L. Sulfuric acid and antiscalant will be added to the RO feed to minimize calcium phosphate ($CaPO_4$) and calcium carbonate ($CaCO_3$) scaling. The RO system will be designed as a 3-stage system with a total recovery of 85%. Key process design parameters for Alternative 1 are found in **Appendix A**. It is estimated that a footprint of 7,000-8,000 ft^2 will be required for Alternative 1.

3.2. ALTERNATIVE 2 – MF/UF + RO +IX

Alternative 2 consists of MF/UF, RO and IX. The absence of a biological process in this train provides an advantage of relatively quicker start-ups and shutdowns compared to Alternative 1. Rapid startup/shutdown is particularly beneficial to seasonally operated systems. The MF/UF system will provide required pretreatment for the RO system with respect to particulate removal. The RO system will provide approximately 80% removal of nitrogen species and almost complete removal of phosphate (<0.1 mg/L). The residual nitrate in the RO permeate (<1.6 mg/L-N) will be removed by an IX process downstream of the RO, thereby achieving the final effluent TN and TP goals of 1.0 and 0.1 mg/L, respectively. Only 50% of the RO permeate will be treated using ion-exchange (560 gpm) and blended with the remaining stream to meet the TN and TP goals of 1.0 mg/L and 0.1 mg/L respectively. **Figure 3** shows the process schematic of the treatment train. Key process design parameters for Alternative 2 are shown in **Appendix A**. It is estimated that the Alternative 2 will require approximately 6,000-7,000 ft^2 of space.

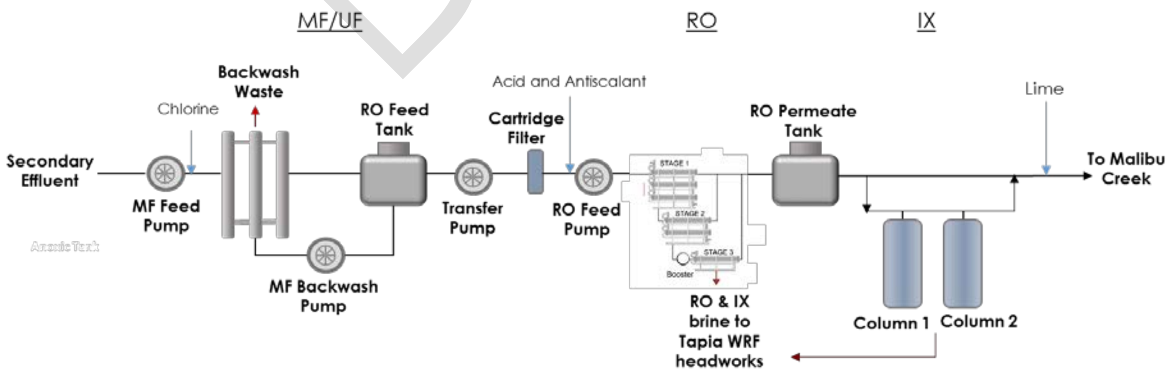


Figure 3 – Process Schematic for Alternative 2

3.3. ALTERNATIVE 3 – BREAKPOINT CHLORINATION OF POTABLE WATER

Alternative 3 provides augmentation flow for Malibu Creek using potable water (**Figure 4**) from the LVMWD distribution system, which originates at Metropolitan Water District's Jensen Water Treatment Plant. Recent sampling of the source water showed that the total phosphorus concentration in the water is already less than <0.1 mg/L but there is small amount of ammonia and nitrate/nitrite causing the TN to occasionally exceed 1 mg/L. Removal of ammonia will be necessary to consistently meet the TN goal and therefore, breakpoint chlorination for ammonia nitrogen removal will be required. For a maximum flow of 2.5 cfs and an estimated hydraulic retention time (HRT) of 20 minutes, a 37,500 gallon chlorine contact tank would be required. The estimated length of pipe required to convey potable water to the tank and then from the tank to the creek is approximately 1,000 ft. If this alternative is selected, bench scale testing should be performed to develop the site-specific breakpoint chlorination curve and determine a more accurate HRT (may range from 5-30 minutes) to optimize the contact tank sizing and dosage requirements. This option requires the addition of sodium hypochlorite for chlorination and sodium bisulfite for dechlorination before the water is discharged into Malibu Creek.

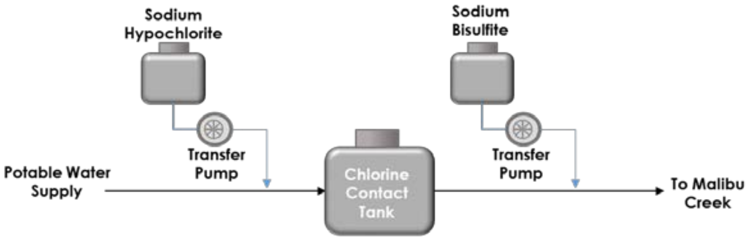


Figure 4 – Process Schematic for Alternative 3

A review of historical records of Metropolitan's Jensen Water Treatment Plant treated water quality for the period 2014-2015 shows a median nitrate concentration of 0.7 mg/L-N and average ammonia concentration of 0.5 mg/L-N. Based on these concentrations, breakpoint chlorination to remove the ammonia would be necessary to bring the potable water into compliance with the TN limit of <1.0 mg/L. However, recent water quality sampling results conducted by LVMWD have shown nitrate at 0.4 mg/L-N and ammonia at 0.4 mg/L-N in the potable supply. This indicates that breakpoint chlorination may not always be required, however the addition of sodium bisulfite for dechlorination must still be practiced. The sampled TP results have been consistently below 0.1 mg/L, as shown in **Table 4**, and therefore it is assumed that no additional treatment process is required for TP removal.

Table 4 – TP Results from Sampling of Potable Water Supply

Sample Date	TP Concentration (mg/L)
2/5/2018	0.067
2/12/2018	0.046
2/26/2018	0.040

3.4. ALTERNATIVE 4 – SECONDARY MBR + RO

Alternative 4 utilizes secondary MBR followed by an RO process. The secondary MBR would be fed primary effluent from Tapia WRF and consist of four-stages (pre-anoxic, aerobic, post-anoxic and membrane basins) to provide nitrification and denitrification. This alternative would add 1.6 MGD of treatment capacity at Tapia WRF. Although, the secondary MBR uses existing carbon in the wastewater, methanol addition to the post-anoxic zone would be required at approximately 75 gpd to achieve effluent nitrate of <4.5 mg/L-N. The MBR effluent will be fed to the RO system which will achieve almost complete phosphorus removal (<0.1 mg/L-P) and lower the effluent TN concentration to <1 mg/L. The RO system will be designed similarly to the RO system for Alternative 1. **Figure 5** depicts the process schematic of the treatment train for Alternative 4 and the key design parameters for the unit processes are shown in **Appendix A**. It is estimated that a footprint of 16,000-17,000 ft^2 will be required for Alternative 4.

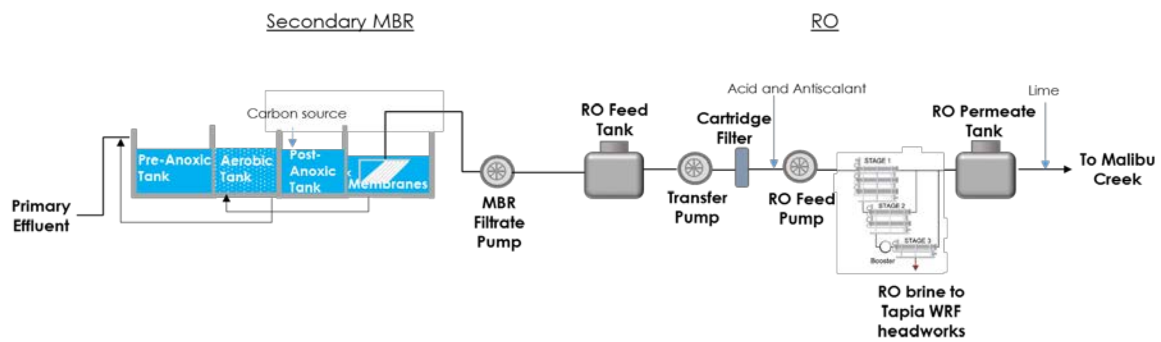


Figure 5 – Process Schematic for Alternative 4

3.5. ALTERNATIVE 5 – TERTIARY BAF + MF + RO

The last alternative consists of tertiary biologically active filtration (BAF) followed by MF/UF and RO. BAF uses reactors filled with tightly packed plastic attached-growth media which serve two functions: (1) provide a surface for microbial growth, and (2) filtration. The process will achieve denitrification to the same level as tertiary MBR and will require methanol addition at a rate of 75 gpd to achieve effluent TN of <4.5 mg/L. This is a relatively simple process compared to MBR but the effluent turbidity is not as low and consistent as with MBR. As a result, the MF/UF is required to reduce the turbidity in the BAF effluent and thereby protect the downstream RO process. The BAF process will be designed for denitrification and the RO will achieve almost complete phosphorus removal (<0.1 mg/L-P) and lower the effluent TN concentration to <1 mg/L. **Figure 6** shows the process schematic of the treatment train and the key process design parameters are shown in **Appendix A**.

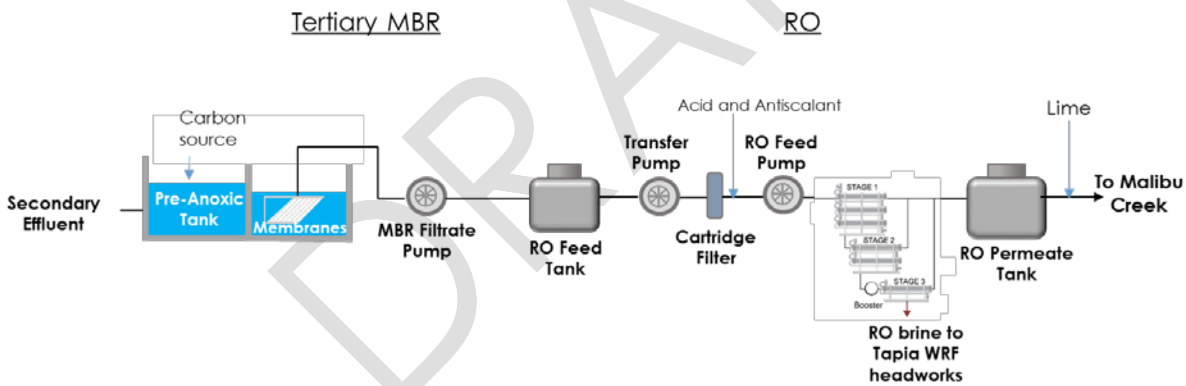


Figure 6 – Process Schematic for Alternative 5

4. EVALUATION OF ALTERNATIVES

The main objective of this study was to identify the preferred alternative to meet TN and TP limits for the Malibu Creek augmentation flow. The selection of a preferred alternative involves evaluating each of the five process train alternatives against a pre-defined set of evaluation criteria. The alternatives were assessed and scored against each criterion, allowing for a relative comparison of alternatives.

This section presents a description for each criterion highlighting the particular considerations in applying the criteria and scores. Each alternative was scored based on qualitative and quantitative analysis within the evaluation criteria using the point system of 1 to 5, with 1 being the least favorable and 5 being the most favorable. A final summary of the scores in presented in Section 5.

4.1. CRITERION 1 – EASE OF SEASONAL OPERATION

While all of the alternatives are able to operate seasonally, some processes within a process train require additional start-up time. For example, biological processes require additional startup time for acclimation before compliant, treated water can be discharged to Malibu Creek. During this start-up period, effluent would have to be sent back to the head of Tapia WRP until the desired effluent quality is achieved. The other processes (MF, RO, IX, breakpoint chlorination) do not require this acclimation period. However, the MF/UF and RO processes require that cleaning and preservation procedures are followed to maintain the process equipment performance, which adds some operational effort and complexity when operating seasonally.

Table 5 presents the scores given to each option based on ease of seasonal operation. The higher the number, the greater flexibility and ease of starting up the treatment processes.

Table 5 – Scores for Criterion 1: Ease of Seasonal Operation

Tertiary MBR + RO	MF/UF + RO + IX	Breakpoint Chlorination of Potable Water	Secondary MBR + RO	Tertiary BAF + MF + RO
1	4	5	1	1

4.2. CRITERION 2 – PERFORMANCE RELIABILITY FOR PERMIT COMPLIANCE

All alternatives are designed to produce compliant effluent to Malibu Creek. However, the biological processes perform best with a consistent influent wastewater flow and characteristics. High variability in influent characteristics and/or presence of toxicity in influent wastewater may affect treatment performance. In contrast, physiochemical processes such as MF and RO can provide fairly consistent level of treatment. However, poor quality feed may result in membranes becoming fouled or damaged affecting treatment effectiveness. Since breakpoint chlorination is the simplest process, it is expected to have the best performance reliability.

Table 6 presents the scores given to each option based on performance reliability. The higher the number, the greater reliability for permit compliance.

Table 6 – Scores for Criterion 2: Performance Reliability for Permit Compliance

Tertiary MBR + RO	MF/UF + RO + IX	Breakpoint Chlorination of Potable Water	Secondary MBR + RO	Tertiary BAF + MF + RO
2	3	4	2	2

4.3. CRITERION 3 – OPERATIONAL COMPLEXITY/FAMILIARITY

The alternative treatment process trains have varying degrees of operational complexity. The combination of biological and membrane processes in MBR adds operational and maintenance complexity over a traditional wastewater treatment process. Physicochemical processes such as MF/UF, RO and IX are not as complicated to operate but would still require additional operator training. Both the biological and physicochemical processes require additional chemicals for cleaning and the biological processes may require carbon addition to meet the effluent requirements. Breakpoint chlorination would be the simplest process to operate, since it operates on a dosage setpoint and requires minimal operator attention compared to the other alternatives. Also, the operations staff at Tapia WRF is familiar with the chlorination/dechlorination process. At present, the operations staff at Tapia WRF is not familiar with the MF and RO processes. It is anticipated they will become so in the future when the Pure Water pilot begins operations. IX is not a process currently used at LVMWD.

Table 7 presents the scores given to each option with higher numbers indicating less operational complexity and/or more operational familiarity.

Table 7 – Scores for Criterion 3: Operational Complexity/Familiarity

Tertiary MBR + RO	MF/UF + RO + IX	Breakpoint Chlorination of Potable Water	Secondary MBR + RO	Tertiary BAF + MF + RO
3	4	5	2	3

4.4. CRITERION 4 – CONSTRUCTION COST

Construction costs were developed based on previous projects for similar facilities in Southern California and the estimated footprints for each process. The construction costs for each alternative are shown in **Table 8**.

Table 8 – Construction Costs of Alternatives

	Tertiary MBR + RO	MF + RO + IX	Breakpoint Chlorination	Sec MBR + RO	BAF + MF + RO
Sitework ($40/sf)	$300,000	$300,000	$50,000	$600,000	$300,000
Canopy ($60/sf)	$190,000	$180,000	$25,000	$360,000	$190,000
Concrete ($45/sf)	$330,000	$300,000	$28,000	$730,000	$340,000
Conveyance Pipeline ($20/diam.-in)	$600,000	$600,000	$300,000	$480,000	$600,000
Process Equipment	$3,000,000	$2,400,000	$130,000	$3,500,000	$3,900,000
Base Subtotal	**$4,400,000**	**$3,800,000**	**$510,000**	**$5,700,000**	**$5,300,000**
Electrical and I&C (20% of Base Subtotal)	$880,000	$760,000	$100,000	$1,140,000	$1,060,000
Mechanical Installation (10% of Base Subtotal)	$440,000	$380,000	$50,000	$570,000	$530,000
Overhead/Profit (15% of Base Subtotal)	$660,000	$570,000	$80,000	$860,000	$800,000
Contingency (20% of Base Subtotal)	$880,000	$760,000	$100,000	$1,140,000	$1,060,000
Construction Cost Subtotal	**$7,300,000**	**$6,300,000**	**$800,000**	**$9,400,000**	**$8,800,000**
Design, Engineering and Administration Fees (20% of Construction Cost Subtotal)	$1,500,000	$1,300,000	$200,000	$1,900,000	$1,800,000
CONSTRUCTION COST	**$8,800,000**	**$7,600,000**	**$1,000,000**	**$11,300,000**	**$10,600,000**

A summary of the associated scores for each alternative are provided in **Table 9**. The higher the number, the **lower** the construction cost.

Table 9 – Scores for Criterion 4: Construction Cost

Tertiary MBR + RO	MF/UF + RO + IX	Breakpoint Chlorination of Potable Water	Secondary MBR + RO	Tertiary BAF + MF + RO
2	2	5	1	1

4.5. CRITERION 5 – OPERATION AND MAINTENANCE COST

This criterion evaluated the alternatives based on their operation and maintenance (O&M) costs are shown in **Table 10**.

Table 10 – O&M Costs of Alternatives

	Tertiary MBR + RO	MF + RO + IX	Breakpoint Chlorination	Sec MBR + RO	BAF + MF + RO
Power	$74,000	$62,000	$600	$101,000	$77,000
Chemicals	$46,000	$46,000	$3,600	$46,000	$58,000
Consumables	$21,000	$22,000	$0	$23,000	$19,000
Maintenance	$24,000	$20,000	$3,000	$31,000	$29,000
Secondary Treatment Savings				-$36,000	
Total O&M Costs	**$170,000**	**$150,000**	**$7,200**	**$170,000**	**$180,000**

O&M costs are based on an assumed annual treated augmentation volume of 160 MG. A summary of the alternative scores based on O&M costs are provided in **Table 11**. The higher the number, the **lower** the O&M cost.

Table 11 – Scores for Criterion 5: Operation and Maintenance Cost

Tertiary MBR + RO	MF/UF + RO + IX	Breakpoint Chlorination of Potable Water	Secondary MBR + RO	Tertiary BAF + MF + RO
2	2	5	2	1

4.6. CRITERION 6 – ENVIRONMENTAL AND COMMUNITY IMPACTS

This criterion evaluated the alternatives based on their carbon emissions and impact on TDS concentration in the Tapia final effluent and recycled water system. Carbon emissions were calculated for each alternative as follows:

- Power consumption (MWh) for process equipment was determined for each train.
- A line loss factor of 1.057 was applied to the equipment power consumption.
- The line loss corrected power consumption was used to calculate equipment carbon dioxide emissions based on an equivalency factor of 0.23 MT CO2e/MWh obtained from SoCal Edison from their annual report for Year 2015.
- Process related carbon emissions from biological processes were obtained from the BioWin model.
- The sum of equipment emissions and process emissions was used to calculate the total emissions.
- A vehicle equivalent of 4.67 MT CO2e emission per vehicle per year was used to obtain a relative number of vehicle emission equivalent per year for each process train.

The RO process concentrates TDS in the brine sidestream. The sidestream is sent back to the Tapia WRF influent for retreatment. Since the conventional treatment processes at Tapia WRF do not remove TDS, the effluent concentration discharged from the WRF is expected to increase due to this brine recycling. The breakpoint chlorination alternative will also result in a slight increase in recycled water TDS, as lower TDS water would go to the Creek instead of slightly diluting the recycled water when used as a supplement.

The results of this evaluation are shown in **Table 12**, which also includes each alternatives score. The higher the number, the **lower** the impacts to the environment and surrounding community.

Table 12 – Scores for Criterion 6: Environmental and Community Impacts

	Tertiary MBR + RO	MF/UF + RO + IX	Breakpoint Chlorination of Potable Water	Secondary MBR + RO	Tertiary BAF + MF + RO
Vehicle Emission Equivalent	27	22	0.2	27	28
Tapia WRF Effluent TDS Concentration Increase from Existing	up to 33%[1]	up to 33%[1]	up to 11%[2]	up to 33%[1]	up to 33%[1]
Score	1	2	4	1	1

1. TDS increase from RO brine is based on 2.5 cfs (1.6 MGD) product flow from RO, and for Tapia WRF: 6.5 MGD average plant flow, 825 mg/L avg TDS

2. TDS increase from lack of potable water dilution is based on: 2.5 cfs (1.6 MGD) potable water dilution, average potable TDS of 375 mg/L, and for Tapia WRF: 6.5 MGD plant flow, 825 mg/L avg TDS

5. RECOMMENDATIONS

Five potential process trains were identified and designed to meet the TN and TP limits for discharge into Malibu Creek. The five trains were evaluated and scored against a set of criteria, which has been summarized in **Table 13.**

Table 13 – Summary of Scores for Alternatives

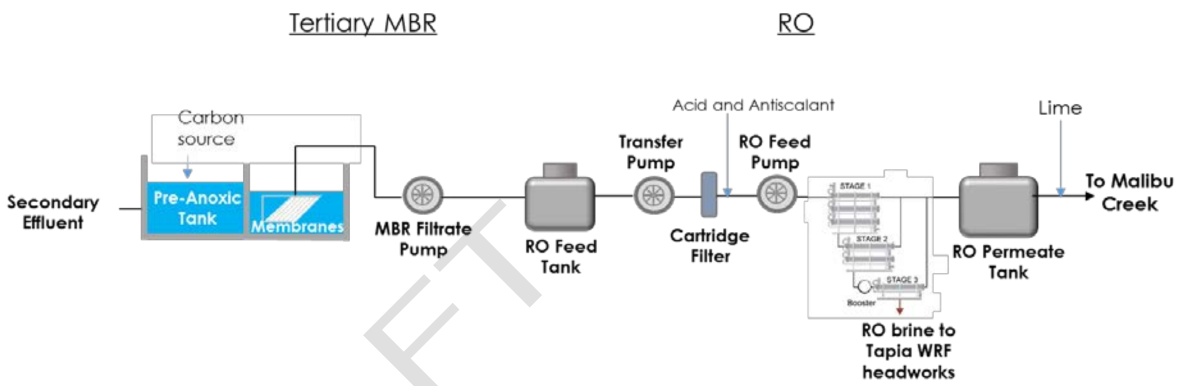
	Tertiary MBR + RO
1. Ease of Seasonal Operation	1
2. Performance Reliability for Permit Compliance	2
3. Operational Complexity/Familiarity	3
4. Construction Cost	2
5. O&M Cost	2
6. Environmental and Community Impacts	1
TOTAL SCORE	**11**

Based on this evaluation, it is recommended that the “Breakpoint Chlorination of Potable Water” be implemented as it provides the greatest operational and water quality reliability, ease of operation, and is most cost-effective.

APPENDIX A – ALTERNATIVE INFORMATION PLATES

Alternative 1 – Tertiary Membrane Bioreactor + Reverse Osmosis

DESIGN CRITERIA		
MEMBRANE BIOREACTOR		
Bioreactor		
Feed Flow-rate	1,348	gpm
Feed Nitrate Concentration	10	mg/L-N
Methanol Feed Rate	75	gpd
Design SRT	10	days
HRT		
Pre-anoxic	1.2	hours
Aerobic/Membrane	0.8	hours
Total Volume	2.0	hours
Total Volume	100,000	gallons
Membrane Tank MLSS	3,600	mg/L
Membrane Filtration		
Membrane Gross Flux	14	gfd
Membrane Filtrate Recovery	90	%
Membrane Cassettes Required	8	
Number of Trains	2	
REVERSE OSMOSIS		
Feed Flow-rate	1,321	gpm
Stage 1		
Flux	11.2	gfd
Number of Elements	193	
Stage 2		
Flux	10.5	gfd
Number of Elements	97	
Stage 3		
Flux	8.5	gfd
Number of Elements	58	
Overall Recovery	85	%
Number of Trains	3	

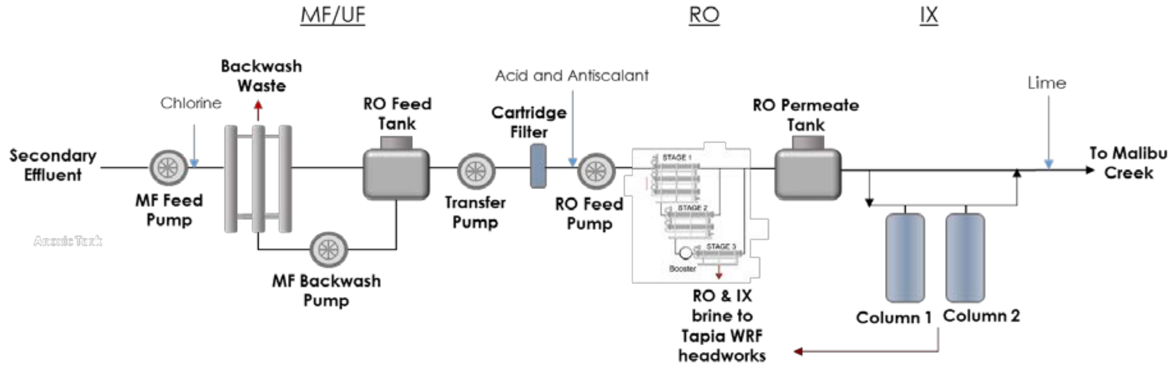


Project Information	
Construction Cost	**$8,800,000**
O&M Cost	**$170,000**
Carbon Emissions (Vehicle Equivalent per year)	**27**
Impact on TDS (% Increase from Existing Effluent)	**33%**
Required Footprint (ft²)	**7,000 – 8,000**

Evaluation Criteria	Score
1. Ease Of Seasonal Operation	1
2. Performance Reliability For Permit Compliance	2
3. Operational Complexity/Familiarity	3
4. Construction Cost	2
5. Operation Cost	2
6. Environmental And Community Impacts	1
TOTAL	**11**

Alternative 2 – Micro/Ultrafiltration + Reverse Osmosis + Ion Exchange

DESIGN CRITERIA		
Microfiltration		
Feed Flow-rate	1,390	gpm
Membrane Gross Flux	42	gfd
Membrane Filtrate Recovery	95	%
Membrane Area per Module	775	ft^2
Membrane Modules Required	62	
Number of Trains	3	
Reverse Osmosis		
Feed Flow-rate	1,321	gpm
Stage 1		
Flux	11.2	gfd
Number of Elements	193	
Stage 2		
Flux	10.5	gfd
Number of Elements	97	
Stage 3		
Flux	8.5	gfd
Number of Elements	58	
Overall Recovery	85%	%
Number of Trains	3	
Ion-exchange		
Feed Flow-rate	864	gpm
Feed Nitate Concentration	1.6	mg/L-N
Number of Trains	3	
Lead Vessel	1	
Lag Vessel	1	
Vessel Diameter	10	ft
Resin Depth	4	ft
Resin Volume Per Vessel	314	ft^3
Total EBCT	16	min
Loading Rate	4	gpm/ft^2
Volumteric Flow	0.9	gpm/ft^3

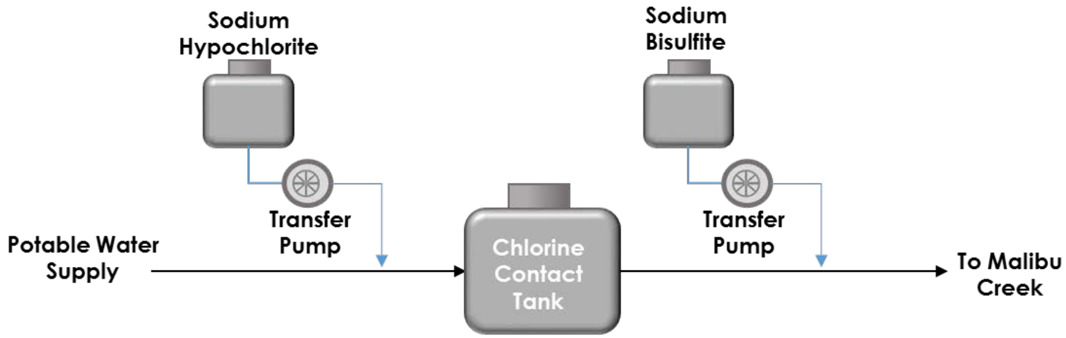


Project Information	
Construction Cost	**$7,600,000**
O&M Cost	**$150,000**
Carbon Emissions (Vehicle Equivalent per year)	**22**
Impact on TDS (% Increase from Existing Effluent)	**33%**
Required Footprint (ft^2)	**6,000 – 7,000**

Evaluation Criteria	Score
1. Ease Of Seasonal Operation	4
2. Performance Reliability For Permit Compliance	3
3. Operational Complexity/Familiarity	4
4. Construction Cost	2
5. Operation Cost	2
6. Environmental And Community Impacts	2
TOTAL	17

Alternative 3 – Breakpoint Chlorination of Potable Water

DESIGN CRITERIA		
Breakpoint Chlorination		
Feed Flow-rate	1,123	gpm
Feed Ammonia Concentration	0.4	mg/L-N
Chlorine dose, range	1 to 4	mg/L as Cl_2
HRT Required	20	min
Contact Tank Efficiency	0.6	
Contact Tank Volume Required	37,400	gal

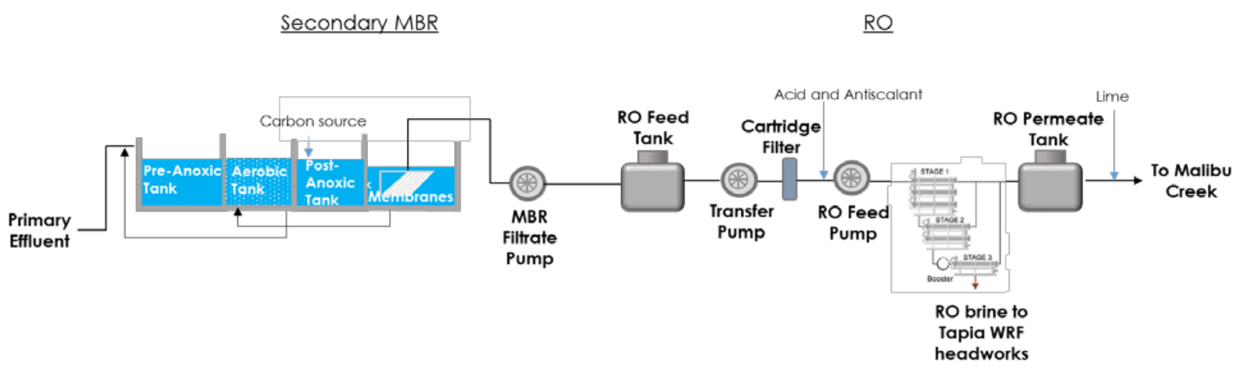


Project Information	
Construction Cost	**$1,000,000**
O&M Cost	**$7,200**
Carbon Emissions (Vehicle Equivalent per year)	**0.2**
Impact on TDS (% Increase from Existing Effluent)	**11%**
Required Footprint (ft^2)	**600 - 700**

Evaluation Criteria	Score
1. Ease Of Seasonal Operation	5
2. Performance Reliability For Permit Compliance	4
3. Operational Complexity/Familiarity	5
4. Construction Cost	5
5. Operation Cost	5
6. Environmental And Community Impacts	4
TOTAL	**28**

Alternative 4 – Secondary Membrane Bioreactor + Reverse Osmosis

DESIGN CRITERIA		
Bioreactor		
Feed Flow-rate	1,348	gpm
Feed Ammonia Concentration	34	mg/L-N
Methanol Feed Rate	75	gpd
Design SRT	12	days
HRT		
Pre-anoxic	2.1	hours
Aerobic	3.4	hours
Post-anoxic	1.0	hours
Membrane	0.4	hours
Total Volume	7	hours
Total Volume	441,000	gallons
Membrane Tank MLSS	6,600	mg/L
Membrane Filtration		
Membrane Gross Flux	14	gfd
Membrane Filtrate Recovery	90	%
Membrane Cassettes Required	8	
Number of MBR Trains	2	
Reverse Osmosis		
Feed Flow-rate	1,321	gpm
Stage 1		
Flux	11.2	gfd
Number of Elements	193	
Stage 2		
Flux	10.5	gfd
Number of Elements	97	
Stage 3		
Flux	8.5	gfd
Number of Elements	58	
Overall Recovery	85%	
Number of Trains	3	

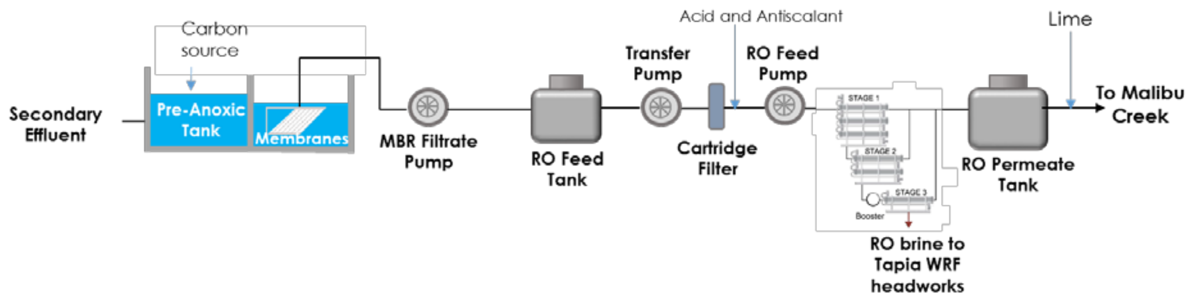


Project Information	
Construction Cost	**$11,300,000**
O&M Cost	**$170,000**
Carbon Emissions (Vehicle Equivalent per year)	**27**
Impact on TDS (% Increase from Existing Effluent)	**33%**
Required Footprint (ft^2)	**16,000 – 17,000**

Evaluation Criteria	Score
1. Ease Of Seasonal Operation	1
2. Performance Reliability For Permit Compliance	2
3. Operational Complexity/Familiarity	2
4. Construction Cost	1
5. Operation Cost	2
6. Environmental And Community Impacts	1
TOTAL	9

Alternative 5 – Tertiary Biologically Active Filtration + Micro/Ultrafiltration +Reverse Osmosis

DESIGN CRITERIA		
Biologically Active Filtration		
Bioreactor		
Feed Flow-rate	1,467	gpm
Feed Nitrate Concentration	10	mg/L-N
Methanol Feed Rate	75	gpd
Filtration Rate	1.5	gpm/ft^2
Loading Rate	1.41	kg NO_3-N/m^3/d
Recovery	95	%
Number of BAF Trains	2	
Microfiltration		
Feed Flow-rate	1,390	gpm
Membrane Gross Flux	42	gfd
Membrane Filtrate Recovery	1	%
Membrane Area per Module	775	ft^2
Membrane Modules Required	62	
Number of Trains	3	
Reverse Osmosis		
Feed Flow-rate	1,321	gpm
Stage 1		
Flux	11.2	gfd
Number of Elements	193	
Stage 2		
Flux	10.5	gfd
Number of Elements	97	
Stage 3		
Flux	8.5	gfd
Number of Elements	58	
Overall Recovery	85	%
Number of Trains	3	



Project Information	
Construction Cost	**$10,600,000**
O&M Cost	**$180,000**
Carbon Emissions (Vehicle Equivalent per year)	**28**
Impact on TDS (% Increase from Existing Effluent)	**33%**
Required Footprint (ft^2)	**7,000 – 8,000**

Evaluation Criteria	Score
1. Ease Of Seasonal Operation	1
2. Performance Reliability For Permit Compliance	2
3. Operational Complexity/Familiarity	3
4. Construction Cost	1
5. Operation Cost	1
6. Environmental And Community Impacts	1
TOTAL	9