ORANGE COUNTY GOVERNMENT FLORIDA

FINAL

Southwest Water Reclamation Facility Conceptual Design and Facility Plan Update

November 2011

PARSONS BRINCKERHOFF

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ORANGE COUNTY UTILITIES
SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

FINAL REPORT
November 2011

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ORANGE COUNTY UTILITIES

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

FINAL REPORT

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

Under Task Authorization (TA) 16 of Contract Y9-901, the Carollo team was retained by Orange County Utilities (OCU) to prepare a conceptual design for the proposed Southwest Water Reclamation Facility (SWWRF), including a review and update of the previous Capital Improvements and Facilities Plan (CDM/PBSJ 2007) prepared for the SWWRF.

The 2002 Water, Wastewater, and Reclaimed Water Master Plan (PBSJ/CH2M Hill) recommended construction of a new SWWRF serving the Southwest Service Area (SWSA) with an initial treatment capacity of 4.4 mgd, on an annual average day flow (AADF) basis. Later, the 2007 Facilities Plan (PBSJ/CDM) recommended construction of the SWWRF in three phases of 5 mgd each with a build-out capacity of 15 mgd. The 2007 Facilities Plan recommended construction of the first two phases simultaneously by the year 2015 with a total capacity of 10 mgd AADF and assumed a 5 mgd diversion of flow from the South Service Area (SSA) to the proposed SWWRF.

The SWSA is comprised primarily of the Horizon West development. Wastewater collected from the SWSA is currently treated at OCU's South Water Reclamation Facility (SWRF) and at the Reedy Creek Improvement District (RCID) wastewater plant (through an interagency agreement).

ES.2 STUDY OBJECTIVES

This work effort is intended to achieve the following three key goals for OCU.

1. Re-evaluate the technology selected for the biological process, in particular the MBR process recommended in the 2007 Facilities Plan.

2. Prepare conceptual design updates for the recommended facilities with revised opinions of probable cost.

3. Using current planning completed by others, update near-term and long-term planning for the SWWRF, including updating proposed project implementation schedules.

ES.3 REPORT ORGANIZATION

This report consists of an Executive Summary plus several technical memoranda as follows:

Executive Summary. Provides background of the previous study efforts, objectives for conducting this phase of the project, an overview of the tasks completed, and describes how the overall report is organized. Summarizes the initial basis of design criteria, the overall proposed liquids treatment strategy, and the “baseline” site layout. Provides planning level costs for capital, operations and maintenance (O&M), and net present worth costs.

Technical Memoranda (TM). A series of technical memoranda that provide supplemental data and further detail on information presented in the Executive Summary.

- **TM 1 - SWWRF Basis of Design Criteria**. This TM summarizes the plant influent characteristics including flow factors and pollutant loadings. The basis of design criteria was used to perform conceptual sizing of the treatment alternatives to be evaluated as part of the SWWRF Conceptual Design and Facilities Update.
- **TM 2 - Identification of Alternative Treatment Technologies.** This TM identifies a list of various BNR process configurations that could be implemented at the proposed SWWRF to satisfy the OCU determined treatment goals, and to meet current water quality requirements for land application and public access reuse (PAR). Further these process configurations were ranked using a set of non-economic parameters to identify the top five that have the highest potential to be implemented at the proposed SWWRF. The list of the top five process alternatives included the MBR process recommended by the 2007 Facilities Plan.
- **TM 3 - Wastewater Load Projections**. This TM updates the wastewater flow projections for the SWSA and estimates pollutant loads for the initial phase (Phase I) of SWWRF, using the latest population and wastewater flow projections for OCU.
- **TM 4 – Reclaimed Water Utilization.** This TM identifies potential water reuse alternatives for the SWWRF as they relate to reclaimed water quality for both the initial phase design and planning for future phases, depending on the type of water reuse practiced.
- **TM 5 – Not Used.**
- **TM 6 – Phase 1 SWWRF Process Alternatives Evaluation.** This TM summarizes the detailed evaluation of the top five treatment process configurations short-listed as part of TM 2, including the MBR alternative, to recommend the most efficient process for implementation.
- **TM 7 – Add-on Treatment Technologies for Future Phases**. This TM screens the feasibility of various add-on processes that can potentially be used at SWWRF for the future phases. The add-on processes will treat the advanced wastewater treatment (AWT) effluent from the initial phase to meet potentially more stringent water quality requirements if OCU finds it necessary to implement additional reclaimed water management options to supplement the PAR and RIBs.

ES.4 PHASE 1 BASIS OF DESIGN CRITERIA

ES.4.1 Phase I Influent Wastewater Characteristics

Phase I of the SWWRF will be designed to treat a flow of 5 mgd, on an annual average day flow (AADF) basis. TM No. 1 – SWWRF Basis of Design Criteria provided the basis for selection of the influent wastewater characteristics used to compare the treatment processes. Anticipated influent wastewater flows for Phase I are presented in Table ES.1

**Table ES.1 SWWRF Phase I Influent Wastewater Flow Characteristics
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities**

Design Parameter	Unit	Value
Annual average influent flow (AADF)(1)	mgd	5.0
Maximum month flow (MMF) peaking factor		1.3
Maximum day flow (MDF) peaking factor		1.7
Peak hour flow (PHF) peaking factor		3.0
Minimum day flow (MnDF) peaking factor		0.3(2)
Maximum month influent flow (MMF)(3)	mgd	6.5
Maximum day influent flow (MDF)(4)	mgd	8.5
Peak hour influent flow (PHF)(5)	mgd	15.0
Minimum day influent flow (MnDF)	mgd	1.5
First year average day flow	mgd	2.0

Notes:
(1) AADF is the flow rate occurring over a 24-hour period based on the annual average flow.
(2) Assumed based on data available from OCU's South Water Reclamation Facility (SWRF).
(3) MMF is the average flow rate occurring over a 24-hour period based on the average flow during the calendar month with the highest average influent flow.
(4) MDF is the maximum flow rate sustained over a 24-hour period during a calendar year.
(5) PHF is maximum flow rate sustained over a 1-hour period during a calendar year.

The influent wastewater pollutant concentrations and mass loadings that were used to size the treatment processes are provided in Table ES.2. The maximum month pollutant mass loadings were used to size the biological process reactors. The peak hour flow was used to size the secondary clarifiers, tertiary filters. The aeration system was sized to handle the maximum day demands. The peak hour flow was used to size the facilities overall hydraulic capacity.

Table ES.2 SWWRF Phase I Influent Wastewater Pollutant Characteristics
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Parameter	Design Condition	Unit	Value
Carbonaceous 5-day Biochemical Oxygen Demand ($cBOD_5$)	$cBOD_5$, AA	mg/l	290
	$cBOD_5$ mass loading, AA	lb/day	12,093
	Mass loading MM/AA peak factor		1.2
	Mass loading MD/AA peak factor		1.8
	$cBOD_5$ mass loading MM	lb/day	14,512
	$cBOD_5$ mass loading MD	lb/day	21,767
Chemical Oxygen Demand (COD)	COD, AA	mg/l	695
	COD mass loading, AA	lb/day	28,982
	Mass loading MM/AA peak factor		1.2
	COD mass loading MM		34,778
Total Suspended Solids (TSS)	TSS, AA	mg/l	300
	TSS mass loading, AA	lb/day	12,510
	Mass loading MM/AA peak factor		1.2
	TSS mass loading, MM	lb/day	15,012
Volatile Suspended Solids (VSS)	VSS, AA	mg/l	240
	VSS mass loading, AA	lb/day	10,008
	Mass loading MM/AA peak factor		1.2
	VSS mass loading, MM		12,010
Total Kjeldahl Nitrogen (TKN)	TKN, AA	mg/l	46
	TKN mass loading, AA	lb/day	1,918
	Mass loading MM/AA peak factor		1.2
	Mass loading MD/AA peak factor		1.6
	TKN mass loading, MM	lb/day	2,302
	TKN mass loading, MD	lb/day	3,069
Total Phosphorus (TP)	TP, AA	mg/l	8
	TP mass loading, AA	lb/day	334
	Mass loading, MM/AA peak factor		1.2
	TP mass loading, MM	lb/day	400

Design values for various other influent wastewater and site characteristics that influence the design of the biological process are provided in Table ES.3.

Table ES.3 SWWRF Phase I Other Characteristics SWWRF Conceptual Design and Facilities Plan Update Orange County Utilities		
Design Parameter	**Unit**	**Value**
Wastewater minimum winter temperature	^{o}C	20
Wastewater maximum summer temperature	^{o}C	30
Wastewater influent pH	pH units	7.4(1)
Site elevation (above MSL)	ft	130
Barometric pressure	psia	14.7
Minimum winter air temperature	^{o}C	0
Maximum summer air temperature	^{o}C	35
Maximum relative humidity	%	90
Wastewater influent alkalinity	mg/l as $CaCO_3$	270(1)

Notes:
(1) Assumed based on data available from OCU's SWRF.

ES.4.2 Phase I Effluent Water Quality Goals

Phase I of the SWWRF will be designed to produce reclaimed water meeting the water quality criteria for both Advanced Wastewater Treatment (AWT) and Public Access Reuse (PAR) in Florida with effluent meeting the Florida "5:5:3:1" standard (5 mg/L $cBOD_5$, 5 mg/L TSS, 3 mg/L total nitrogen (TN), and 1 mg/L TP, respectively) with high level disinfection (Title XXIX Chap. 403.086 (4) (a) (b) F.S.). Table ES. 4 provides a summary of the reclaimed water quality goals from the first phase of SWWRF. Plans call for effluent from the first phase of the SWWRF to be used for PAR, with possible wet weather discharge to the Water Conserv II (WC II) RIBs.

RIBs normally require secondary treatment with basic disinfection and effluent nitrate-nitrogen less than 12 mg/L, per the current rules of the FDEP (Chapter 62-610, F.A.C.). However, a substantial area of the northern part of RIB Site 6 falls within the Wekiva Study Area. The RIBs within this part of the site cover portions of the Primary, Secondary and Tertiary Protection Zones defined in the document titled: "Report of Investigations No. 104: Wekiva Aquifer Vulnerability Assessment" (FGS, 2005).

The Wekiva Wastewater Rule (62-600.550, F.A.C.) states that when land application systems are located in two or more protection zones, the more stringent protection zone control measures shall apply to the entire application system. These most stringent control measures would require the reclaimed water applied to the RIBs to have annual average TN concentrations below 3 mg/L.

Table ES.4	SWWRF Phase I – Effluent Water Quality Goals SWWRF Conceptual Design and Facilities Plan Update Orange County Utilities
Parameter	**SWWRF Phase I WQ Goal(1)**
$cBOD_5$, mg/l	≤ 5 mg/l (annual average)
TSS, mg/l	≤ 5 mg/l (annual average)
TN, mg/l	≤ 3 mg/l (annual average)
TP, mg/l	≤ 1 mg/l (annual average)
pH (s.u.)	6.0 – 8.5
Chlorine disinfection mixing criteria(2)	Rapid and uniform
Fecal coliform(2), #/100 ml	Over a 30-day period, 75% of values below detection limits. Any one sample ≤ 25 per 100 mL sample
Chlorine residual(2), mg/l	1.0 mg/l single sample minimum
Chlorine contact time at peak hour(2)	≥ 15 minutes
Product of total chlorine residual and contact time (CT) at peak hour flow(3)	≥ 25 mg/l-min

Notes:
(1) OCU has adopted a policy that regardless of the reclaimed water management alternative, the SWWRF will be designed to produce effluent water quality to meet Florida AWT standards.
(2) High-level disinfection requirements are specified in Rules 62-600.440(5) and 62-610.460 of the F.A.C.
(3) Assuming a fecal coliform concentration less than 1000 /100 ml prior to chlorine disinfection.

ES.4.3 Secondary Liquid Treatment Alternatives Analysis

A total of five liquid treatment alternatives were evaluated for Phase 1 of SWWRF. The five alternatives are:

- Alternative No. 1 – Five-stage Bardenpho (B5) process, secondary clarifiers, and disk filters.
- Alternative No. 2 – B5 process, secondary clarifiers, and tertiary membrane filters.
- Alternative No. 3 – Step-feed BNR process with post-anoxic zones, secondary clarifiers, and disk filters.
- Alternative No. 4 – Three-stage BNR process, secondary clarifiers, and denitrification filters.
- Alternative No. 5 – B5 / MBR process (recommended in the 2007 Facilities Plan).

ES.4.3.1 Evaluation of Alternatives

The alternatives evaluation did not include a qualitative review of technologies or evaluations of unit processes that are common to the five alternatives such as screening, grit removal, odor control, secondary clarification, tertiary filtration (unless specific and special to the biological alternative being evaluated), disinfection, and biosolids handling. Design criteria for these unit processes were adopted from the 2007 Facilities Plan (PBS&J/CDM) recommendations. However, planning level cost estimates (capital, O&M, and life cycle costs) developed for each of the five alternatives included all unit processes.

Each of the five alternatives assumed the following at a minimum:

- Preliminary treatment consisting of center flow traveling band screens (6 mm opening) followed by a vortex type grit removal system and odor control.
- Secondary effluent will be disinfected using bulk sodium hypochlorite in chlorine contact tanks.
- The disinfected water will be transferred to a reclaimed water storage tank with vertical turbine type pumps mounted in a sump at the end of the chlorine contact tanks.
- Reclaimed water will be pumped using another set of vertical turbine type pumps from the ground storage tank(s) to the reclaimed water distribution system.
- In the event, the treated secondary effluent does not meet the reclaimed water quality standards (typically when an alarm is registered for high turbidity, > 2 NTU, or low chlorine residual, < 0.5 mg/l), the transfer pumps will divert the water to a reject water storage tank. Substandard reclaimed water (reject water) is required to be either stored for subsequent additional treatment or be discharged to another permitted effluent disposal system (as specified under 62:610.463(2) of F.A.C). The reject water will be pumped to RIB Site 6 with provisions to pump it back to the head of the plant for re-treatment or the head of the tertiary filters in a manner similar to the operating permit requirements for OCU's South Water Reclamation Facility (SWRF). This analysis assumes reject water will be stored in a pre-stressed concrete tank(s) before being diverted to any of the three above disposal systems.
- Waste activated sludge (WAS) from the biological process will be initially held in aerobic holding tanks. The WAS will be dewatered using screw presses. It is assumed that dewatered cake will be either further processed on-site or hauled off-site for further processing. The economic analysis performed as part of this task does not include dewatered cake processing.

ES.4.3.2 Qualitative Evaluation

To help compare the five liquid treatment alternatives, a weighted evaluation matrix was created. Table ES.5 provides a list of six criteria having the most influence on the choice of the liquid treatment alternative. Also included is a qualitative rating of each criterion for each alternative. For each alternative, each criterion was individually scored on a scale of 1 to 5 depending on how the alternative was judged to perform relative to that criterion with 1 being the least favorable score and 5 being the most favorable score. The estimates for capital and life cycle costs, footprint, energy consumption, chemical consumption, and sludge production were converted to a numeric score based on a linear interpolation between the lowest estimate and the highest estimate.

The evaluation criteria were assigned a subjective weight from 1 to 6 based on the perceived overall significance of the criteria to the project. The criteria with the most significance received a weight of 6 and those with the least significance received a weight of 1. The numeric scores for these criteria are included in a matrix scoring as presented in Table ES.6.

For each alternative, the score for each criterion was then multiplied by the criterion weight and the multiplication products were summed to obtain the overall score for each alternative. The best alternative is the one with the highest score.

Table ES.5 Scoring for Evaluation Criteria Used for Comparing the Five Treatment Alternatives
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Evaluation Criteria	Alternative No. 1		Alternative No. 2		Alternative No. 3		Alternative No. 4		Alternative No. 5	
	B5 process with disk filters		B5 with tertiary membrane filters		Step-feed BNR with disk filters		Three-stage BNR with denitrification filters		B5/MBR process	
	Estimate	Raw Score	Estimate	Raw Score	Estimate	Raw Score	Estimate	Raw Score	Estimate	Raw Score
Total installed cost	$26,190,000		$29,810,000		$24,240,000		$26,060,000		$27,410,000	
Capital cost ($)	$61,600,000	3	$70,300,000	1	$57,100,000	5	$61,300,000	4	$62,700,000	2
Life cycle cost ($)	$92,200,000	4	$107,300,000	1	$85,900,000	5	$93,400,000	3	$103,200,000	2
Facility footprint(1) (ft^2)	76,900	2	77,700	1	71,600	4	72,100	3	19,800	5
Energy consumption (kWh/yr)	6,447,700	5	6,617,200	3	6,502,400	4	6,486,300	3	7,590,100	1
Chemical consumption (gallons/yr)(2)	152,000	5	156,000	3	152,000	5	214,000	1	160,000	2
Sludge production (tons/month)	177	3	177	3	183	3	189	3	180	3

Notes:
(1) Estimated facility footprints include the land area required for the activated sludge treatment basins, secondary clarifiers, and filters. The remaining unit processes will be same for all five alternatives.
(2) Based on the total quantity of liquid chemicals used annually for facility O&M. Quantity of dewatering polymer is estimated to be almost equal for all the five alternatives and is not included.

Table ES.6 Weighted Matrix for Comparing the Five Treatment Alternatives
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Evaluation Criteria	**Weighting (1 – 6)[1]**	**Alternative No. 1** B5 process with disk filters		**Alternative No. 2** B5 process with tertiary membrane filters		**Alternative No. 3** Step-feed BNR with disk filters		**Alternative No. 4** Three-stage BNR with denitrification filters		**Alternative No. 5** B5/MBR process	
		Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted
Capital cost	6	3	18	1	6	5	30	4	24	2	12
Life cycle cost	5	4	20	1	5	5	25	3	15	2	10
Facility footprint	2	2	4	1	2	4	8	3	6	5	10
Energy consumption	4	5	20	3	12	4	16	3	12	1	4
Chemical consumption	3	5	15	3	9	5	15	1	3	2	6
Sludge production	1	3	3	3	3	3	3	3	3	3	3
Total score			80		37		97		63		45
Overall rank		**2**		**5**		**1**		**3**		**4**	

Notes:
(1) The weight is proportional to the importance of the criteria. The criterion judged most important has the highest weight, while the criterion judged to be least important has the least weight.

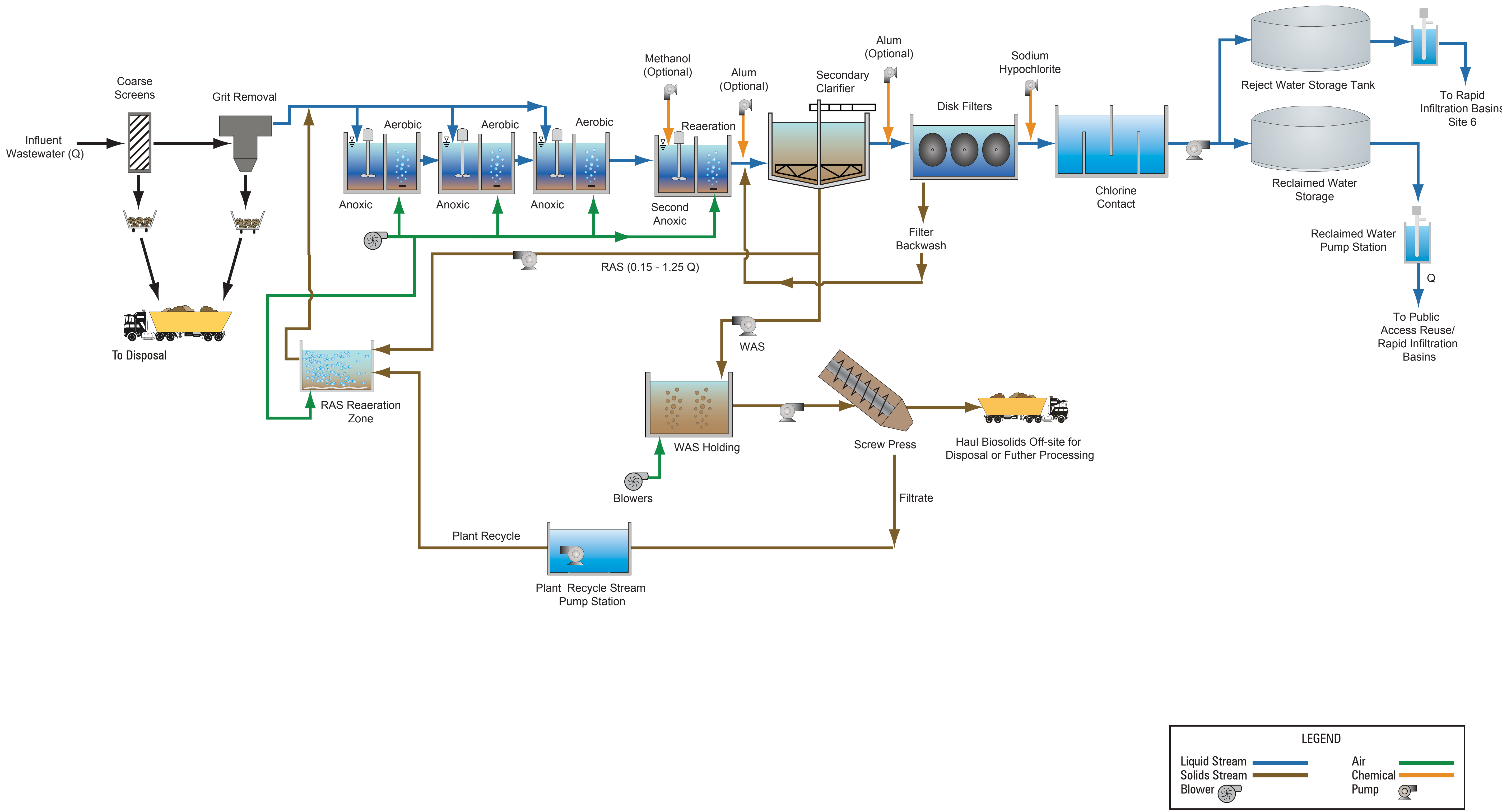
ES.4.3.3 Recommendation

Based on the weighted matrix analysis shown in Table ES 6, Alternative No. 3 (Step-feed BNR with secondary clarifiers and cloth disk filters) had the highest score followed by Alternative No. 1 (B5 process with secondary clarifiers and cloth disk filters). Alternative No. 5 (B5/MBR process), the baseline alternative recommended by the 2007 Facilities Plan, has the second lowest score. The weighted analysis is a highly subjective method for ranking the various alternatives and a difference of less than 10 percent in the scores cannot justify selecting one alternative over the other on this method alone. However, the highest ranked alternative, Alternative No. 3, has a score more than 20 percent higher than the next best alternative (Alternative No. 1). Moderate changes to the criteria weights or slight changes to the individual scores do not change the relative rank of the alternatives.

The above results were presented to OCU during Workshop No. 3 held on August 24, 2011 to confirm the ranking of the alternatives. Based on OCU's concurrence, Alternative No. 3 – the Step-feed BNR with secondary clarifiers and cloth disk filters is recommended as the preferred secondary liquid treatment technology for the proposed SWWRF.

Step-feed BNR is a specific arrangement of an activated sludge reactor where the feed is split and distributed to multiple locations within the process tank. The configuration used for this evaluation is based on a three pass step-feed BNR basin with each of the three passes having a series of three pre-anoxic zones followed by an aerobic zone. The evaluation did not include internal recycle between the aerobic and the pre-anoxic zone, although this feature could be investigated during detailed design for further optimization of the step-feed process. In addition, this alternative does not include an upstream anaerobic zone although modeling suggests that the first pass anoxic zone will function as an anaerobic zone. Biological phosphorus removal could be limited with this configuration and chemical (alum) addition may be necessary to achieve the effluent TP goal of less than 1 mg/l, although preliminary process modeling predicts sufficient bio-P removal to achieve this goal. Ultimately, the selected design parameters for the treatment process should be such that would produce a stable effluent meeting the AWT requirements.

Figure ES.1 presents the process flow diagram, while Figure ES 2 presents the conceptual site layout for this alternative.



EXECUTIVE SUMMARY

ORANGE COUNTY GOVERNMENT F L O R I D A

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SWWRF PHASE I ALTERNATIVE NO. 3 - STEP-FEED BNR WITH SECONDARY CLARIFIERS AND DISK FILTERS

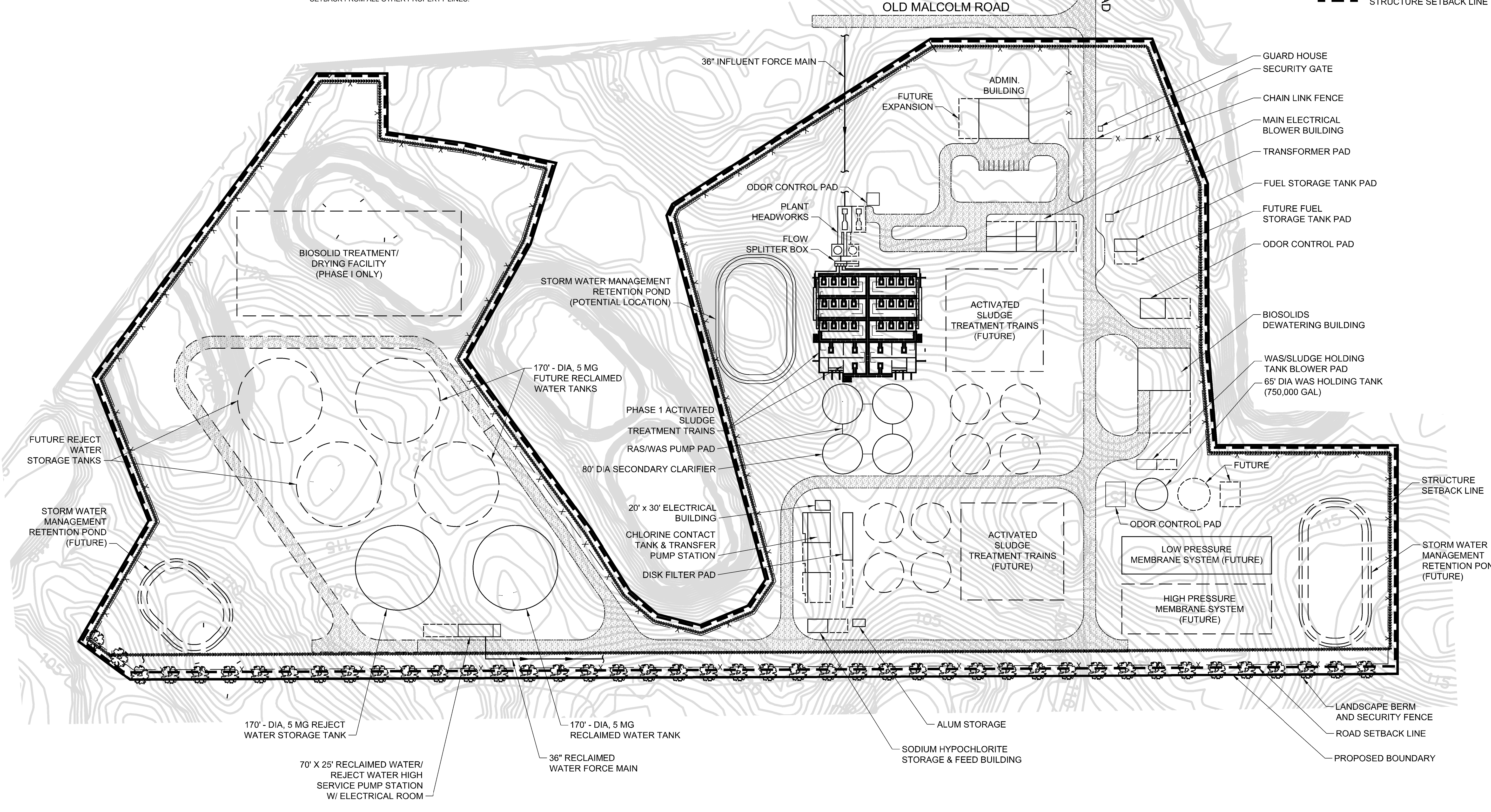
FIGURE ES-1

NOTES:

1. SITE LAYOUT IS PROVIDED PRIMARILY FOR COMPARING ALTERNATIVE LIQUID TREATMENT TECHNOLOGIES AND TO ILLUSTRATE ONE POSSIBLE CONCEPT FOR USE OF THE SITE BASED ON THE TREATMENT PROCESS PROPOSED FOR THE ALTERNATIVE. ACTUAL LAYOUT WILL BE DETERMINED DURING PRELIMINARY AND FINAL DESIGN.
2. SETBACKS:
   a. MINIMUM 15' ROAD SETBACK FROM SOUTH PROPERTY LINE.
   b. MINIMUM 5' ROAD SETBACK FROM ALL OTHER PROPERTY LINES.
   c. MINIMUM 50' TREATMENT UNIT/STORAGE UNIT STRUCTURE SETBACK FROM SOUTH PROPERTY LINE.
   d. MINIMUM 15' TREATMENT UNIT/STORAGE UNIT STRUCTURE SETBACK FROM ALL OTHER PROPERTY LINES.

LEGEND:

- ASPHATIC PAVEMENT
- CHAIN LINK FENCE
- FUTUTE CONSTRUCTION
- PROPOSED BOUNDARY
- ROAD SETBACK LINE
- STRUCTURE SETBACK LINE



ORANGE COUNTY GOVERNMENT FLORIDA

EXECUTIVE SUMMARY
PROCESS ALTERNATIVES EVALUATION

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STEP-FEED WITH SECONDARY CLARIFIERS & DISK FILTERS - CONCEPTUAL SITE LAYOUT

FIGURE ES-2

ES.4.4 Future Reclaimed Water Management Alternatives

Phase I of SWWRF will produce reclaimed water meeting Florida AWT standards, and will use PAR and RIBs for managing its reclaimed effluent. AWT treatment meets the requirements for land application and reuse systems located in the Primary Protection Zone of the Wekiva Study Area as described in Section 369.318, F.S. AWT treatment would also help reduce the nitrate concentrations in the surficial aquifer near the RIB site. For the long term, beyond meeting PAR and RIB requirements, other reuse alternatives such as surface water discharge to nearby lakes and direct aquifer injection were evaluated. Table ES.7 summarizes the major SWWRF effluent water quality parameters required to satisfy the anticipated permit limits for the various potential future reclaimed water management alternatives. Table ES.7 also includes, for comparison, the various water quality requirements chosen by OCU for Phase 1 of the SWWRF.

Table ES.7	Anticipated Effluent Water Quality Criteria for Various Reclaimed Water Management Alternatives SWWRF Conceptual Design and Facilities Plan Update Orange County Utilities			
Parameter	**OCU Policy(1)**	**PAR and RIBs(2)**	**Lake Augmentation and Surface Water Discharge(3)**	**Direct Aquifer Recharge(4)**
BOD, mg/l	≤ 5	≤ 20	NA	NA
TSS, mg/l	≤ 5	≤ 5	≤ 5	≤ 5
TN, mg/l	≤ 3	≤ 10	0.51 – 1.27(5)	≤ 10
TP, mg/l	≤ 1	NA	0.01 – 0.05(5)	NA
TOC, mg/l	NA	NA	NA	≤ 3 (average); ≤ 5 (single sample)
TOX, mg/l	NA	NA	NA	≤ 0.2 (average); ≤ 0.3 (single sample)
Other	High level disinfection(6)	High level disinfection(6)	Chlorophyll *a*(5)	Meet all primary and secondary drinking water standards and high level disinfection

Notes:
(1) OCU has adopted a policy that regardless of the reclaimed water management alternative, the SWWRF will be designed to produce effluent water quality to meet the Florida AWT standards.
(2) Phase 1 reclaimed water management alternative. In accordance with Chapter 62-610 F.A.C., Part III for Slow-Rate Land Application Systems for Public Access Areas, Residential irrigation, and Edible Crops and Part IV for Rapid-Rate Land Application Systems (RIBs and Absorption Fields)
(3) Possible reclaimed water management alternative for future phases as necessary in accordance with 62-600.430 F.A.C. for Additional Treatment – Water Quality Based Effluent Limitations (WQBELs)
(4) Possible reclaimed water management alternative for future phases as necessary in accordance with Chapter 62-610 F.A.C., Part V for Ground Water Recharge and Indirect Potable Reuse.
(5) Numeric nutrient criteria (NNC) for the Peninsula Nutrient Watershed Region in accordance with 40 C.F.R. §131.43.
(6) High-level disinfection requirements are specified in Rules 62-600.440(5) and 62-610.460 F.A.C.

It was concluded that the best short-term options for implementing reclaimed water management for the SWWRF are PAR plus RIBs or RIBs alone. In the long term, direct recharge or aquifer recharge and recovery (ARR) could be attractive as a means of liberating some of the RIB sites for other uses. Part of the attraction of this option depends on the future course of regulations and their effect on the current PAR and RIB operations.

Considerations for future treatment alternatives at the SWWRF should therefore focus on alternatives that facilitate (or at least preserve) the option of direct aquifer recharge and recovery facilities. If direct aquifer recharge is the sole wet weather management option available to the SWWRF in the future, the treatment and injection capacity of such a system may need to be sized to accommodate the full plant flow.

The pending minimum flows and levels (MFL) regulations to be established by the St. Johns River Water Management District (SJRWMD) make lake augmentation, especially to Lake Avalon, a potentially attractive option for maintaining OCU's full allocation of groundwater. The effective capacity of the lake augmentation option is expected to be very limited (< 1 mgd) as discussed in TM 4. Hence, only a small portion of the treated effluent from the SWWRF would need further treatment to remove nutrients prior to discharge to area lakes. However, lake augmentation is not the most favored option from a facilities permitting perspective. FDEP does not favor surface water discharge as a reclaimed water management tool, except as a necessary wet-weather backup. Therefore, from a permitting and economic standpoint, using groundwater rather than reclaimed water for lake augmentation may be more feasible.

In summary direct aquifer injection and lake augmentation are the most feasible reclaimed water management alternatives to supplement PAR and RIBs in the future.

ES.4.4.1 Add-On Processes to Meet Surface Water Discharge Requirements

The following two add-on configurations show promise for future evaluation should lake augmentation be selected as a supplemental reclaimed water management alternative in the future.

- Alternative 1: GAC Followed by High-Rate Clarification

  A small portion of the treated effluent from the Phase 1 SWWRF will be filtered using GAC filters. The SWWRF Phase 1 effluent will have sufficient nutrients to support biological growth within the GAC filter media. Together with adsorption of dissolved organic nitrogen (DON) on to the media, additional denitrification can be expected within the filter. Following the GAC filter and upstream of the high-rate clarification process, ion exchange (IX) with cation or anion resins or both may be required to reduce the inorganic species of total nitrogen (TN) such as ammonia (NH_3-N), nitrate (NO_3-N) and nitrite (NO_2-N) to trace levels. The requirement will depend on the efficacy of the GAC filters alone to reduce ammonia, nitrite, and nitrate to the concentrations needed to achieve a TN limit of less than 1.27 mg/l for lake augmentation (assuming EPA NNC is promulgated). Following GAC /IX, a high rate clarification process using iron salts (ferric chloride) will treat the filtered effluent to reduce the total phosphorus (TP) to the desired level of less than 0.05 mg/l. Alternatively, a two-stage reactive filtration system or another adsorption or ion exchange process may be necessary downstream of the GAC/IX process for achieving the TP goal of 0.05 mg/l.

If significant concentrations of refractory DON or dissolved organic phosphorus (DOP) exist in the reclaimed water from Phase 1, and are not removed by GAC, an oxidation process may be required before GAC to transform the refractory organic materials into other compounds that could be removed by biological or physical/chemical methods.

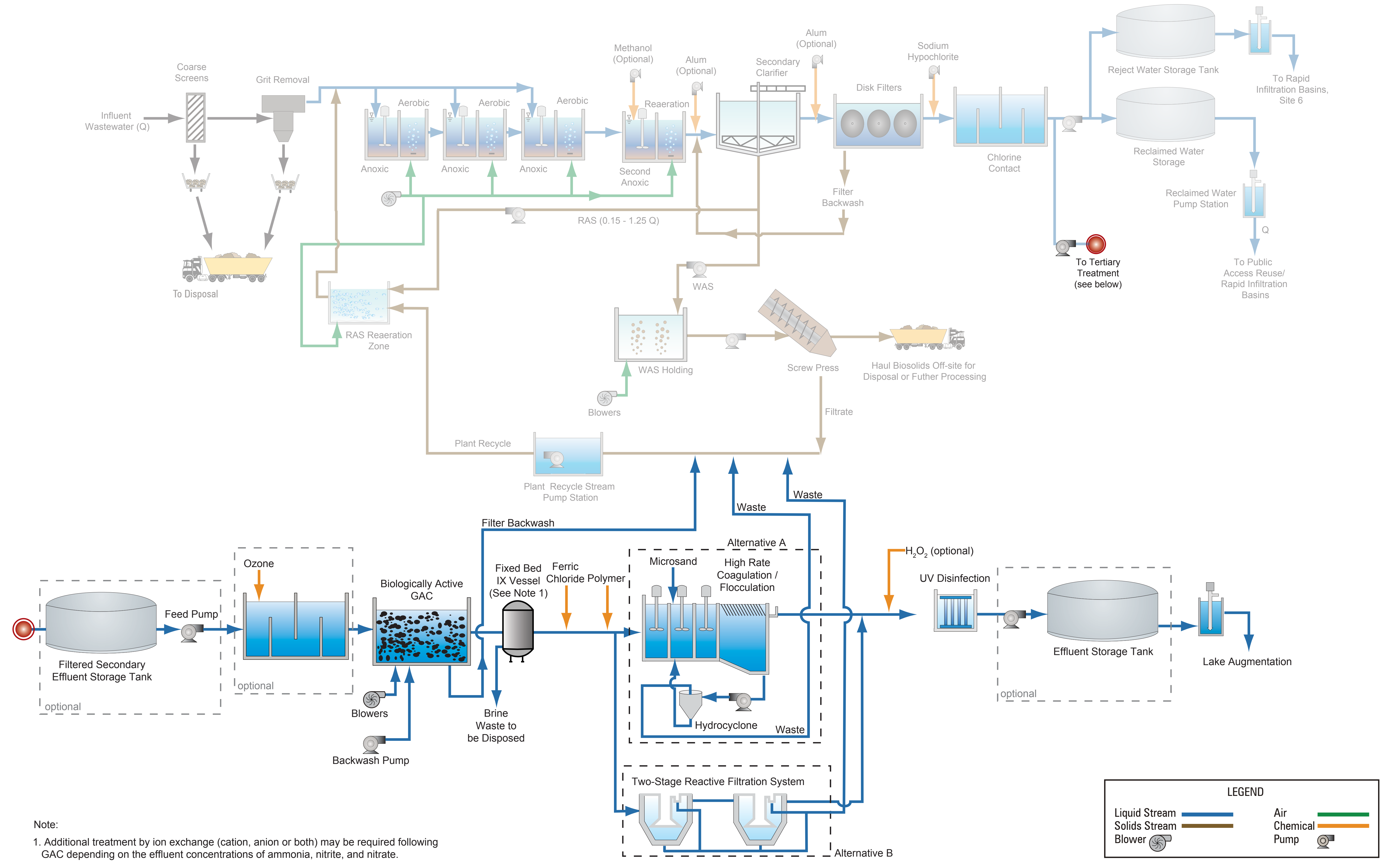
Finally, the effluent will be disinfected using UV light before being stored in a ground storage tank. UV disinfection will provide the necessary barrier against protozoan cysts and other pathogens. A new pump station will pump the highly treated effluent to nearby Lake Avalon as necessary to meet MFL goals.

Bench-scale and pilot scale testing would be required to confirm the effectiveness of this process configuration. Prior to bench-scale testing, the AWT effluent from the SWWRF should be analyzed for DON and DOP concentrations. The concentrations of refractory DON and non-reactive DOP concentration would determine if additional pretreatment using advanced oxidation (prior to high rate clarification or the reactive filtration process) would be necessary.

- Alternative 2 - UF Membranes followed by RO Membranes.

  A small portion of the effluent from Phase 1 of the SWWRF will be initially filtered with low-pressure ultrafiltration (UF) membranes. The UF membrane could be either an immersed membrane system or an in-vessel pressurized membrane system. The UF membrane will act as a pretreatment for the subsequent reverse osmosis (RO) membranes. The RO membranes will reduce the TP to less than 0.05 mg/l and TN to less than 1.27 mg/l. As described in Alternative 1, the effluent will be disinfected using UV light, stored in a ground storage tank, and pumped to nearby Lake Avalon as necessary to meet MFL goals. Similar to Alternative 1, bench-scale and pilot scale testing would be required to confirm the effectiveness of this process configuration before proceeding with implementation, and to measure its relative performance and cost against Alternative 1.

Figure ES.3 and Figure ES.4 provides a process flow diagram for each of the two process configurations.



Note:

1. Additional treatment by ion exchange (cation, anion or both) may be required following GAC depending on the effluent concentrations of ammonia, nitrite, and nitrate.

ORANGE COUNTY GOVERNMENT FLORIDA

EXECUTIVE SUMMARY

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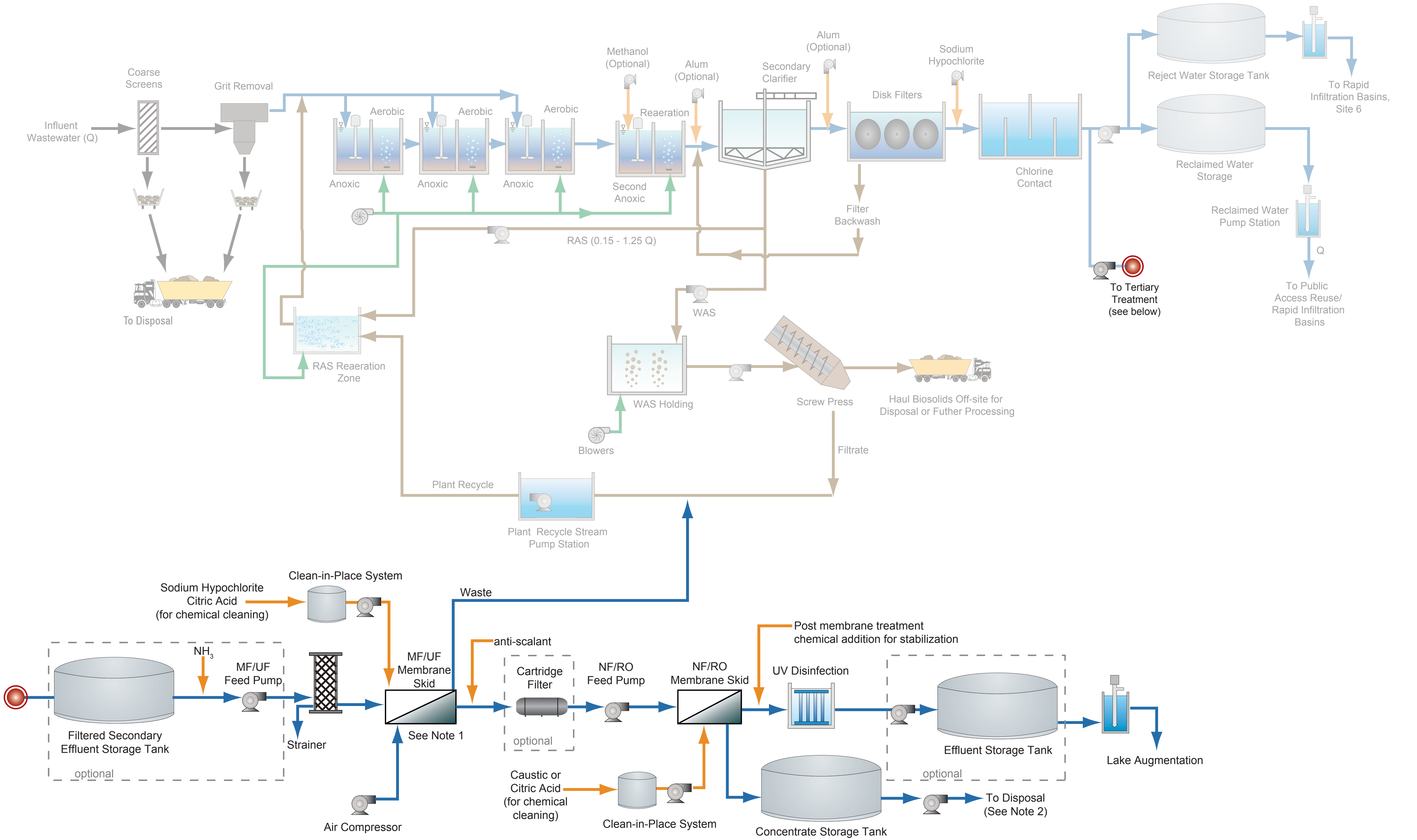
ADD-ON TREATMENT TRAIN FOR FUTURE PHASES - LAKE AUGMENTATION - ALTERNATIVE 1

FIGURE ES-3



LEGEND

Liquid Stream	(blue line)	Air	(green line)
Solids Stream	(brown line)	Chemical	(orange line)
Blower	(symbol)	Pump	(symbol)

Notes:
1. Schematic shows a pressurized MF/UF membrane. MF/UF membranes can also be submerged type. Final determination to be made at later time.
2. Depending on concentrate total dissolved solids (TDS), chloride concentration and other ion concentrations, concentrate could be disinfected, blended with reclaimed water for disposal to PAR. Detailed analysis should be conducted to confirm suitability. Alternatively, other means of concentrate disposal such as crystallization/evaporation or deep well injection may be required.

ADD-ON TREATMENT TRAIN FOR FUTURE PHASES - LAKE AUGMENTATION - ALTERNATIVE 2

FIGURE ES-4

ES.4.4.2 Add-On Processes to Meet Direct Aquifer Injection Requirements

The following two add-on process configurations show excellent potential to be considered for further evaluation to treat a portion of the effluent downstream of the SWWRF Phase I AWT process to meet the water quality limits for direct aquifer recharge.

- Alternative 1 - Ozonation followed by Biologically Active Filters followed by UV Disinfection

  Under this alternative, the effluent from the Phase 1 SWWRF will be subjected to oxidation and disinfection using an appropriate dose of ozone. The ozonated effluent will then be filtered using biologically active filters (BAF) with GAC media. Recent studies have shown that this combination has been able to reduce the TOC of a secondary treated effluent to below 3 mg/l, the regulatory limit in Florida for direct aquifer injection (Rule 62-610.560 F.A.C.). Alternatively, a sand mono-medium filter such as a deep-bed filter could be investigated in lieu of a GAC media filter. The ozone-BAF process has also shown to significantly reduce or completely remove a host of emerging substances of concern (ESOCs) from wastewater effluent. Similarly, an intermediate MF/UF low-pressure membrane after the BAFs may be necessary to provide a final barrier to particulate matter. Following filtration, the effluent will be further disinfected using UV light as an additional barrier to pathogens and other ESOCs. Bench-scale and pilot scale testing should be performed to confirm the effectiveness of this process configuration prior to implementation, and to evaluate the economics of this configuration in comparison to UF/RO.

- Alternative 2 - Low-Pressure (UF) Membranes followed by RO Membranes followed by UV/H_2O_2

  This process configuration is the same as the one described above as Alternative 2 for the lake augmentation scenario. OCU has already conducted a comprehensive pilot study using this process configuration to produce an effluent amenable for direct aquifer injection. The results of the pilot study confirmed that this process configuration would work well and meet all requirements of the rule 62-610.560 F.A.C. The results of the pilot study have also been accepted by the Florida Department of Environmental Protection.

Process flow diagram for each of the two process configurations are provided in Figure ES.5 and ES.6.

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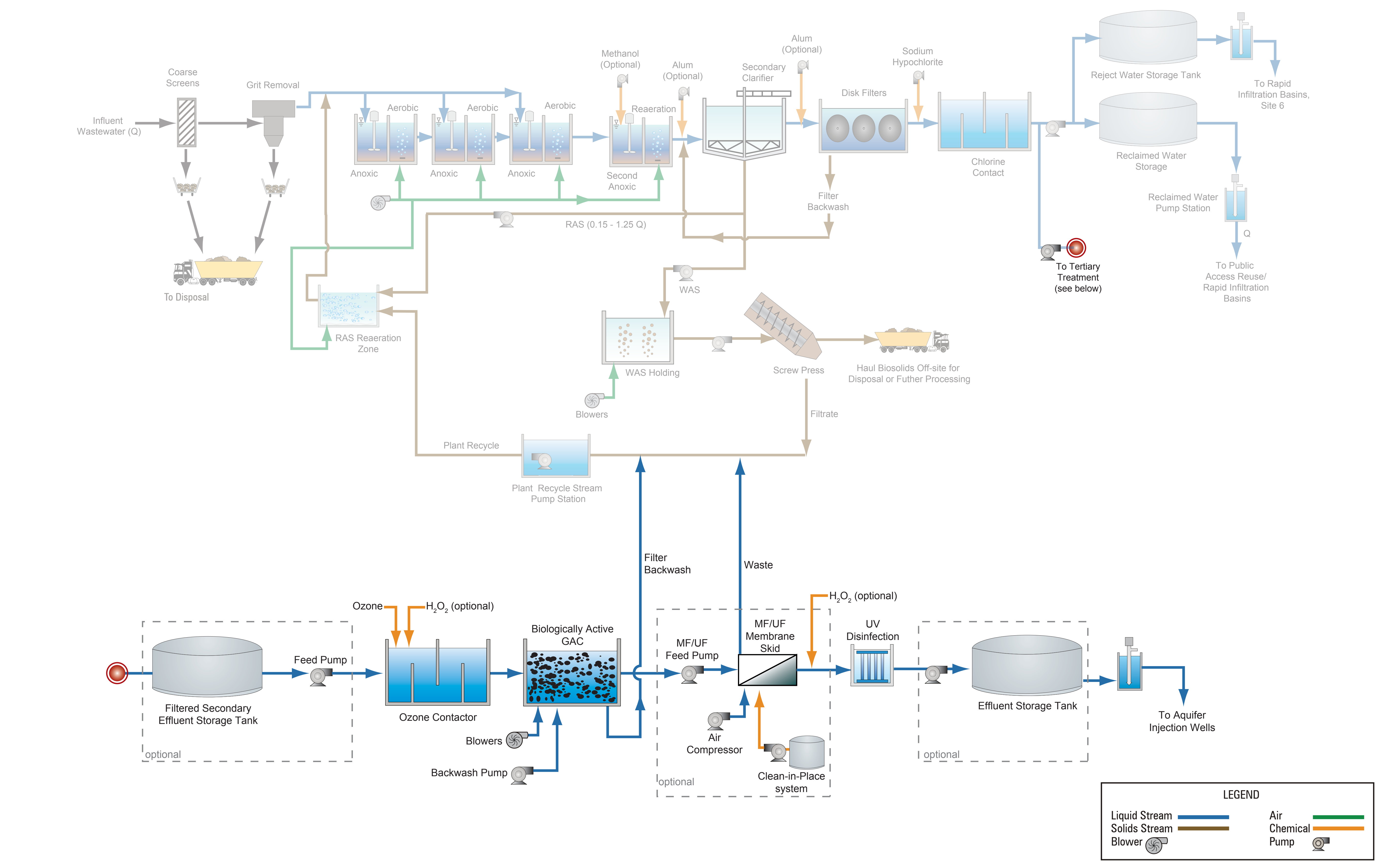

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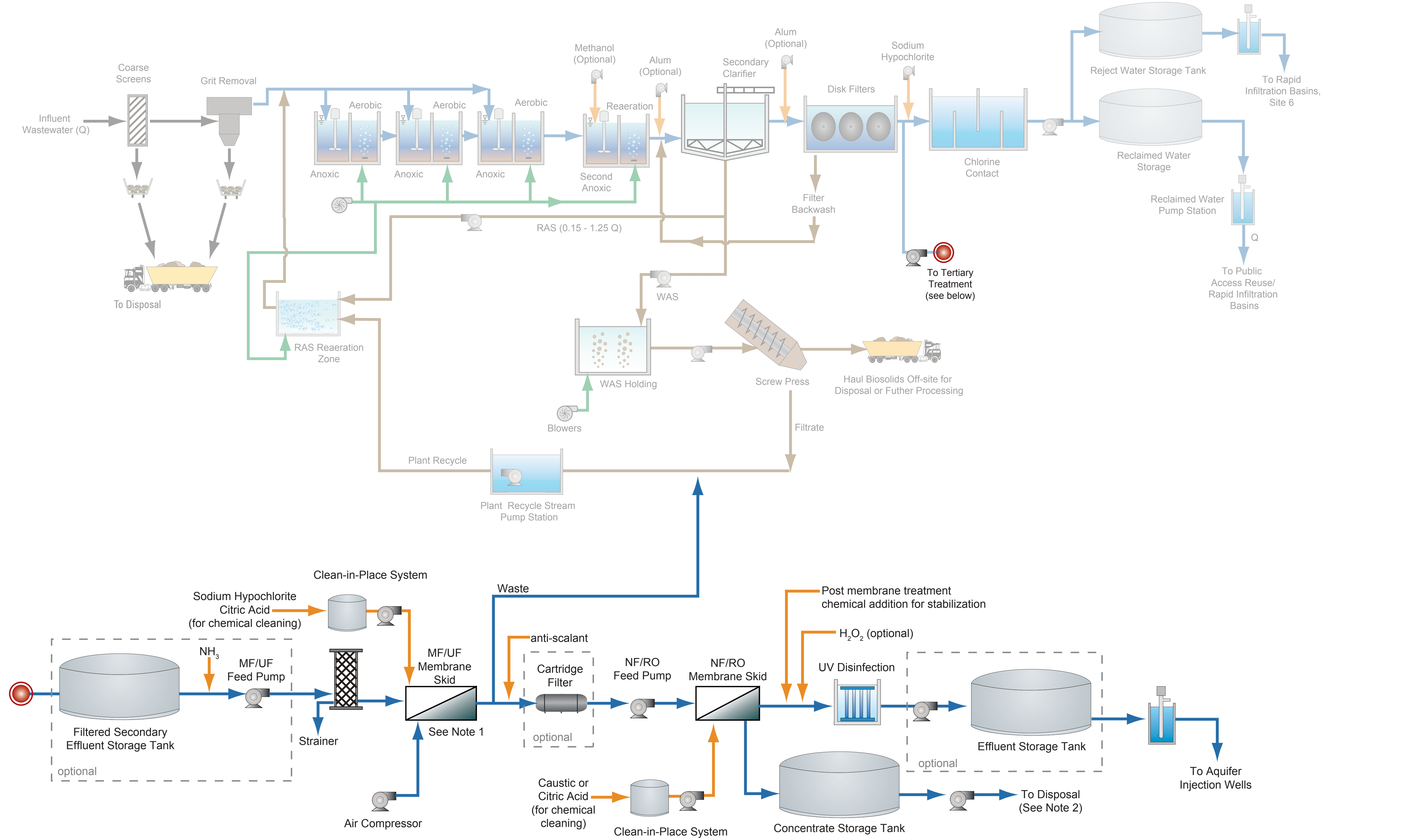
ADD-ON TREATMENT TRAIN FOR FUTURE PHASES - DIRECT AQUIFER INJECTION - ALTERNATIVE 1

FIGURE ES-5



Notes: 1. Schematic shows a pressurized MF/UF membrane. MF/UF membranes can also be submerged type. Final determination to be made at later time.
2. Depending on concentrate total dissolved solids (TDS), chloride concentration and other ion concentrations, concentrate could be disinfected, blended with reclaimed water for disposal to PAR. Detailed analysis should be conducted to confirm suitability. Alternatively, other means of concentrate disposal such as crystallization/evaporation or deep well injection may be required.

LEGEND

Liquid Stream
Solids Stream
Blower
Air
Chemical
Pump

ADD-ON TREATMENT TRAIN FOR FUTURE PHASES - DIRECT AQUIFER INJECTION - ALTERNATIVE 2

FIGURE ES-6

ES.4.4.3 Conclusion & Recommendation

Several technologies were evaluated for reduction of nutrients to trace levels to meet the numeric nutrient criteria (NNC) for discharge to lakes. Similarly, several technologies were evaluated for removal of TOC and TOX to meet the "full treatment and disinfection" requirements of Rule 62-610.563(3), F.A.C for direct aquifer injection. Several of these technologies identified are applicable to both reclaimed water management options.

Four add-on treatment trains have been identified for further treatment of the AWT effluent from the Phase I SWWRF to produce a higher quality effluent amenable either to discharge to lakes for augmentation or to inject into the aquifer in the future. Two of the four identified add-on treatment trains (low-pressure membranes followed by RO membranes) are common to both reclaimed water management options. OCU has successfully pilot tested an integrated membrane treatment process to produce an effluent suitable for direct aquifer recharge. Further bench scale and pilot-scale testing should be conducted for the other two add-on treatment process trains (Alternative 1 for both reclaimed water management options) to confirm performance of the process schemes to meet the desired water quality, to provide sufficient data to determine design parameters, and to estimate capital and life cycle costs. Ultimately, the most cost effective process train should be selected for implementation at full scale to produce the desired water quality pursuant to the reclaimed water management option as deemed necessary in the future.

APPENDIX A – TECHNICAL MEMORANDA

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

TECHNICAL MEMORANDUM NO. 1

SWWRF BASIS OF DESIGN CRITERIA

FINAL

October 2011

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SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

SWWRF BASIS OF DESIGN CRITERIA

TECHNICAL MEMORANDUM NO. 1

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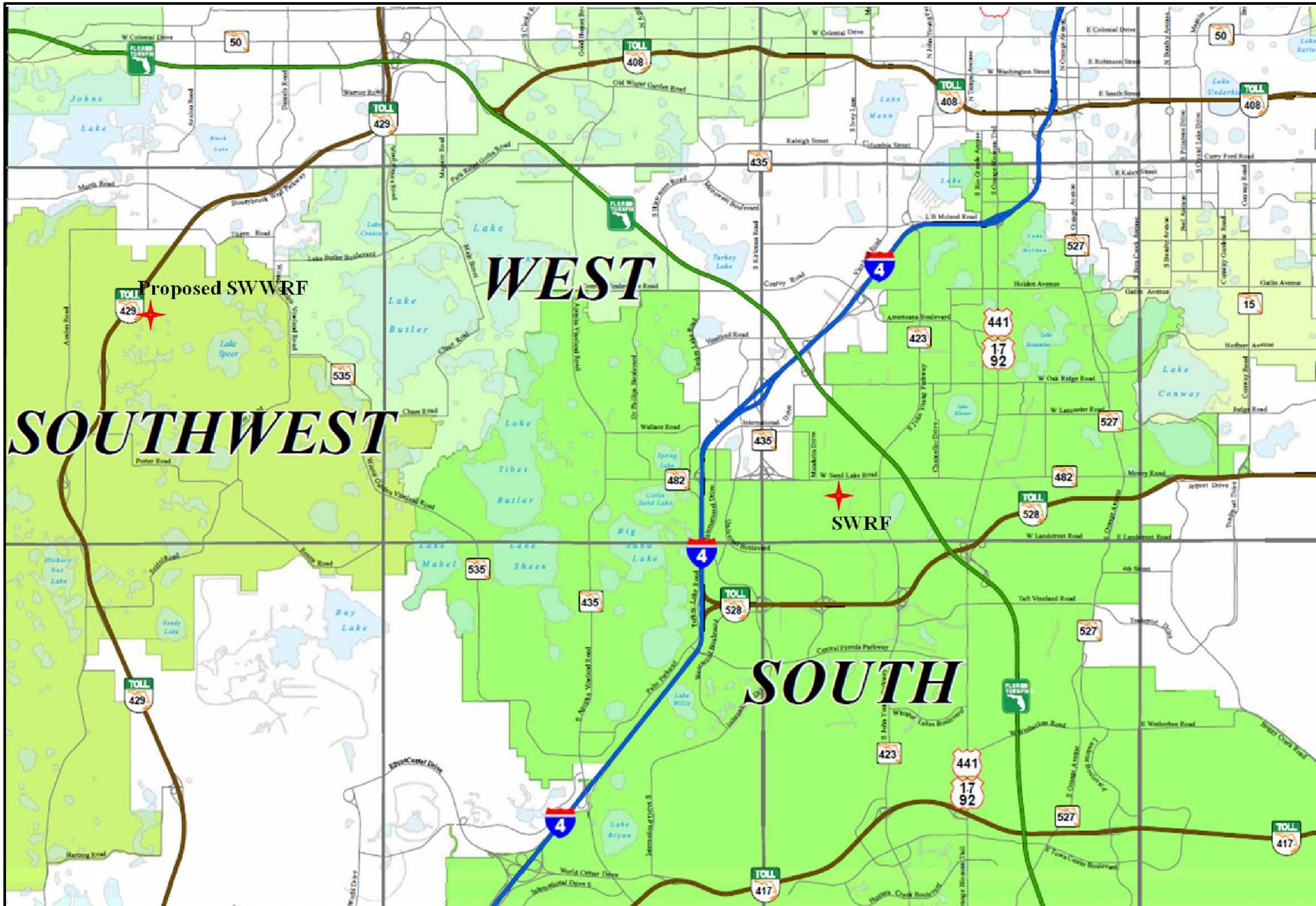
1.0 INTRODUCTION

Under Task Authorization (TA) 16 of Contract Y9-901, the Carollo team was retained by Orange County Utilities (OCU) to prepare a conceptual design for the proposed Southwest Water Reclamation Facility (SWWRF), including a review and update of the previous Capital Improvements and Facilities Plan (CDM/PBSJ 2007) prepared for the SWWRF. The 2007 Facilities Plan provides the basis of design criteria for the proposed SWWRF, which was derived assuming that the plant influent characteristics for the SWWRF would be similar to those of the existing Northwest Water Reclamation Facility (NWRF). At the project kick-off meeting held on November 10, 2010, OCU requested that the basis of design criteria for the SWWRF be updated using more recent plant influent data obtained at the NWRF as part of the Phase III expansion. However, geographically, the new SWWRF and its Southwest Service Area (SWSA) fall closer to and adjacent to the existing South Service Area (SSA) of the South Water Reclamation Facility (SWRF), and a portion of the flow currently being treated at the SWRF will be treated at the SWWRF. OCU is also in the process of expanding the capacity of the SWRF, and the design consultant has prepared the basis of design for this expansion. Figure 1 shows the approximate demarcation for the West Service Area (WSA) which is served by the NWRF, and the SWSA and SSA service areas which are served by the SWRF. Therefore, consideration will also be given to the SWRF plant influent characteristics in establishing the basis of design criteria for the proposed SWWRF.

1.1 Background

This technical memorandum summarizes the plant influent characteristics including flow factors and pollutant loadings developed for the proposed expansions of the NWRF and the SWRF. These criteria are compared with the basis of design criteria for the proposed SWWRF established in the 2007 Facilities Plan, and are used to update the basis of design criteria for this technical memorandum. The revised basis of design criteria will be used to perform conceptual sizing of the treatment alternatives to be evaluated as part of the SWWRF Conceptual Design and Facilities Update, and ultimately to prepare the Request for Proposals (RFP) for OCU to select a design consultant for the design of the proposed facility.



OCU Wastewater Service Areas

SWWRF Conceptual Design and Facilities Plant Update

TM1 - SWWRF Basis of Design Criteria

FIGURE 1

ORANGE COUNTY GOVERNMENT F L O R I D A

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2.0 PREVIOUSLY DEVELOPED SWWRF BASIS OF DESIGN SUMMARY

A summary of the basis of design used to develop the 2007 Facilities Plan for the proposed SWWRF is presented in Table 1. The wastewater data was developed using data from the NWRF based on similarities in the characteristics of both service areas. The 2007 Facilities Plan recommended maximum month (MM), maximum day (MD) and peak hour (PH) peaking factors of 1.2, 1.21 and 2.5 respectively for influent flows. Similarly, for influent 5-day carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), and total phosphorus (TP) loads, the Facilities Plan recommended a MM peaking factor of 1.2. However, for influent $cBOD_5$ and TKN loads, the 2007 Facilities Plan recommended MD peaking factors of 1.35 and 1.31 respectively.

Table 1 Summary of the Basis of Design for the SWWRF in the 2007 Facilities Plan
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Parameter	Annual Average	Maximum Month	Maximum Day	Peak Hour	Peaking Factors		
					Max. Month	Max. Day	Peak hour
Flow, mgd	15.0	18.0	18.15	37.50	1.2	1.21	2.5
$cBOD_5$, mg/L	220						
$cBOD_5$, lb/d	27,522	33,026	37,155		1.2	1.35	
TSS, mg/L	260						
TSS, lb/d	32,526	39,031			1.2		
TKN, mg/L	45						
TKN, lb/d	5,630	6,755	7,375		1.2	1.31	
TP, mg/L	6						
TP, lb/d	751	901			1.2		

3.0 NWRF PHASE III EXPANSION BASIS OF DESIGN SUMMARY

As part of the on-going design of the Phase III expansion of the NWRF from a treatment capacity of 7.5 mgd to 11.25 mgd, OCU together with the design consultant, Black and Veatch (B&V), performed additional sampling and analysis of the plant influent water quality characteristics to establish the basis of design for the proposed expansion. The plant influent characteristics, as presented in Technical Memorandum 3 (B&V, August 22, 2008) for the design of the Phase III expansion, are summarized in Table 2 on the following page. The revised design criteria adopted the 2007 Facilities Plan's suggested MM/AA (maximum month/annual average) influent load peaking factor of 1.2 for influent $cBOD_5$, TSS, TKN, and TP. However, based on historical plant influent data from 2005 to 2007, the MD load peaking factors for $cBOD_5$ and TKN were revised to 1.8 and 1.6, respectively.

Table 2	Summary of the Influent Flows, Pollutant Concentrations and Mass Loads Established for the Design of the Phase III Expansion of the NWRF SWWRF Conceptual Design and Facilities Plan Update Orange County Utilities						
Parameter	Annual Average	Maximum Month	Maximum Day	Peak Hour	Peaking Factors		
					Max. Month	Max. Day	Peak Hour
Flow, mgd	11.25	14.6	19.1	33.75	1.3	1.7	3.0
$cBOD_5$, mg/L	293						
$cBOD_5$, lb/d	27,491	32,989	49,483		1.2	1.8	
TSS, mg/L	301						
TSS, lb/d	28,241	33,890			1.2		
TKN, mg/L	46.4						
TKN, lb/d	4,353	5,224	6,965		1.2	1.6	
TP, mg/L	7.5						
TP, lb/d	704	844			1.2		

4.0 SWRF PHASE V EXPANSION BASIS OF DESIGN SUMMARY

As part of the on-going design of the Phase V expansion of the SWRF from a treatment capacity of 43 mgd to 56 mgd, OCU together with the design consultant (B&V) reviewed the plant influent characteristics historical data from January 2006 to February 2010 to determine the basis of design for the proposed expansion. The influent data at the SWRF includes all plant recycle streams including the nutrient rich recycle from the anaerobic digestion process. The plant influent characteristics used for the Phase V expansion as presented in Technical Memorandum No. 5 (B&V, November 11, 2010) are summarized in Table 3.

Table 3 Summary of the Basis of Design for Modifications to the Southeast Train at the SWRF as part of Phase V Expansion
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Parameter	Annual Average	Maximum Month	Maximum Day	Peak Hour	Peaking Factors		
					Max. Month	Max. Day	Peak hour
Flow, mgd	16.0	19.2	24.0	40.0	1.2	1.5	2.5
$cBOD_5$, mg/L(1)	210						
$cBOD_5$, lb/d	28,022	33,626			1.2		
TSS, mg/L(1)	280						
TSS, lb/d	37,363	46,704			1.25		
TKN, mg/L(1)	50						
TKN, lb/d	6,672	8,674			1.3		
TP, mg/L(1)	12						
TP, lb/d	1,601	2,082			1.3		

Notes:
(1) The values presented in the table include loadings from plant recycle streams.

5.0 SWWRF BASIS OF DESIGN CONFIRMATION AND VALIDATION

Based on the review of the NWRF and SWRF plant influent characteristics developed as part of the proposed plant expansions in comparison with the SWWRF basis of design established in the 2007 Facilities Plan, Carollo recommends that the basis of design established in the 2007 Facilities Plan should be revised to address current conditions. The most recent population estimates, prepared by PB Americas as part of their Water Resource Plan (WRP) contract, show that the population and service area characteristics of the SWSA will be similar to the Northwest Service Area with an approximate ratio of 65 percent residential and 35 percent commercial developments. In comparison, the service area for the SSA has approximately 35 percent residential and 65 percent commercial developments.

Table 4 presents a comparison of pollutant concentrations for the three plants based on the data from the different sources. The data shows a significant increase in influent pollutant concentrations, especially $cBOD_5$ and TSS for the NWRF. With water conservation measures being adopted in the service areas, this increase is expected. The data also shows a significant difference in the $cBOD_5$ concentrations for the NWRF and SWRF which could indicate that the NWRF service area is more residential when compared to the SSA. On the other hand, SWRF data shows higher nutrient concentrations as compared to the NWRF. The SWRF has anaerobic digesters which contribute to a higher nutrient recycle loading to the head of the plant. Influent sampling is performed downstream of the addition of this recycle stream, and therefore accounts for this increased load. The NWRF does not have any additional sludge treatment, other than aerobic holding tanks followed by dewatering, so recycle streams do not impact the plant influent loading.

Table 4 Comparison of Pollutant Concentrations for the Three Facilities Based on Different Sources
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Parameter	2007 Facilities Plan			NWRF (Revised for Phase III expansion)	SWRF (Revised for Phase V expansion)(1)
	SWWRF	NWRF	SWRF		
$cBOD_5$, mg/L	220	220	190	293	210
TSS, mg/L	260	260	210	301	280
TKN, mg/L	45	45	35	46.4	50
TP, mg/L	6	6	9	7.5	12

Notes:
(1) Values include loadings from plant recycle streams.

Since the SWSA will mainly be comprised of new development and infrastructure with construction governed by recent updates to the building and plumbing codes, the conveyance system should allow less infiltration-inflow compared to the much older SSA conveyance system. Therefore, Carollo concludes that the anticipated pollutant concentrations at the SWWRF will be more representative of those anticipated at the NWRF. The recommended influent characteristics for use in preparation of the SWWRF Conceptual Design and 2011 Facilities Plan Update are presented in Table 5.

Table 5 Recommended Influent Characteristics for Conceptual Design and 2011 Facility Plan Update
SWWRF Conceptual Design and Facilities Plan Update
Orange County Utilities

Parameter	Annual Average	Maximum Month	Maximum Day	Peak Hour	Peaking Factors		
					Max. Month	Max. Day	Peak hour
Flow, mgd	15.0 (1)	19.5	25.5	45.0	1.3	1.7	3.0
$cBOD_5$, mg/L	290(2)						
$cBOD_5$, lb/d	36,280	43,535	65,302		1.2	1.8	
TSS, mg/L	300(2)						
TSS, lb/d	37,530	45,036			1.2		
TKN, mg/L	46.0(2)						
TKN, lb/d	5,755	6,906	9,207		1.2	1.6	
TP, mg/L	8(2)						
TP, lb/d	1,001	1,201			1.2		

Notes:

(1) The annual average flow of 15 mgd is taken from the 2007 Facilities Plan. This values will be revised as part of the phasing analysis performed under the SSA/SWSA Conveyance plan update task (Task 11).

(2) Values rounded to the nearest digit.

The criteria for the influent characteristics at the SWRF and NWRF were developed from large data sets collected over long periods of time. Given the extensive databases available for both facilities, the historical magnitude and variability of the influent flows, concentrations, and mass loads can be determined with a high degree of certainty. In turn, this allows projection of future concentrations and mass loads with a reasonable degree of confidence.

A comparable set of data on flows and concentrations does not exist for the proposed SWWRF. Additional composite sampling for $cBOD_5$, TSS, TKN and TP could be performed at the Alexandria Pump Station for a limited period of time, since this pump station will serve as one of the master lift stations for the proposed SWWRF. Collection of water quality data from the Alexandria Pump Station would allow the wastewater characteristics for the existing SWWRF service area to be established, however, since the project schedule does not allow for sampling and analysis over a long period of time, there will be a relatively high degree of uncertainty associated with the data. In addition, since the western part of the current SSA is still relatively undeveloped, and the wastewater characteristics of the entire service area relative to that of the Alexandria Pump Station influent characteristics could change with future growth, Carollo does not recommend any sampling from the Alexandria Pump Station to support this Facility Plan Update.

6.0 SPECIAL SAMPLING FOR RECLAIMED WATER QUALITY DATA

OCU has adopted a policy that Phase 1 of the SWWRF will be designed to meet water quality criteria for Advanced Wastewater Treatment (AWT) in Florida with effluent meeting the “5:5:3:1” standard ($cBOD_5$, TSS, TN, and TP, respectively), with high level disinfection and filtration. Effluent from Phase 1 of the SWWRF will be used for public access reuse (PAR), with possible wet weather discharge to the Water Conserv II (WC II) Site 6 rapid infiltration basins (RIBs). The future phases may require the effluent to be treated to higher levels to implement other reclaimed water management alternatives such as surface water discharge to nearby lakes or direct aquifer recharge to supplement the PAR and RIB systems.

Under a scenario where discharge to nearby lakes in the future is deemed suitable as a supplemental reclaimed water management alternative, the effluent will be required to meet the EPA numeric nutrient criteria for freshwater lakes, streams and springs in Florida. Carollo recommends that OCU analyze samples of the reclaimed water from the SWWRF Phase 1 at a later time to measure the concentrations of dissolved, non-degradable, organic nitrogen (DON) and phosphorus (DOP). Knowing the quantity and particle size distributions (or molecular weight distributions) of the DON and DOP in the effluent from the existing treatment facilities will assist in evaluating in greater detail potential treatment technologies that may be needed at the proposed SWWRF in the future. Under the current scope of work, Carollo will use published data on quantity of the DON and DOP in AWT effluents to screen several applicable “add-on” process technologies to recommend up to two process trains for each - surface water discharge to nearby lakes or direct aquifer recharge to supplement the PAR and RIB systems in the future.

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

TECHNICAL MEMORANDUM NO. 2

IDENTIFICATION OF ALTERNATIVE TREATMENT TECHNOLOGIES

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SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

IDENTIFICATION OF ALTERNATIVE TREATMENT TECHNOLOGIES

TECHNICAL MEMORANDUM
NO. 2

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IDENTIFICATION OF ALTERNATIVE TREATMENT TECHNOLOGIES

1.0 INTRODUCTION

Under Task Authorization (TA) 16 of Contract Y9-901, the Carollo team was retained by Orange County Utilities (OCU) to prepare a conceptual design for the proposed Southwest Water Reclamation Facility (SWWRF). This task includes a review and update of the previous Capital Improvements and Facilities Plan prepared for this plant. The SWWRF conceptual design will update near-term and long-term planning for the SWWRF including the selection of treatment technologies, conceptual design of the plant site, and facility phasing.

1.1 Background

The 2002 Water, Wastewater, and Reclaimed Water Master Plan (PBS&J) recommended a separate SWWRF by the year 2020 to serve the new Southwest Service Area (SWSA) and those portions of the South Service Area (SSA) west of I-4. Subsequently, the 2007 OCU Facilities Plan (PBS&J/CDM) further developed the concepts for a new SWWRF, including an estimate of the required maximum (build-out) treatment capacity through the year 2050 using the flow projections developed in the 2002 Master Plan. The 2007 Facilities Plan proposed three phases for implementing the SWWRF: two 5-mgd phases to be constructed by 2015, and a third 5-mgd phase to be constructed by 2025 to provide an ultimate total capacity of 15 mgd. Based on recommendations from an OCU Process Review Team (PRT) in 2007, the proposed SWWRF will use a three-stage biological nutrient removal (BNR) process coupled with membrane separation (a BNR/MBR process). MBR stands for membrane bioreactor, the name most commonly used for an activated sludge process using membrane separation.

1.2 Scope/Objectives of this Technical Memorandum (TM)

As part of this task, the previous 2007 Facilities Plan, particularly the selection of the BNR/MBR liquid treatment process, will be re-evaluated and updated as necessary. Currently, OCU owns and operates three regional water reclamation facilities. Each facility uses a conventional BNR treatment process such as the Modified Bardenpho™ process (EWRF), the Modified Ludzack-Ettinger (MLE) process (SWRF and NWRF), or Step-feed BNR process (SWRF) followed by secondary clarification, cloth disk or automatic backwash (ABW) sand filters, disinfection with chlorine gas or sodium hypochlorite solution, and effluent pumping.

This TM identifies a list of various BNR process configurations that could be used at the proposed SWWRF to satisfy the OCU determined treatment goals, and to meet current water quality requirements for land application and public access reuse (PAR). Further, these process configurations will be ranked using a set of non-economic parameters to identify the four that have the highest potential to be implemented at the proposed SWWRF.

The evaluations in this task will not include a review of technologies or unit processes for the headworks (i.e., pumping, screening, and grit removal), odor control, gravity secondary clarification, disinfection, and biosolids handling beyond identifying the expected quantity and quality of sludge to be produced by the various liquid treatment processes under evaluation.

1.3 Treatment Objectives/Anticipated Permit Requirements

Effluent from the initial phase of the SWWRF is anticipated to be used for PAR, with possible wet weather discharge to the Water Conserv II (WC II) Site 6 rapid infiltration basins (RIBs). Current rules of the Florida Department of Environmental Protection (FDEP) (Chap. 62-610, Florida Administrative Code, Reuse of Reclaimed Water and Land Application) require treatment to meet effluent water quality limits of 5 mg/L total suspended solids (TSS) 20 mg/L 5-day carbonarous biological oxygen demand ($cBOD_5$), and 12 mg/L nitrate-nitrogen (NO_3-N), and high level disinfection. Although the majority of RIB site 6 falls primarily within the Secondary Protection Zone for Wekiwa Springs, a portion of it is located in the Primary Protection Zone. The Wekiva Parkway and Protection Act (Title XXVIII, Chapter 369, Part II, Wekiva River Protection) states that when land application systems are located in two or more protection zones, the more stringent of the protection zone control measures shall apply to the entire application system. Through an affirmative demonstration previously submitted to the FDEP, the existing WCII RIB sites (including RIB site 6) are already exempt from the Wekiva Wastewater Rule requirements. New RIBs constructed to expand WCII or support OCU's SWWRF would need to meet this requirement only if located in the Wekiva Springs Study Area. If Wekiva Wastewater Rule constraints are not applicable, application to the RIBs only requires that the NO_3-N in the effluent be less than 12 mg/L. However, ground water (Upper Floridan Aquifer) samples collected from the new exploratory wells drilled as part of the ongoing well-field investigations for the new Malcolm Road Water Supply Facility (MRWSF) to be constructed in the vicinity of the SWWRF showed elevated nitrate concentrations (in the range of 4 mg/L). This nitrate is thought to be directly correlated to reclaimed water applied at WCII RIB Site 6. To alleviate any of the above issues and meet any future, and possibly more stringent treatment goals, OCU has implemented a policy that the initial phase of the SWWRF should be designed as an Advanced Wastewater Treatment (AWT) plant with effluent meeting a treatment goal of 5:5:3:1 (mg/L $cBOD_5$, TSS, Total Nitrogen (TN), and Total Phosphorus (TP), respectively).

1.4 Facility Location

OCU is currently in the process of acquiring a 50-acre parcel of property on the current WC II RIB Site 6, owned jointly by the City of Orlando and Orange County for the construction of the SWWRF. Figure 1 presents an aerial photograph of the property selected for the SWWRF. The site shown on Figure 1 is just north of the property that was shown to be the potential site in the 2007 Facilities Plan.

1.5 Technical Memorandum Organization

The main objective of this task is to identify the principal liquid treatment technologies to be used in the proposed SWWRF. The TM is organized as follows.

Section 1.0 – Introduction – This section provides an introduction to the project including project background, objective of this TM, treatment goals and anticipated permit limits, and the facility location for the proposed SWWRF.

Section 2.0 – Methodology for Selection of Process Configurations – This section presents a long list of nitrogen and phosphorus removal technologies. The list includes established technologies that have been proven at full-scale facilities. This section also provides the mandatory selection criteria to be used to narrow the long list of potential technologies to a short list of those that have the highest potential to meet the selection criteria. Finally, this section presents the working list of potential process configurations for further evaluation.

Section 3.0 – Description of Process Configurations for Further Evaluation – This section presents "Technology Fact Sheets" for each of the process configurations that are recommended to be considered for further evaluation. A fact sheet is a short document that includes a brief process description, a process flow schematic, and certain facts about the technology such as process reliability, major advantages and disadvantages, operational considerations, energy usage, footprint, and chemicals used.

Section 4.0 – Qualitative Evaluation Criteria – This section provides a list of non-cost parameters that will be used to compare the treatment technologies on the working list. The technologies on the working list will be compared in a weighted matrix evaluation using the selected evaluation criteria. The top four process configurations from the working list will be subjected to more detailed evaluations in subsequent tasks.

ORANGE COUNTY GOVERNMENT FLORIDA

TM 2 - IDENTIFICATION OF ALTERNATIVE TREATMENT TECHNOLOGIES

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AERIAL PHOTO OF THE PROPOSED LOCATION FOR THE SWWRF

FIGURE 1

2.0 SELECTION OF PROCESS CONFIGURATIONS

A long list was created of biological treatment technologies that are capable of removing nitrogen and phosphorus from municipal wastewater. The long list of technologies was then narrowed to a working list that includes only those technologies or combination of technologies that were judged to be capable of meeting the criteria established by OCU and the anticipated permit limits. The working list of potential process configurations was then qualitatively evaluated against a set of evaluation criteria judged to be important to OCU. Ten non-cost parameters were identified, as described in Section 4.0. These criteria will be used during the workshop to compare and rank the alternatives on the working list using a weighted matrix approach. The purpose of the qualitative evaluation of the working list is to narrow the working list to four configurations that will be evaluated in detail against the currently proposed BNR/MBR process configuration.

2.1 Preliminary List of Potential BNR Process Configurations

Municipal wastewater treatment plants in Florida mostly rely on a relatively small number of activated sludge processes incorporating multiple anaerobic and anoxic zones to remove nitrogen and phosphorus. From a global perspective; however, an amazingly large number of diverse process configurations have been devised to remove nutrients from municipal wastewater. To begin we created a long list of biological wastewater treatment technologies capable of removing nitrogen and phosphorus. We've only focused on biological processes since they have generally been proven to be more economical than physical/chemical processes for removal of nitrogen from municipal wastewater. Physical/ chemical nutrient removal processes have not been considered for this study other than the use of metal salts to precipitate phosphorus. (See Section 2.2). Similarly, land based technologies are also typically not used to remove nutrients from municipal domestic wastewater treatment plants and will not be considered further.

To facilitate selecting a nutrient removal process for the SWWRF, the technologies on the long list have been grouped according to a few of their primary physical characteristics including their use of microorganisms (suspended growth or attached growth) and their physical configurations (land based, aquatic, or mechanical facility). A graphical representation of this grouping of comparable biological treatment technologies for removal of nitrogen and phosphorus from wastewaters is provided in Figure 2.

The long list provides a broad spectrum of technologies that are well proven for municipal wastewater treatment. The technologies range from conventional single sludge process to lesser used multiple sludge, temporally phased, and attached growth methods.

Biological processes used to remove nitrogen and phosphorus must foster the growth of communities of microorganisms that provide certain basic functions. These functions are the oxidation of ammonia to nitrite or nitrate (nitrification), the reduction of nitrite (NO_2) or nitrate (NO_3) to nitrogen gas (denitrification), and the uptake of phosphorus in quantities greater than that required for normal growth (enhanced biological phosphorus removal). Even though different groups of microorganisms perform carbon oxidation and denitrification [ordinary heterotrophic organisms (OHO)], and nitrification [ammonia oxidizing bacteria (AOBs) and nitrite oxidizing bacteria (NOBs)], all three functions can be accomplished within the same process. Alternately, separate reactors or stages can be dedicated to each function, or carbon oxidation and nitrification can be combined in a separate process followed by denitrification as a subsequent process. Whenever significant denitrification must occur after carbon oxidation, supplemental carbon must be added to provide the carbon source for the OHOs.

Similarly, enhanced biological phosphorus removal (EBPR) can be achieved by providing an anaerobic zone followed by an aerobic zone encouraging the growth of phosphorus accumulating organisms (PAOs). Typical activated sludge biomass contains 1.5 to 2.5 percent phosphorus by weight in the volatile suspended solids. With enhanced biological phosphorus removal (EBPR) the biomass can accumulate phosphorus levels up to 6 to 8 percent by weight in the VSS. As a general rule of thumb, EBPR processes require an influent $cBOD_5$: TP ratio of at least 20:1 to reduce effluent phosphorus to less than 1.0 mg/L. In addition, the influent wastewater should contain short chain volatile fatty acids (VFAs), primarily acetic and propionic acids, in sufficient concentrations as these are the preferred substrates for PAOs.

Biological suspended growth systems can be distinguished between single sludge and multiple sludge systems depending on the location of the solids separation/clarification unit process. Single sludge systems can be further distinguished between process with multiple stages and those with multiple phases. Multiple stage systems are those processes with various combinations of anaerobic, anoxic, and aerobic reactors or zones but only one process for separating and recycling the mixed liquor suspended solids (MLSS). The differentiating features between BNR processes with multiple stages are primarily the number and sequence of the anaerobic, anoxic, and aerobic zones and the number and location of mixed liquor recycle streams. Accordingly, a two-stage single sludge system may include any combination of two anaerobic, anoxic, and aerobic stages while three-stage and higher systems include all three types of reactors in a particular sequence with appropriate mixed liquor recycle streams based on the targeted nutrient to be removed. While multiple stage processes typically provide physical separation of the stages, multiple phase systems use a single reactor but separate the stages in time using a pre-determined sequence of aeration and mixing to create anaerobic, anoxic, and aerobic modes. The modes or stages can be implemented according to a fixed time sequence or they can be started and stopped in response to online sensors measuring ammonia, nitrate, or dissolved oxygen concentrations.

Attached growth type systems use a stationary or moving media to support microbial growth on the surface of the media. Typically, wastewater is evenly distributed from the top or bottom of the reactor tank depending on the configuration as it flows across the stationary or moving media, and in the process is treated. The system configuration could be single stage where both $cBOD_5$ and nitrification occur in a single reactor or as a two-stage process where the first stage is used for $cBOD_5$ removal, and nitrification occurs in the second reactor. Alternately, the system can even be configured as a three-stage process where $cBOD_5$ is removed in the first stage, nitrification occurs in the second, and denitrification in the third stage. Attached growth systems typically have a very compact footprint compared to a suspended growth system due to the higher biomass concentrations that can be maintained.

Attached growth processes can be coupled with suspended growth processes to provide enhanced nutrient removal. Integrated Fixed Film Activated Sludge (IFAS) process is such a process where attached growth and suspended growth biomass is combined into the same reactor. In the IFAS process, floating or fixed media is introduced inside the aeration tanks. The combination of suspended and attached biomass results in an equivalent concentration of mixed liquor suspended solids that is significantly higher than for a suspended growth process alone. This provides two important benefits. First, the required volume of the aeration tank is substantially reduced. Second, the attached biomass places no additional load on the final clarifiers with the result that the solids loading to the clarifiers is substantially reduced from that imposed by a suspended growth process with the same SRT.

The Moving Bed Bioreactor (MBBR) process, although similar in appearance to an IFAS process, is an attached growth process where biofilm grows on the surface of an inert suspended media that is retained with the tank by screens or sieves. The distinguishing characteristic between IFAS and MBBR processes is the lack of return sludge in MBBR processes. As a result, the only significant biomass in the reactors is that attached to the media. The media can be used in either aerated or mixed tanks. In aerobic processes, the biofilm carriers are kept in suspension by the agitation created by air from diffusers, while in anoxic processes, mixers keep the carriers in motion. As with IFAS processes, an outlet sieve or screen is required to maintain floating media. The design of the sieves or screens depends on the type of carrier chosen, the hydraulic load, and whether the reactor is mixed by aeration or mixers.

Multiple sludge processes have two or three separate activated sludge systems in series, each with a set of clarifiers, where each stage is optimized for carbon oxidation, nitrification or denitrification, or some combination of treatment objectives. The same concepts can be implemented using either suspended or attached growth processes for individual stages.

Treatment facilities with sludge stabilization processes that provide significant destruction of biomass, such as anaerobic digestion, produce sidestreams with significantly elevated concentrations of nitrogen and phosphorus. When such sludges are dewatered, the resulting filtrate or centrate can contain a mass of nitrogen or phosphorus that is equivalent to 10% to 30% of the influent nutrient loads. Depending on the specific situation, treatment of the sidestreams to remove nutrients can be more economical than increasing the size of the main process to treat the incremental nutrient load. Several sidestream nutrient removal processes that use biological methods are also listed in Figure 2. In many sidestream processes, the nitrifiers grown in the sidestream process will enhance the performance of the mainstream nitrification process to which they are returned. In the simplest sidestream treatment processes, the nutrient rich sidestream is added to a separate reactor receiving all or a portion of the return activated sludge. Sufficient air, and alkalinity if needed, is introduced into the sidestream reactor to nitrify the ammonia nitrogen and the mixed liquor is then recycled back to the main treatment process. The primary benefit of bioaugmentation is to seed nitrifying organisms into the main treatment process. This reduces the volume of the aeration tank required by reducing the aerobic SRT needed to maintain an adequate inventory of nitrifiers in the process. If denitrification is desired in the side-stream process, an anoxic zone can be added with the addition of supplemental carbon to reduce the nitrate or NO_2 to nitrogen gas. Several of the newer sidestream processes used for nitrogen removal rely on maintaining an environment where the nitrification reaction is cut short to produce NO_2 from oxidation of ammonia, and also cultivating organisms that can reduce the nitrite to nitrogen gas. This reduces the overall operating cost of the system by reducing the quantity of air required for the oxidation of ammonia as well as decreasing the quantity of supplemental carbon required to reduce the nitrite to nitrogen gas. Other sidestream processes are designed to recover phosphorus, and in some instances nitrogen, for reuse as fertilizer. Sidestream processes designed to recycle nutrients typically use physical/chemical processes like precipitation, air stripping, or vacuum distillation.

A simple process flow diagram together with a brief summary of the capability of the technology for removing nitrogen and phosphorus is presented in Appendix A for most of the technologies listed in Figure 2.

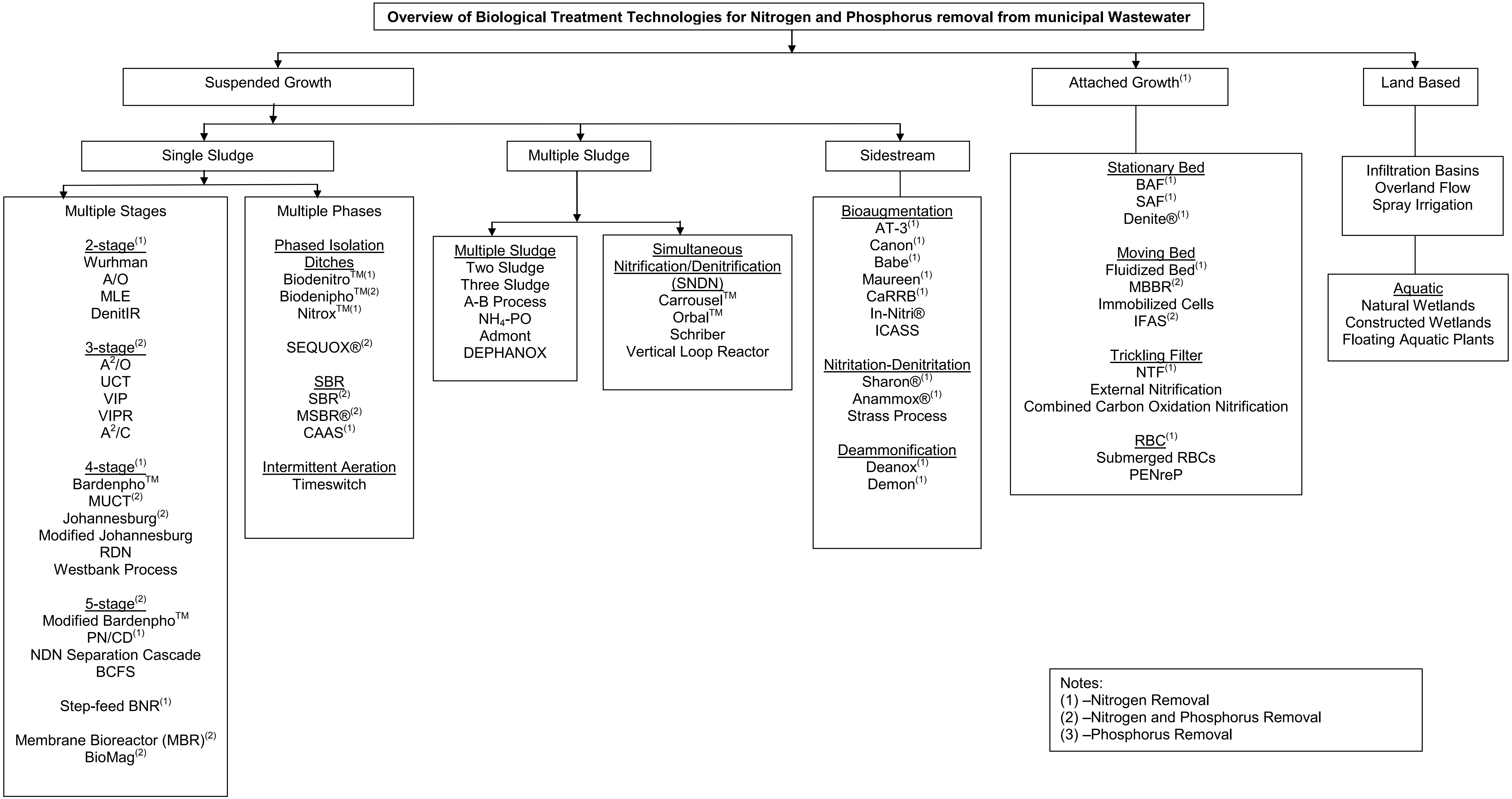


Figure 2 Overview of Biological Technologies for Nitrogen & Phosphorus Removal from Municipal Wastewater

2.2 Working List of Potential Biological Process Configurations

The working list of specific combinations of treatment technologies judged to have the best potential for meeting OCU requirements for the SWWRF is presented in Table 1. The following two criteria were used to select process configurations for the working list of treatment alternatives to be considered for further evaluation:

1. As determined by OCU, the initial phase of the facility should be designed to produce an effluent that meets the water quality requirements for PAR and Florida AWT.
2. Only process configurations were selected that have been used successfully at a similar size facility (5 mgd) for at least five years.

Since the solids handling systems for the SWWRF are yet to be determined, and because it's unlikely that the selected biosolids system will generate sidestreams with significant nutrient concentrations, sidestream treatment (treatment of plant recycles from biosolids treatment) are not considered as part of this analysis. Biological phosphorus removal was given preference with a provision to add a metal salt for effluent polishing to meet the TP goal of 1 mg/L.

**Table 1 Working List of Major BNR Process Configurations to Meet Florida AWT Water Quality Requirements
Identification of Alternative Treatment Technologies
Orange County Utilities**

Configuration No.	BNR Process Configuration
1	Three-stage activated sludge process such as A^2/O or UCT activated sludge process with secondary clarifiers followed by denitrification filters.
2	Five-stage BNR process such as Bardenpho™ with secondary clarifiers followed by disk filters.
3	Five-stage BNR process such as Bardenpho™ using an oxidation ditch with pre anaerobic and post anoxic zones with secondary clarifiers followed by disk filters.
4	Step-feed BNR process with post-anoxic zones with secondary clarifiers and disk filters with chemical P removal.
5	Five-stage BNR process such as Bardenpho™ with IFAS media with secondary clarifiers followed by disk filters.
6	Five-stage BNR process such as Bardenpho™ with secondary clarifiers followed by low-pressure tertiary membranes.
7	Five-stage MBBR process with dissolved air flotation solids separation followed by disk filters
8	Five-stage BNR process such as Bardenpho™ with MBR(2).

Notes:
(1) All process combinations assume chemical addition to trim effluent TP concentrations as needed.
(2). Configuration no. 8 was recommended in the 2007 Facilities Plan and will be considered as the base alternative for comparison.

The complete list of technologies described in this TM for both biological processes and filtration processes provide OCU a broad choice of options from which to choose. Table 1 can be modified to include any combinations as desired by OCU. The process configurations chosen for further evaluation should be sufficiently flexible to facilitate upgrading the Phase 1 SWWRF to meet more stringent effluent water quality limits, if necessary, at some future time.

2.3 Phosphorus Removal

Phosphorus can be removed from wastewater by biological mechanisms, by chemical precipitation, or by a combination of the two. Chemical precipitation will remove only the orthophosphate from wastewater. The colloidal and particulate portion will generally be removed during solids separation processes. Chemical precipitation can be very effective at achieving low phosphorus concentrations in the final effluent of a wastewater treatment facility. Iron or aluminum salts can be added upstream or downstream of biological processes. When the iron or aluminum salts are added upstream of the biological process, care must be taken to maintain a residual phosphorus concentration in the biological process as phosphorus is a necessary nutrient for cell growth. When the iron or aluminum salts are added downstream of the biological process, the dosage can be adjusted as necessary to ensure the desired effluent concentration is achieved. Phosphorus removal by chemical precipitation requires chemical storage and feed facilities. In addition, chemical precipitation produces metal hydroxides and phosphates that are inert to the biological system, and displace active biomass. When the metal salts is added after secondary clarification the precipitated solids increase the solids load on the filtration process. Accordingly, phosphorus removal by chemical precipitation increases solids handling and processing requirements, and increases solids disposal costs.

Based on anticipated average pollutant loadings to the SWWRF, as described in TM1 of this task authorization, a $cBOD_5$: TP ratio of approximately 40:1 is anticipated (average Influent $cBOD_5$ = 290 mg/L; average influent TP = 7.5 mg/L). Enhanced biological phosphorus removal (EBPR) using an anaerobic tank with chemical polishing would be the best choice in terms of phosphorus removal (to achieve an effluent TP limit of 1 mg/L) for SWWRF. Figure 3 shows a comparison of estimated present worth costs for EBPR versus chemical phosphorus removal based on process assumptions similar to those anticipated for the SWWRF. The evaluation of process alternatives assumes the use of biological phosphorus removal with chemical polishing as needed to achieve the proposed effluent TP goal of 1 mg/L.

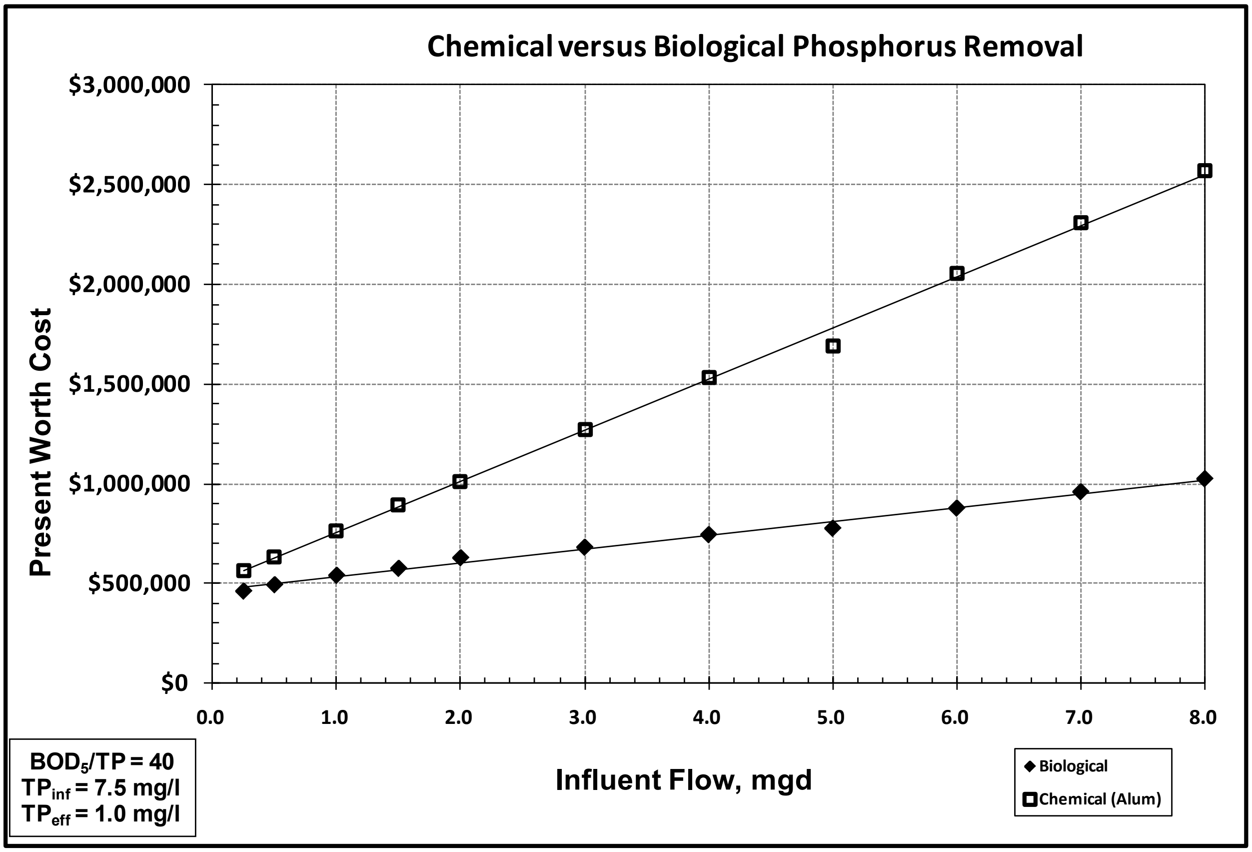


Figure 3 Estimated Present Worth Costs for Biological versus Chemical Phosphorus Removal at the Proposed SWWRF

2.4 Tertiary Filtration

Secondary effluent filtration will be necessary at SWWRF to produce an effluent that meets PAR requirements. Additionally, filtration will also be necessary to remove particulate nitrogen and phosphorus from the secondary treatment process to achieve the TN goal of 3 mg/L and TP goal of 1 mg/L. Typical filtration technologies available in the municipal market can be differentiated by filtration mechanisms: depth filtration, surface filtration, and membrane filtration. Figure 4 provides a listing of currently available filtration technologies according to the filtration mechanism on which they rely. A detailed description of various commercially available filtration technologies is presented in Appendix B of this TM.

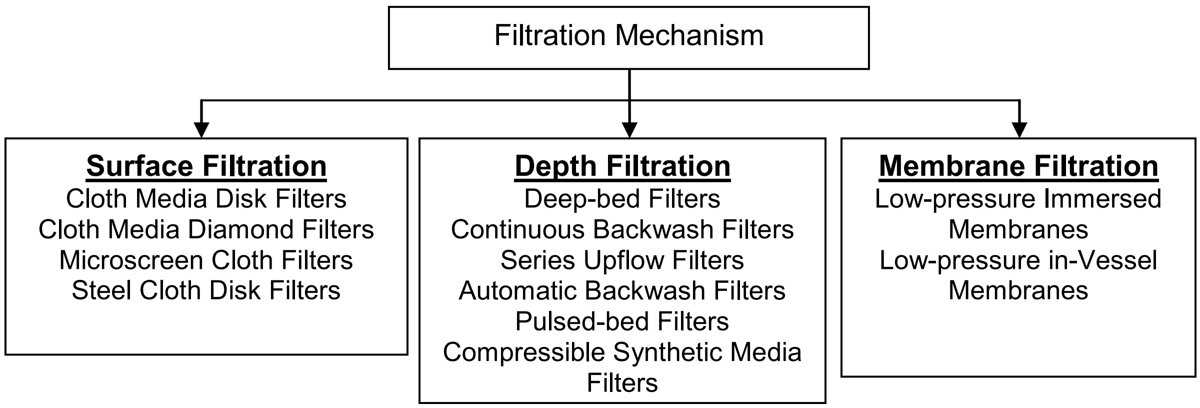


Figure 4 Wastewater Filtration Technologies Classified According to Filtration Mechanism

The emphasis on tertiary filtration is crucial since the goal of this alternatives analysis is to compare conventional processes with an MBR process, as proposed in the 2007 Facilities Plan. In general, the implementation of the BNR system in a conventional treatment system is nearly the same as in a MBR process. The biological reactors for the MBR alternative however, are much smaller, almost half the size of that of the conventional alternative, and operate at more than two times the MLSS concentration. The biggest difference between the two alternatives is the solids separation mechanisms. The conventional alternative relies on gravity settling in a secondary clarifier followed by depth or surface filtration. On the other hand, the MBR uses a low-pressure membrane filter to separate the biomass from the reclaimed water. Hence, the inherent differences in the solids separation mechanisms form the basis of the comparison of the two alternatives. A brief comparison of media characteristics and performance of several filtration technologies in terms of effluent water quality is presented in Appendix C of this TM.

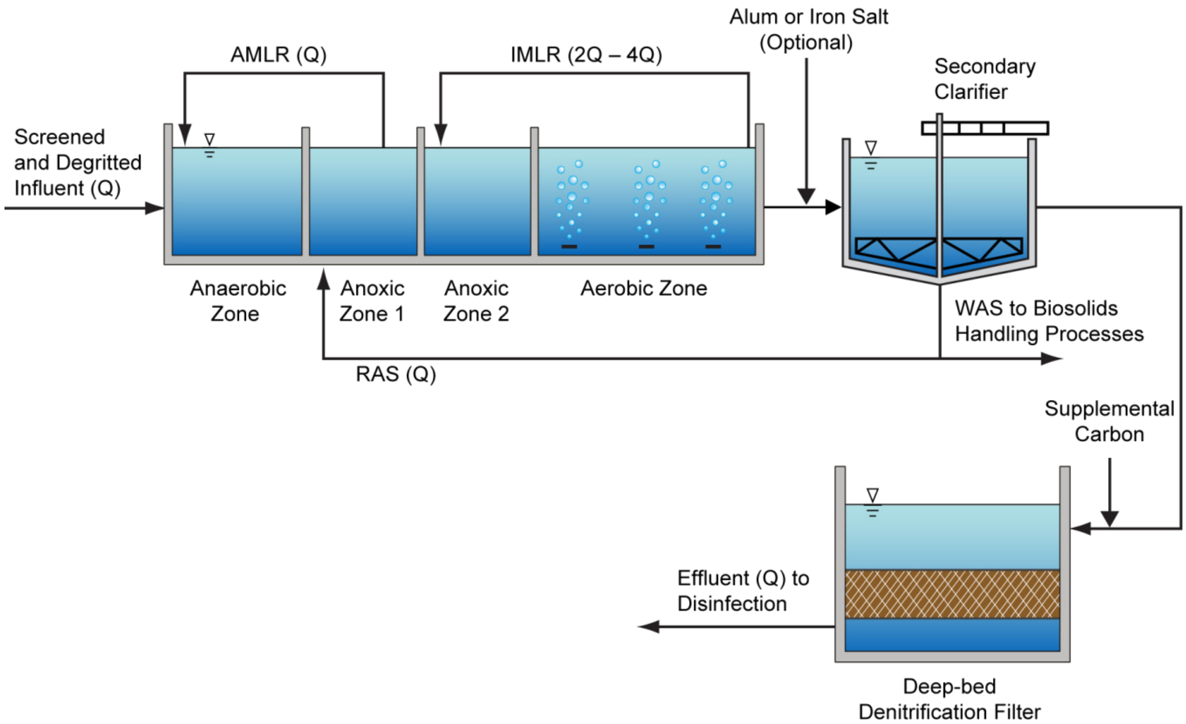
3.0 DESCRIPTION OF PROCESS CONFIGURATIONS PROPOSED FOR DETAILED EVALUATION

Technology fact sheets have been developed for each of the eight process configurations on the working list (see Table 1). Each fact sheet is a short document that provides a brief process description, a simplified process flow schematic, and basic facts about the technology such as perceived process reliability, major advantages and disadvantages, operational considerations, relative energy usage, footprint, sludge production, chemicals used, and impact on neighbors.

The emphasis in the process flow diagrams is to show the general arrangement of the various secondary and tertiary treatment unit processes including recycle streams.

Configuration 1 Technology Fact Sheet

Process Configuration 1 - Three-stage suspended growth BNR processes such as A^2/O, University of Cape Town (UCT), VIP, or the Modified University of Cape Town (MUCT) process followed by secondary clarifiers followed by denitrification filters



Process Schematic for Configuration 1

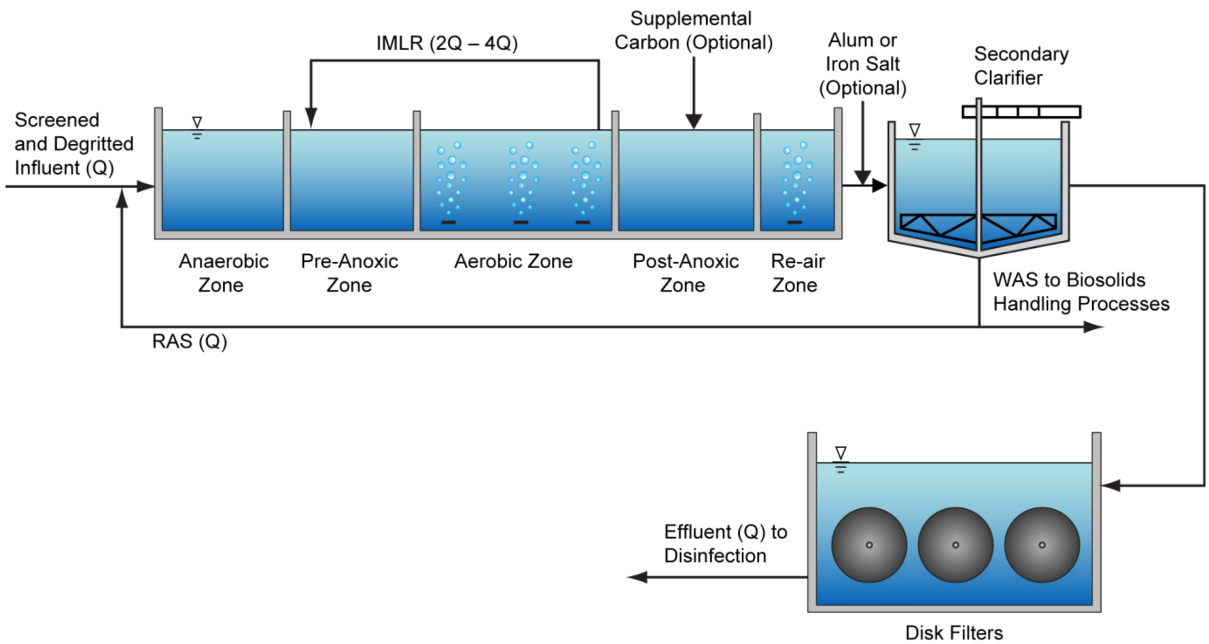
Process Description	Three-stage suspended growth processes use anaerobic, anoxic and aerobic stages to obtain both nitrogen and phosphorus removal. Three-stage process configurations consist of an anaerobic zone followed by an anoxic zone followed by an aerobic zone. The MUCT process is a modification of the UCT process where the anoxic zone is split into two smaller zones. A second internal recycle (AMLR) is added between anoxic zone 1 and the anaerobic zone. The RAS is recycled back to the anoxic zone. This process eliminates the recycle of nitrate-nitrogen to the anaerobic zone. Hence, this process provides more consistent EBPR. Typical IMLR rates vary from 2Q to 4Q (where Q is the influent flow). Higher IMLR rates provide marginal benefits and also increase the potential for dissolved oxygen recycle back to the anoxic zone. The effluent TN concentrations achievable with three-stage BNR

	processes are in the range of 6 – 10 mg/L. Hence an additional process downstream is required of the secondary clarifiers to reduce the TN to 3 mg/L. The use of denitrification filters provides this capability. The filters will also remove solids to meet the TSS limit of 5 mg/L.
Proprietary Process/Equipment	None known. No special or sole-source equipment required.
National Experience/Success	Sufficient. There are a number of plants using three-stage BNR processes. There are also numerous plants using denitrification deep-bed filters.
Process Reliability	Process is reliable and well proven. Performance data from a recently conducted national survey concluded that plants with a separate denitrification stage or a polishing step with supplemental carbon such as methanol allowed more precise control of effluent quality than other processes with single sludge flow sheets (like Bardenpho) offer.
Major Advantages	• Configuration can meet TN goal of 3 mg/L and TP goal of 1 mg/L. • Deep-bed filtration technology is more robust and reliable than most other types of filters.
Major Drawbacks	• MUCT process has two mixed liquor recycle streams in addition to RAS, and therefore requires more pumping equipment and power to operate the pumps. • Denitrification filters will require supplemental carbon. Methanol typically used as supplemental carbon, and this poses safety concerns.
Pre-Treatment Requirements	Traditional screening and grit removal. Similar to other OCU WRFs.
Operational Considerations	• Similar to other OCU WRFs with the exception of the filters. • Denitrification filters are a new process for OCU. • So far alternative supplemental carbon sources for denitrification filters have not worked well including Micro-C and others.

Chemical Requirements	• Methanol or equivalent supplemental carbon for the denitrification filters. • Standby use of alum or ferric chloride for phosphorus removal.
Footprint	Comparable to OCU's other WRFs
Residuals Management	Waste activated sludge with characteristics similar to other OCU WRFs
Energy Use	Literature value suggests energy usage would be around 2.0 – 2.4 kWh/kgal. Overall plant energy usage should be comparable to other OCU WRFs.
Ease Of Expansion/Upgrade	• Expansion requires the construction of parallel trains. • Upgrading the level of treatment requires the addition of tertiary treatment processes.
Impact On Neighbors	• Noise and odor comparable to other OCU WRFs • Increased truck traffic to deliver chemicals such as supplemental carbon for denitrification compared to other configurations.

Configuration 2 Technology Fact Sheet

Process Configuration - Five-stage BNR process such as Modified Bardenpho™ with secondary clarifiers followed by disk filters



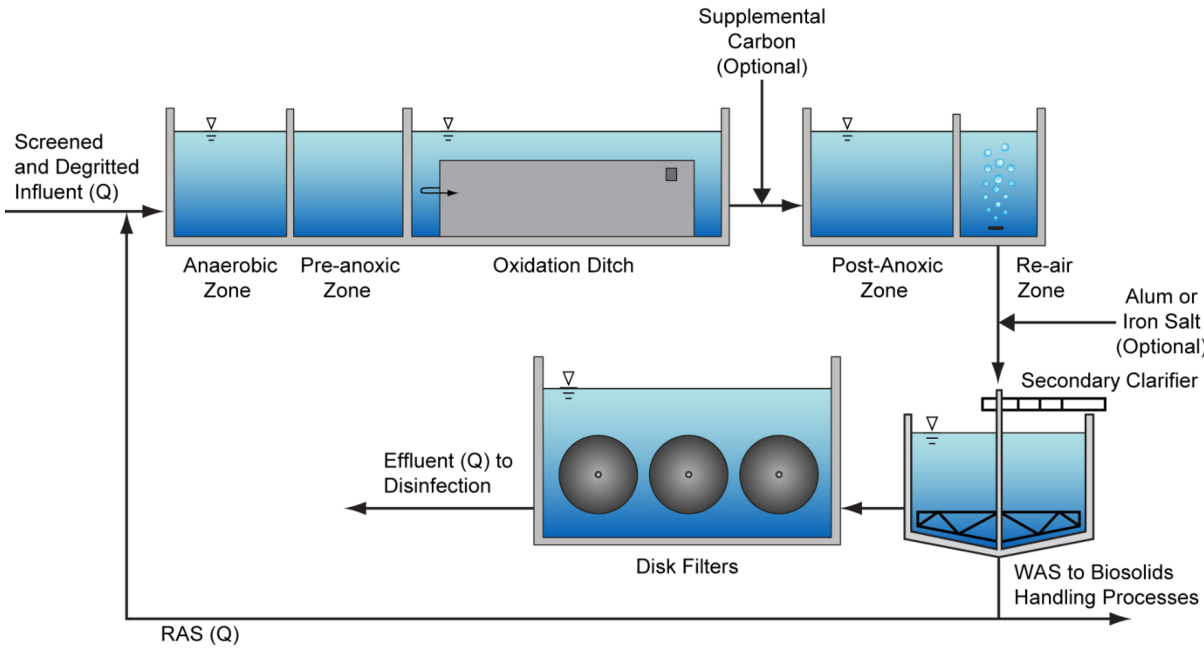
Process Schematic for Configuration 2

Process Description	The conventional Modified (five-stage) Bardenpho™ process consists of anaerobic, pre-anoxic, aerobic, post anoxic, and reaeration zones in sequence. Traditional gravity clarifiers separate the mixed liquor generated within the biological process. Suspended solids escaping the secondary clarifiers are further removed using disk filters. The anaerobic zone provides for the uptake of volatile fatty acids and release of orthophosphate. The mixed liquor then enters the pre-anoxic zone where the remaining $cBOD_5$ is used by heterotrophic bacteria to reduce the nitrates recycled back from the aerobic zone to nitrogen gas. The denitrification reaction rate within the second anoxic zone is generally endogenous and slower than that compared to the denitrification rate within the first anoxic zone upstream of the aerobic zone. However, the size of the second anoxic zone can be reduced with addition of external carbon source such as methanol or other forms of organic carbon. A small final aeration step is added after the second anoxic zone to strip nitrogen gas and to convert any ammonia released in the second anoxic zone to NO_3-N.The

	five-stage Bardenpho^{TM} process can consistently achieve effluent TN concentrations of less than 3 mg/L and a TP concentration of less than 1 mg/L. A simple filtration technology such as the cloth disk filters can provide the solids removal needed to achieve the TSS limit of 5 mg/L required for PAR.
Proprietary Process/Equipment	None known. No special sole-source equipment required
National Experience/Success	Many successful plants in Florida and elsewhere currently use the five-stage Bardenpho^{TM} process.
Process Reliability	Reliable and well proven. Several five-stage Bardenpho plants meet the monthly TN goal of 3 mg/L, 95% of the time.
Major Advantages	Configuration can consistently meet TN goal of 3 mg/L and TP goal of 1 mg/L.
Major Drawbacks	None compared to others.
Pre-Treatment Requirements	Traditional screening and grit removal. Similar to other OCU WRFs.
Operational Considerations	Similar to other OCU WRFs.
Chemical Requirements	Standby use of alum or ferric chloride for phosphorus removal.
Footprint	Comparable to OCU’s other WRFs based on plant capacity
Residuals Management	WAS similar to other OCU WRFs
Energy Use	Literature value suggests energy usage would be around 2.0 – 2.4 kWh/kgal. Overall plant energy usage should be comparable to other OCU WRFs.
Process Flexibility And Ease Of Expansion/Upgrade	• Expansion requires the construction of parallel trains. • Upgrading the level of treatment requires the addition of tertiary treatment processes.
Impact On Neighbors	• Noise and odor comparable to other OCU WRFs.

Configuration 3 Technology Fact Sheet

Process Configuration- Five-stage BNR process such as Modified Bardenpho™ using an oxidation ditch with pre-aeration and post aeration anoxic zones with secondary clarifiers followed by disk filters.



Process Schematic for Configuration 3

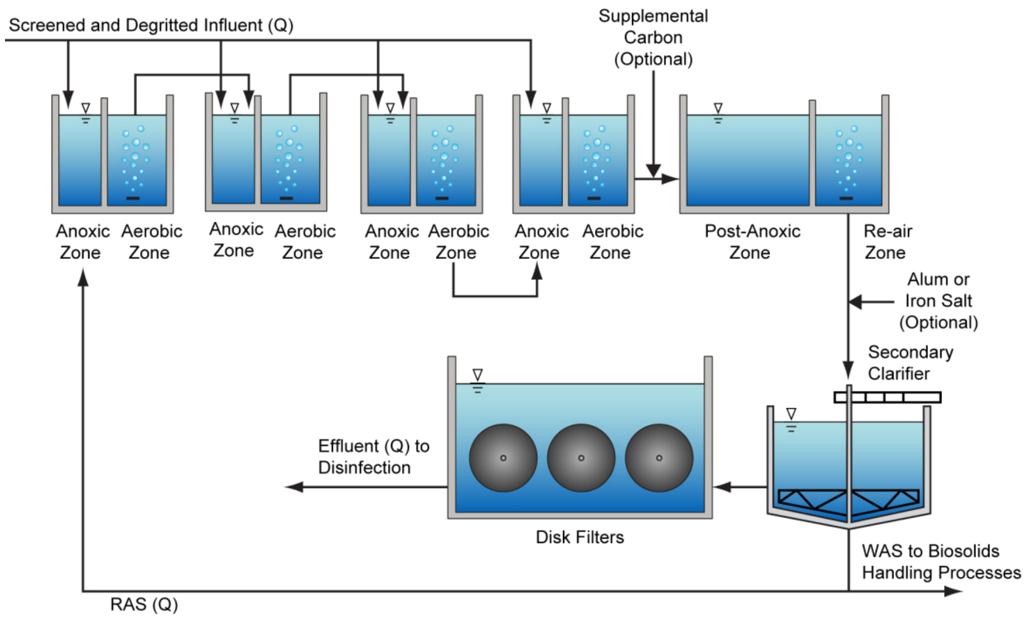
Process Description	An oxidation ditch is a specific arrangement of the activated sludge reactor with a long single channel, or multi-channels, that are looped to form a continuous oval, ring or horseshoe shaped reactor. Due to this configuration and the method of aeration, oxidation ditches often provide a significant amount of simultaneous nitrification-denitrification. An oxidation ditch can be configured to provide nutrient removal by addition of anaerobic and anoxic zones upstream and downstream of the ditch, or by operating at low dissolved oxygen concentrations so that simultaneous nitrification and denitrification is allowed to occur. Alternately, as is the case for phased isolation ditches, aerobic and anoxic environments are created by turning the aeration off and on. The oxidation ditches have shown excellent capability to provide simultaneous nitrification/denitrification within the same reactor and recent data supports this claim. Provision of an upstream anaerobic zone provides the conditions needed for EBPR. Post anoxic tanks will be used to denitrify the wastewater to achieve the

	TN goal of 3 mg/L. Secondary clarifiers will be used to separate mixed liquor suspended solids. Suspended solids escaping the secondary clarifiers are further removed using disk filters. The denitrification reaction rate within the second anoxic zone is generally endogenous and slower than that compared to the denitrification rate within the first anoxic zone upstream of the aerobic zone. However, the size of the second anoxic zone can be reduced with addition of external carbon source such as methanol or other forms of organic carbon.
Proprietary Process/Equipment	Some oxidation ditch process configurations are proprietary processes with patents either expired or in-place.
National Experience/Success	Several successful plants in Florida and elsewhere.
Process Reliability	Well proven and reliable process. The Kalkaska, Michigan plant (a cold climate plant) has shown good performance reaching very close to 3 mg/L TN on a 95th percentile monthly basis.
Major Advantages	• Configuration can meet TN goal of 3 mg/L and TP goal of 1 mg/L. • An oxidation ditch process is a very robust and reliable process configuration.
Major Drawbacks	Process requires timer or sensor based controls to vary process conditions and motor operated values or gates to change flow directions.
Pre-Treatment Requirements	Traditional screening and grit removal. Similar to other OCU WRFs.
Operational Considerations	Aspects are similar to other OCU WRFs.
Chemical Requirements	Standby use of alum or ferric chloride for phosphorus removal.
Footprint	Comparable to OCU's other WRFs based on plant capacity
Residuals Management	WAS produced will be similar to other OCU WRFs

Energy Use	Energy use depends on the type of aeration equipment provided, and the potential to control short-cut nitrification. Literature suggests average energy consumption in the range of 1.8 – 3.9 kWh/kgal.
Process Flexibility And Ease Of Expansion/Upgrade	• Expansion requires the construction of parallel trains. • Upgrading the level of treatment requires the addition of tertiary treatment processes.
Impact On Neighbors	• Noise and odor comparable to other OCU WRFs

Configuration 4 Technology Fact Sheet

Process Configuration: Step-feed BNR process with post-anoxic zones, secondary clarifiers and disk filters with chemical P removal.



Process Schematic for Configuration 4

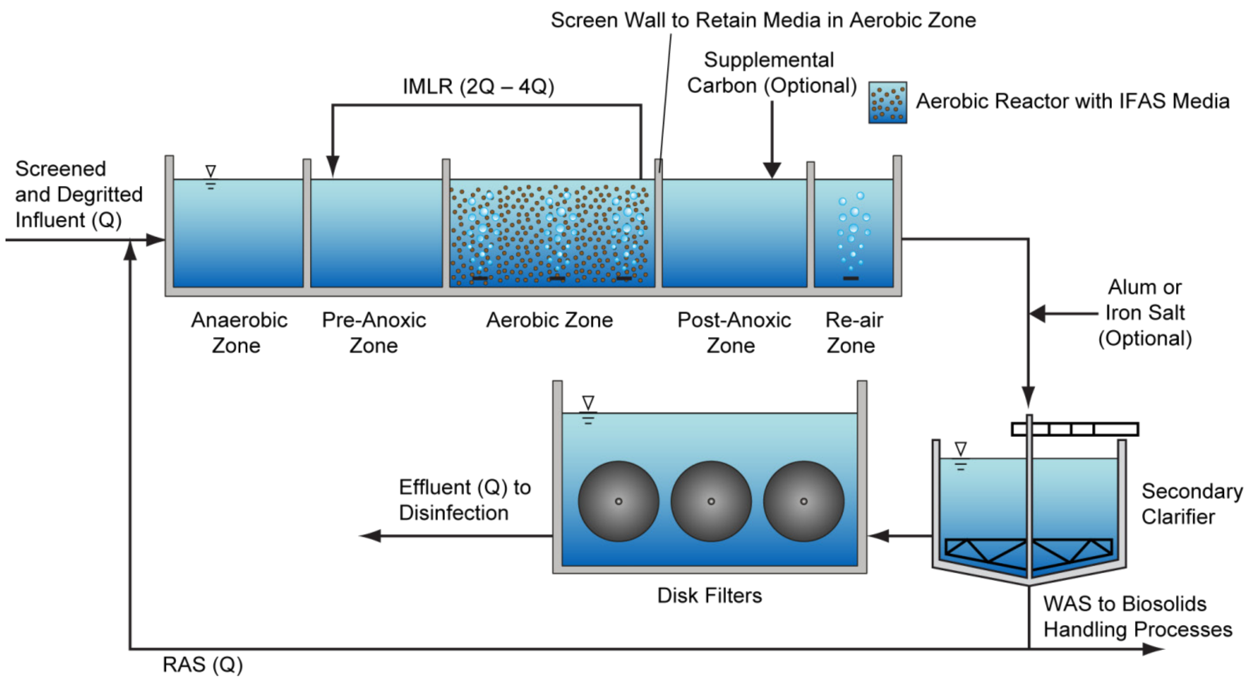
Process Description	Step-feed BNR is a specific arrangement of an activated sludge reactor where the feed is split and distributed to multiple locations within the process tank. Step-feed was original developed to equalize the spatial distribution of the oxygen demand throughout the aeration tank. However, the split feed arrangement also creates a gradient in the MLSS concentration with the highest concentration occurring in the first pass with the MLSS concentration reducing after each subsequent feed point in proportion to the dilution factor of the feed added at each feed point. As a result the total biomass inventory in a step-feed bioreactor is significantly higher than in a conventional bioreactor of the same volume with one feed point at the beginning of the tank. The Step-feed BNR process configuration uses unaerated zones at each feed point thus creating a sequence of anoxic/anaerobic and aerobic zones along the length of the bioreactor. Post anoxic tanks are needed to achieve the TN goal of 3 mg/L. A small re-aeration zone will strip nitrogen bubbles from the biomass and nitrify any residual ammonia created in the post anoxic zone. Secondary clarifiers will be used to separate mixed liquor. Suspended solids escaping the secondary clarifiers are further

	removed using disk filters. The denitrification reaction rate in the second anoxic zone is generally endogenous and slower than that compared to the denitrification rate within the first anoxic zone upstream of the aerobic zone. However, the size of the second anoxic zone can be reduced with addition of external carbon source such as methanol or other forms of organic carbon. A metal salt will be added to remove phosphorus as needed
Proprietary Process/Equipment	None known. No special sole-source equipment required
National Experience/Success	Several successful plants in Florida and elsewhere use step-feed BNR to meet limits of 8-12 mg/L TN. It's use with a post aeration anoxic tank to meet limits of 3 mg/L TN is limited.
Process Reliability	Well proven for meeting limits of 8-12 mg/L TN.
Major Advantages	• Volume of process tanks is reduced as compared to other activated sludge process configurations for the same design SRT and loading. • Solids loading on the clarifiers is the same as for a conventional bioreactor even though the process carries a higher inventory of MLSS. • No mixed liquor recycle required.
Major Drawbacks	Proper design and operation required to ensure complete nitrification.
Pre-Treatment Requirements	Traditional screening and grit removal. Similar to other OCU WRFs.
Operational Considerations	Similar to other OCU WRFs.
Chemical Requirements	Use of chemical phosphorus removal may be preferred depending on the expected ability to attain EBPR.
Footprint	Smaller footprint than most other activated sludge processes with the exception of contact stabilization, MBRs, IFAS and MBBR.
Residuals Management	WAS produced will be similar to other OCU WRFs.
Energy Use	Comparable to OCUs EWRF.

Process Flexibility And Ease Of Expansion/Upgrade	• Expansion requires the construction of parallel trains. • Upgrading the level of treatment requires the addition of tertiary treatment processes.
Impact On Neighbors	• Noise and odor comparable to other OCU WRFs • Increased truck traffic due to chemical deliveries for chemical phosphorus removal compared to other configurations.

Configuration 5 Technology Fact Sheet

Process Configuration: Five-stage BNR process such as Modified Bardenpho™ with IFAS media, secondary clarifiers followed by disk filters.



Process Schematic for Configuration 5

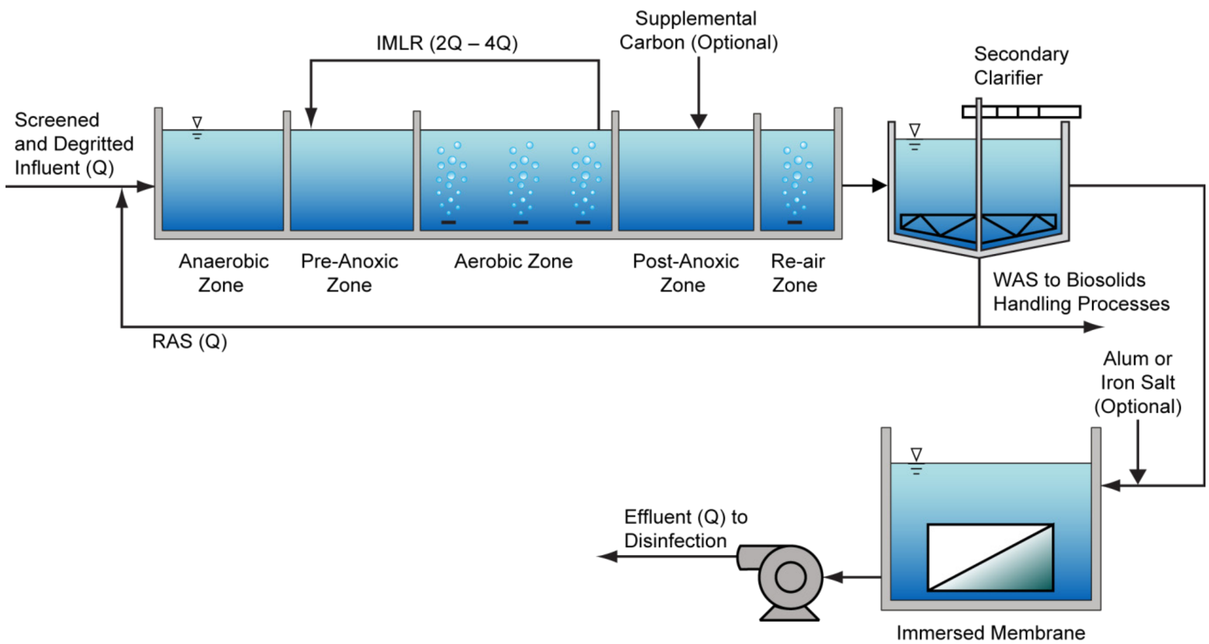
Process Description	An IFAS process is a hybrid process where the biomass in the process is a combination of suspended and attached growth. By adding stationary or floating media to the aeration tank, the size of the tank and the solids loading on the clarifiers is considerably reduced. The equivalent mixed liquor concentration attained by adding the media to the tank is significantly higher than can be maintained in a suspended growth process alone. IFAS process with floating media must use screens at the effluent from each tank to retain the media.
Proprietary Process/Equipment	Several vendors provide IFAS media and equipment; however, most of unique and proprietary. Available types of media include rope, sponge carriers, hard plastic carriers, trickling filter media, and flat sheets.

National Experience/Success	Much more wide spread in Europe although its use in the USA is growing.
Process Reliability	Reliable process.
Major Advantages	• Solids loading to secondary clarifiers reduced since fraction of biomass retained in aeration basins. • Volume of process tanks is reduced.
Major Drawbacks	• Requires coarse bubble diffuser aeration system for aerobic reactor. • Screens required to retain media. May require additional pumping to move media away from screens.
Pre-Treatment Requirements	Requires fine screens (< 6 mm) and preferably primary treatment to remove large particulate matter that tends to clog media and media-capture screens.
Operational Considerations	• Wear rate of media: normal life expectancy is 10-30 years depending on the type of media. • Screens impose additional hydraulic head loss • Potential for screen plugging • Maintenance of aeration system: media must be removed from system and displaced during maintenance.
Chemical Requirements	Standby use of alum or ferric chloride for phosphorus removal.
Footprint	Smaller footprint than most activated sludge configurations other than MBR.
Residuals Management	WAS produced will be similar to that from other OCU WRFs
Energy Use	Comparatively energy inefficient. The attached biomass requires that a higher dissolved oxygen concentration be maintained than for comparable suspended growth processes thus lowering the field oxygen transfer efficiency.

Process Flexibility And Ease Of Expansion/Upgrade	• Depending on the initial design, capacity may be increased by adding additional media. Otherwise, expansion requires the construction of parallel trains. • Upgrading the level of treatment requires the addition of tertiary treatment processes.`
Impact On Neighbors	• Noise and odor comparable to other OCU WRFs.

Configuration 6 Technology Fact Sheet

Process Configuration: Five-stage BNR process such as Modified Bardenpho™ with secondary clarifiers followed by low-pressure tertiary membranes.

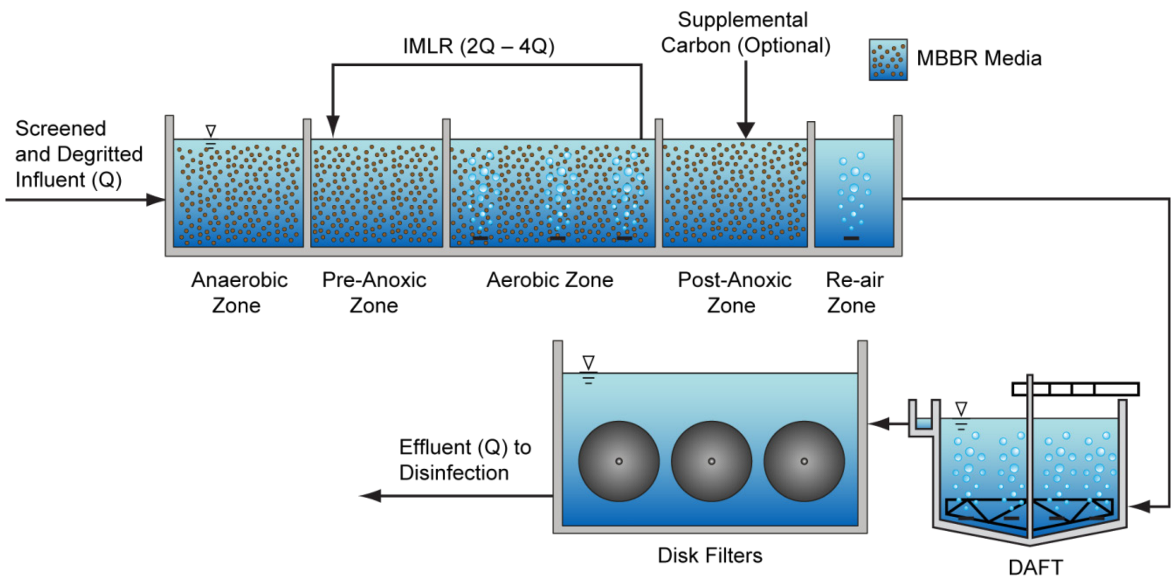


Process Schematic for Configuration 6

Process Description	This process configuration is very similar to configuration no. 2 except that the disk filters have been replaced with tertiary low-pressure membranes. Tertiary membranes are less energy intensive as compared to the MBR process as they do not require continuous air scour to control fouling of the membranes, and are operated at much higher flux (20 - 40 gfd compared to 8-15 gfd for MBRs). The effluent quality from tertiary membrane filters and MBRs is the same.
Proprietary Process/Equipment	None known.
National Experience/Success	The number of municipal plants using membrane technology is growing at a rapid rate. The largest plant using tertiary membranes is a 70 mgd plant near Atlanta, GA.
Process Reliability	Reliable process.

Major Advantages	• Very high quality effluent. • Membrane process is automated.
Major Drawbacks	• More mechanical equipment. • More chemical usage to keep membranes clean. • More pumping than conventional process. • Redundancy is key – more membranes needed to handle wet weather flow.
Pre-Treatment Requirements	Requires fine screening (< 2 mm) to remove fine solids including hair and fibers.
Operational Considerations	• More mechanical equipment to maintain • Membrane process is automated. • Periodic (every 4 to 8 weeks) membrane cleaning required.
Chemical Requirements	• Sodium hypochlorite and citric acid for chemical cleaning of membranes. • Standby use of alum or ferric chloride for phosphorus removal.
Footprint	The biological activated sludge process has a very similar footprint to the other process configurations discussed above. Tertiary membrane filters would require a larger footprint as compared with disk filters.
Residuals Management	WAS produced will be similar to that from other OCU WRFs
Energy Use	Slightly higher than for a process with disk or granular media filters since head requirements are higher.
Process Flexibility And Ease Of Expansion/Upgrade	• Expansion requires the construction of additional process trains and membrane units. • Upgrading the level of treatment could be easier than for processes with disk or granular media filtration since the water quality is sufficient to feed directly to high-pressure membranes.
Impact On Neighbors	• Noise and odor comparable to other OCU WRFs • Increased truck traffic compared to other OCU WRFs to deliver chemicals for cleaning membranes, and phosphorus removal.

Process Configuration: Five-stage MBBR BNR process such as Modified Bardenpho™ with DAFTs and disk filters.



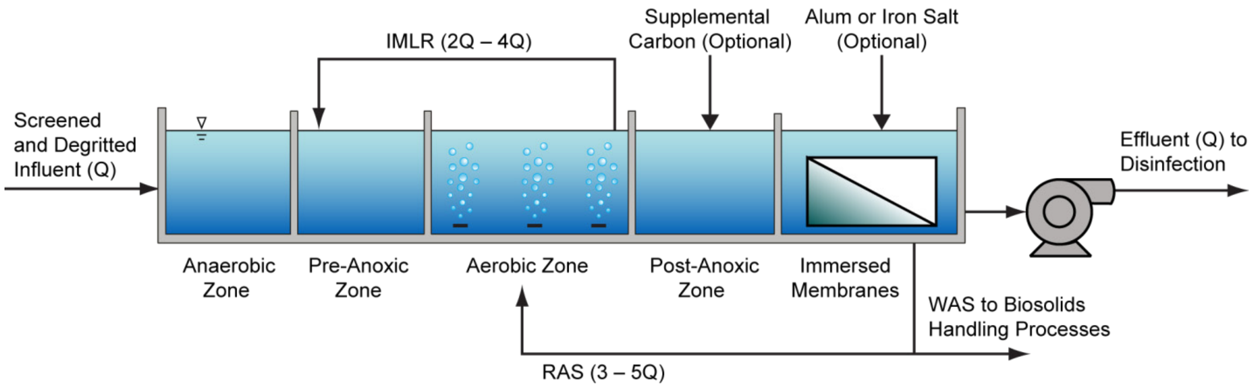
Process Schematic for Configuration 7

Process Description	The moving bed bioreactor (MBBR) process is an attached growth process which is similar in appearance and configuration to the IFAS process. Anaerobic, anoxic, and aerobic zones can be created in MBBR processes in a manner analogous to conventional BNR processes. In aerobic reactors the biofilm carriers are kept in suspension by the agitation created by air from aeration diffusers, while in anoxic reactors mixers keep the carriers in motion. A MBBR process is much simpler to operate as compared to activated sludge processes as there is no return activated sludge (RAS) or SRT control. The solids generated in the process can be separated from the treated water by clarification or flotation.
Proprietary Process/Equipment	Several vendors provide media and equipment; however, most are unique and proprietary. Free floating, hard plastic media has been most commonly used.
National Experience/Success	Much more widely used in Northern Europe than in the USA.

Process Reliability	Largely unknown at present as there are no full-scale operating plants in the USA treating to AWT standards.
Major Advantages	• No RAS pumping • Less sludge production • Volume of process tanks is reduced.
Major Drawbacks	• Requires coarse bubble diffuser aeration system for aerobic reactors. • Screens required to retain media in bioreactors – adds hydraulic head loss. May require additional pumping.
Pre-Treatment Requirements	Requires fine screens (< 3 mm) and preferably primary treatment to remove large particulate matters that tend to clog media and media-capture screen.
Operational Considerations	• Wear rate of media: normal life expectancy is 10-30 years depending on the type of media. • Screens impose additional hydraulic head loss • Potential for screen plugging • Maintenance of aeration system: media must be removed from system and displaced during maintenance.
Chemical Requirements	Standby use of alum or ferric chloride for phosphorus removal.
Footprint	Smaller footprint than most activated sludge configurations other than MBR
Residuals Management	As an attached growth process, sludge production and management would be less as compared to other configurations.
Energy Use	Comparatively energy inefficient. The attached biomass requires that a higher dissolved oxygen concentration be maintained than for comparable suspended growth processes thus lowering the field oxygen transfer efficiency.
Process Flexibility And Ease Of Expansion/Upgrade	• Depending on the initial design capacity may be increased by adding additional media. Otherwise, expansion requires the construction of parallel trains. • Upgrading the level of treatment requires the addition of tertiary treatment processes.
Impact On Neighbors	• Smaller footprint can provide less visual impact • Noise and odors comparable to other OCU WRFs.

Configuration 8 Technology Fact Sheet

Process Configuration: Five-stage BNR process such as Modified Bardenpho™ with MBR – Base Alternative.



Process Schematic for Configuration 8

Process Description	The membrane bioreactor (MBR) process couples the activated sludge process with low-pressure membranes. The membranes provide solids separation, and replace the secondary clarification and tertiary filtration processes with one process. The upstream biological treatment process is nearly the same – a five-stage Bardenpho™ process. However, the reactor size is almost half that of conventional treatment since most MBR processes operate at very high MLSS concentrations – in the range of 6,000 to 10,000 mg/L.
Proprietary Process/Equipment	Each membrane system is unique and proprietary.
National Experience/Success	Over 100 municipal treatment plants worldwide use an MBR process.
Process Reliability	Fairly reliable process.
Major Advantages	• Small footprint. Operates at high MLSS concentrations. • Very high quality effluent. • Membrane process is typically automated.

Major Drawbacks	• More mechanical equipment. • Energy intensive • More chemical usage to keep membranes clean. • More pumping than conventional process. • Units susceptible to foam and scum entrapment. • Redundancy is key – need more membranes to handle wet weather flow
Pre-Treatment Requirements	Requires fine screening (< 2 mm) to remove fine solids such as hair and fibers.
Operational Considerations	• More mechanical equipment to maintain • Membrane process is typically automated. • Periodic membrane cleaning will be required. • Reliable access to membrane is key.
Chemical Requirements	• Sodium hypochlorite and citric acid for chemical cleaning of membranes. • Standby use of alum or ferric chloride for phosphorus removal.
Footprint	Smallest footprint of any proven full-scale biological treatment technology.
Residuals Management	WAS produced will be similar to other OCU WRFs
Energy Use	MBRs are energy intensive. Literature suggests energy consumption is higher than most other available treatment technologies.
Process Flexibility And Ease Of Expansion/Upgrade	• Expansion requires the construction of additional process trains and membrane units. • Upgrading the level of treatment could be easier than for processes with disk or granular media filtration since the water quality is sufficient to feed directly to high-pressure membranes.
Impact On Neighbors	• More blowers resulting in more noise. • Relatively more aeration producing musty odors • Can be housed inside a building to provide a barrier for visual, noise and odor impacts due to the extremely small footprint.

4.0 QUALITATIVE EVALUATION CRITERIA

Table 2 provides a suggested list of eleven non-economic factors to be used to compare the working list of process configurations. Information presented in Table 3 was used to receive input from OCU at Workshop No. 2, held on April 29, 2011 and formed the basis for the alternatives ranking analysis as described below.

Table 2 Process Evaluation Criteria and Brief Evaluation of Alternatives
Identification of Alternative Treatment Technologies
Orange County Utilities

	Potential Screening Criterion	**Configuration No.1** Three-stage BNR process, secondary clarifiers and denitrification filters.	**Configuration No.2** Five-stage BNR process, secondary clarifiers and disk filters	**Configuration No.3** Five-stage BNR using an oxidation ditch with secondary clarifiers and disk filters	**Configuration No.4** Step-feed BNR process with post-anoxic zones, secondary clarifiers and disk filters with Chemical P	**Configuration No.5** Five-stage IFAS / BNR process with secondary clarifiers and disk filters	**Configuration No.6** Five-stage BNR process with low-pressure tertiary membranes	**Configuration No.7** Five-stage MBBR / BNR process with DAFs and disk filters	**Configuration No.8** Five-stage BNR / MBR process **Base Alternative**
1	Plant Footprint	Slightly smaller footprint compared to configuration 2	Larger footprint compared to configuration 5	Largest footprint	Larger footprint compared to configuration 5	Slightly larger footprint compared to configuration 7	Larger footprint. compared to OCU's existing WRFs	Slightly larger footprint compared to configuration 8	Smallest footprint
2	National Experience/Success	Few	Extensive	Extensive	Few	Very few	Moderate	Very few	Moderate
3	Similarity With Processes Used In Plants Currently Owned And Operated By OCU	Some similarities	Very similar	Very similar	Very similar	Some similarities	Some similarities	None	None
4	Operation Considerations (Equipment To Maintain, Staffing Levels, Automation)	Simple	Simple	Simple	Simple	Complex	Complex	Complex	Complex
5	Plant Automation	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple
6	Dependable Compliance Or Process Reliability	Good	Excellent	Very Good	Good	Good	Excellent	Excellent	Excellent
7	Chemical Use	High	Minor	Minor	High	Minor	Moderate.	Moderate	Moderate.
8	Energy Use	Moderate	Moderate	High	Moderate	High	Higher	Higher	Highest
9	Residuals Management	Comparable to OCU's existing WRFs	Comparable to OCU's existing WRFs	Comparable to OCU's existing WRFs	Comparable to OCU's existing WRFs	Comparable to OCU's existing WRFs	Comparable to OCU's existing WRFs	Slightly Less than OCU's existing WRFs	Comparable to OCU's existing WRFs
10	Impact On Neighbors (Noise Odor, Truck Traffic And Aesthetics)	Moderate	Less	Less	Moderate	Less	Less	Less	Less
11	Effluent Water Quality	Very Good	Good	Good	Good	Good	Excellent	Good	Excellent

4.1 Process Evaluation Criteria

Process reliability can be defined as the ability to meet the specified requirements based on the known and reported performance from other facilities as available.

In general, the two major sources of energy consumption in an activated sludge treatment plant are aeration and pumping. Together these two functions consume almost 60 – 70% of the total energy consumption of a wastewater treatment plant. BNR treatment processes with mixed liquor recycle streams consume slightly more energy than conventional activated sludge processes for pumping; however, the oxygen credit from increased denitrification and the increased oxygen transfer efficiency resulting from operating at longer SRT can result in an overall reduction in power demand. The Electric Power Research Institute (EPRI) has been conducting energy audits at water and wastewater treatment plants for over a decade, and Table 3 provides the energy consumption reported in several studies for wastewater treatment plants employing various unit processes.

**Table 3 Literature Values of Energy Consumption for Wastewater Treatment by Facility Type (EPRI 1994, EPRI 1996; ECW 2002; Pearce 2008)
Identification of Alternative Treatment Technologies
Orange County Utilities**

Wastewater Treatment Facility Type	Energy Consumption (kWh/kgal)	Typical Range (kWh/kgal)
Lagoons	0.8	0.3 - 1.2
Trickling Filter	1.0	0.7 - 1.6
Activated Sludge	1.7	1.3 - 2.4
Advanced Treatment W/Nitrification	1.9	Not available
Oxidation Ditch / Extended Aeration	2.9	1.8 - 3.9
Membrane Bioreactors	3.7[a]	4.5 - 5.6[b]

Notes:
(1) Data for Large MBR plants (> 5 mgd).
(2) Data for Small MBR plants (< 1 mgd).

Similarly, the SRT and the MLSS concentration determine the overall footprint of the secondary treatment process. Here too, BNR treatment processes require a slightly bigger footprint as the SRT required to achieve complete nitrification is more than just carbon oxidation. Also, activated sludge processes with secondary clarifiers and tertiary media filters require more space than those coupled with a membrane as for MBRs.

Sludge production is also a function of the SRT; the higher the SRT, the lower the microbial yield and thus the lower the sludge production. Similarly, use of chemicals such as alum or iron salts produces additional sludge that must be handled and disposed.

Chemical usage is another major component of operations and maintenance cost. In addition, the presence of chemical storage and handling facilities can present significant health and safety concerns for the operating staff. Considering the proposed use of EBPR and the anticipated strength of the influent wastewater, the use of alum or iron salts should be low. Similarly, achieving an effluent TN goal of 3 mg/L should not require supplemental carbon given the high anticipated $cBOD_5$ to TKN ratio (> 6). In addition, the warm climate and generally flat terrain promote the generation of VFAs in the collection and transmission system. The presence of relatively high concentrations of VFAs can foster the growth of PAOs for EBPR and provide readily available carbon for denitrification. However, those process configurations with the denitrification process located after the main aeration zone, such as denitrification filters, will still require the use of supplemental carbon. Membrane treatment processes require periodic chemical cleaning (sodium hypochlorite and citric acid) to control fouling of the membranes.

Evaluation of the operations and maintenance requirements for each configuration needs to consider things like the number of unit processes, the number and type of routine control adjustments required (RAS, WAS, air, etc.); the ability to automate the process (manual only, automation required), the types of mechanical equipment used (blowers, pumps, aerators, valves, screens, generators, etc.), the numbers of installed pieces of equipment, adjustments needed to handle to peak flows, necessity of obtaining accurate flow splits, the availability of spare parts, and the availability of repair personnel.

Treatment plants affect their neighbors because of odors and noise generated by the treatment facilities, and by the physical appearance of the property relative to the surrounding land uses. All wastewater treatment plants will generate odors from headworks and sludge handling. Processes with higher air use will generate larger volumes of air with musty odors. Processes that use chemicals or produce larger volumes of sludge will produce more truck traffic. Processes with bigger structures, deeper tanks or higher structures will have more visual impact. Processes with more mechanical equipment, and especially those that have large motors that run all the time, will generate more noise.

4.2 Process Evaluation Criteria Scoring

The above information was presented to OCU team at Workshop No. 2. The goal of the workshop was to discuss each criteria and it’s significance on the process selection and rank each of the eight process configurations to select up to four process configurations in addition to the five-stage BNR/MBR alternative (called as the Base Alternative) as recommended in the 2007.

The evaluation criteria (table 2) was assigned a weighted value from one to eleven based on the overall significance of the criterion on the process selection. The criteria with most significance received a weight of eleven and those with the least significance received a weight of one. Each process configuration was individually scored on a scale of one to five depending on how the configuration would perform against that criterion with one being the least favorable and five being the most favorable.

The estimates for power consumption were converted to a numeric score based on a linear interpolation between the lowest estimate and the highest estimate. Other qualitative criteria were scored based on a combination of published past performance data and the subjective opinion of the Carollo team with input from the OCU staff at the Workshop. The numeric scores for these criteria were then included in the matrix scoring table.

The score for each configuration was multiplied by the weighted criteria value. Each multiplication product was then added to calculate the overall score for the process configuration. Table 4 provides the overall score and respective rank for each of the eight process alternatives.

Based on the scoring, there was a tie between configuration No. 3 (5-Stage BNR using Oxidation ditch) and configuration no. 6 (Five-stage BNR process with secondary clarifiers and tertiary membranes). The consensus was that the configuration no. 6 be evaluated further, since the configuration no. 3 is very similar to the configuration no. 2 with the only difference in the process reactor configuration. On the other hand, configuration no. 6 would provide a superior effluent quality with the use of a tertiary membrane comparable to the BNR/MBR alternative.

Table 4 Process Evaluation Criteria Scoring Spreadsheet
Identification of Alternative Treatment Technologies
Orange County Utilities

			Configuration No.1 Three-stage BNR process, secondary clarifiers and denitrification filters.		**Configuration No.2** Five-stage BNR process, secondary clarifiers and disk filters		**Configuration No.3** Five-stage BNR process using an oxidation ditch with secondary clarifiers and disk filters		**Configuration No.4** Step-feed BNR process with post-anoxic zones, secondary clarifiers and disk filters		**Configuration No.5** Five-stage BNR / IFAS process with secondary clarifiers and disk filters		**Configuration No.6** Five-stage BNR process with secondary clarifiers and tertiary membranes		**Configuration No.7** Five-stage BNR / MBBR process with DAFs and disk filters		**Configuration No.8** Five-stage BNR / MBR Process **Base Alternative**	
	Potential Screening Criterion	Weighting (1 – 11)	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted score	Raw Score	Weighted score
1	Plant Footprint	2	3	6	2	4	1	2	3	6	4	8	2	4	4	8	5	10
2	National Experience/Success	3	4	12	5	15	5	15	2	6	2	6	3	9	1	3	3	9
3	Similarity With Processes Used In Plants Currently Owned And Operated By OCU	4	3	12	5	20	5	20	4	16	1	4	2	8	1	4	2	8
4	Operating Complexity & Maintenance Intensity (Equipment To Maintain, Staffing Levels, Automation)	7	2	14	3	21	3	21	3	21	2	14	2	14	2	14	2	14
5	Plant Automation	9	4	36	4	36	4	36	4	36	4	36	4	36	4	36	4	36
6	Dependable Compliance Or Process Reliability	8	4	32	5	40	5	40	4	32	3	24	5	40	3	24	5	40
7	Chemical Use	5	1	5	5	25	5	25	3	15	4	20	2	10	3	15	2	10
8	Energy Use	6	4	24	4	24	2	12	4	24	3	18	3	18	3	18	1	6
9	Residuals Management	1	3	3	3	3	3	3	3	3	3	3	3	3	4	4	3	3
10	Impact On Neighbors (Noise Odor, Truck Traffic And Aesthetics)	10	2	20	4	40	2	20	4	40	3	30	3	30	3	30	4	40
11	Effluent Water Quality	11	4	44	3	33	3	33	3	33	2	22	5	55	2	22	5	55
	Total Score			**208**		**261**		**227**		**232**		**185**		**227**		**178**		**231**
	RANK			**4**		**1**		**3**		**2**		**5**		**3**		**6**		**Base Alt**

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the ranking analysis, the following five process configurations are recommended to be evaluated in more detail in subsequent tasks.

- Configuration no. 1 – Three stage BNR process, secondary clarifiers, denitrification filters.
- Configuration no. 2 – Five stage BNR process, secondary clarifiers and disk filters.
- Configuration no. 4 – Step-feed BNR process with post anoxic zones, secondary clarifiers and disk filters.
- Configuration no. 6 – Five stage BNR process, secondary clarifiers and tertiary membrane filters.
- Configuration no. 8 – Five stage BNR/MBR process

REFERENCES

Orange County Utilities Facilities Plan, 2007 prepared by PBSJ/CDM

EPRI. (1994) Energy Audit Manual for Water/Wastewater Facilities; CEC Report CR-104300. EPRI, Palo Alto, CA.

EPRI. (1996) Water and Wastewater Industries: Characteristics and Energy Management Opportunities; Product ID # CR-106491. EPRI, Palo Alto, CA.

Energy Center of Wisconsin (ECW). (2002) Roadmap for the Wisconsin Municipal Water & Wastewater Industry, October 2002. ECW, Wisconsin.

Pearce, G. 2008. Introduction to Membrane Bioreactors, Filtration & Separation, V 45 (1), 32-35.

TABLE A – LIST OF BNR TREATMENT PROCESSES

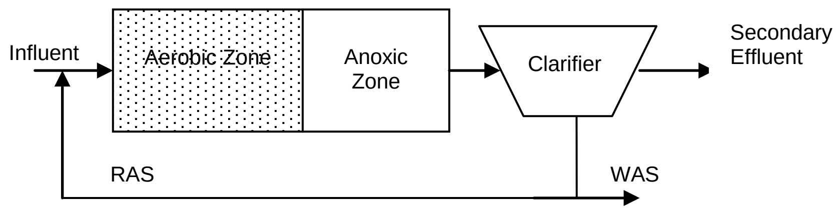
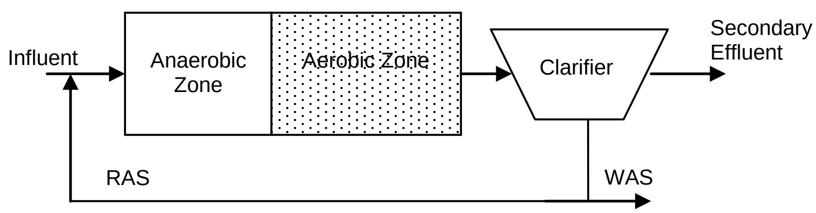
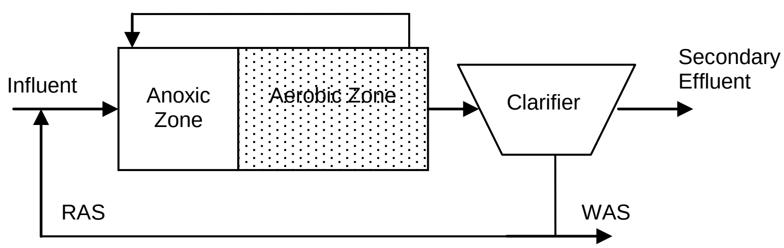
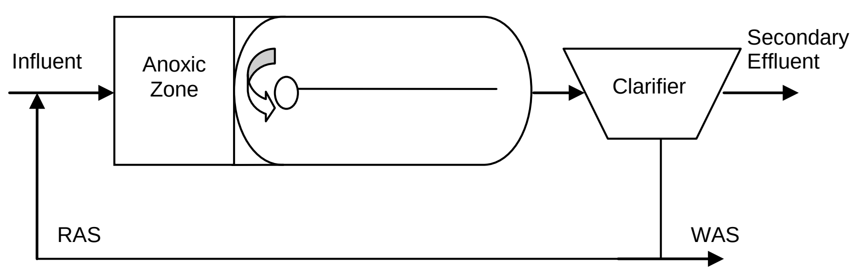
<table>
<tr><td colspan="3">Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities</td></tr>
<tr><th>BNR Process</th><th>Process Schematic</th><th>Process Performance</th></tr>
<tr><td colspan="3">SUSPENDED GROWTH BIOLIGICAL NUTRIENT REMOVAL PROCESS</td></tr>
<tr><td colspan="3">Single Sludge Multiple-zone processes</td></tr>
<tr><td colspan="3">2-stage suspended growth activated sludge processes</td></tr>
<tr><td>Wurhman process</td><td>
</td><td>Typical Effluent
BOD < 20 mg/l
TSS < 20 mg/l
TIN ~ 25 mg/l
TP - NA</td></tr>
<tr><td>A/O process</td><td>
</td><td>Typical Effluent
BOD < 20 mg/l
TSS < 20 mg/l
TIN ~ 25 mg/l
TP < 2 mg/l</td></tr>
<tr><td>Modified Ludzack Ettinger (MLE)</td><td>
</td><td>Typical Effluent
BOD < 20 mg/l
TSS < 20 mg/l
TN < 12 mg/l
TP - NA</td></tr>
<tr><td>Carrousel DenitIR^{TM} process[(1)]</td><td>
</td><td>Typical Effluent
BOD < 20 mg/l
TSS < 20 mg/l
TN < 12 mg/l
TP - NA</td></tr>
</table>

Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

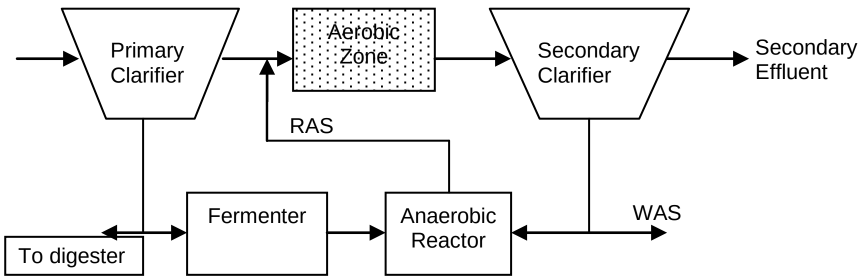
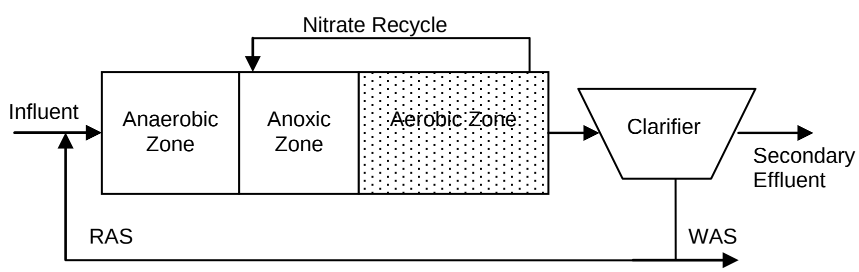
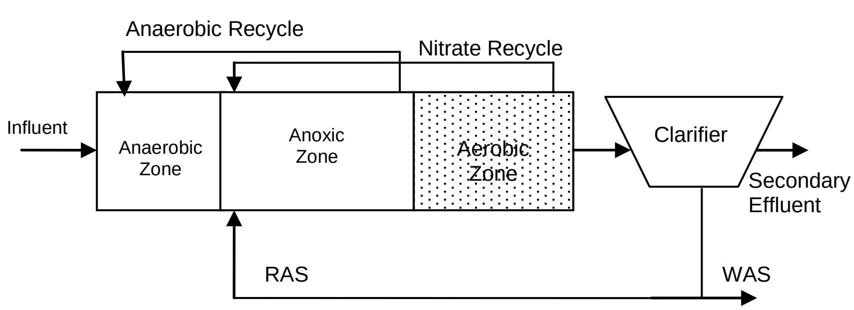
BNR Process	Process Schematic	Process Performance
OWASA Nutrification process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TIN ~ 25 mg/l TP < 2 mg/l
	3-stage suspended growth activated sludge processes	
A^2/O process(1)		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP < 2 mg/l
University of Cape Town (UCT) process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP < 2 mg/l

Table A — Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

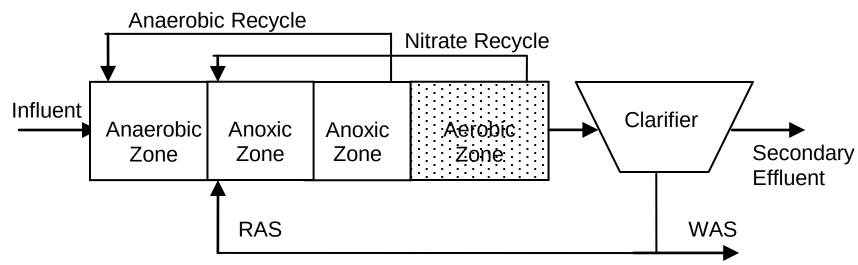
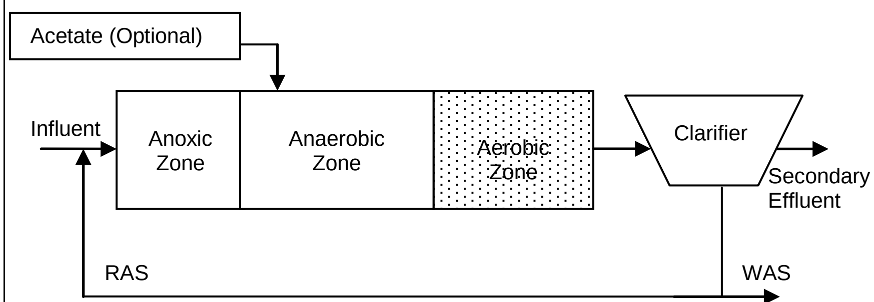
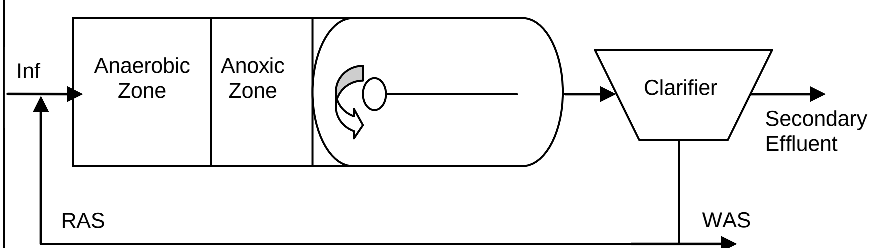
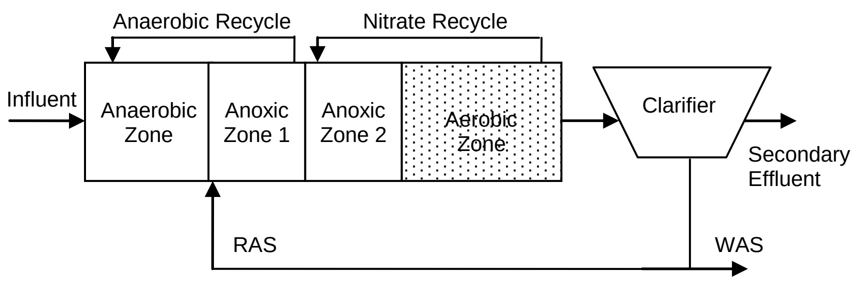
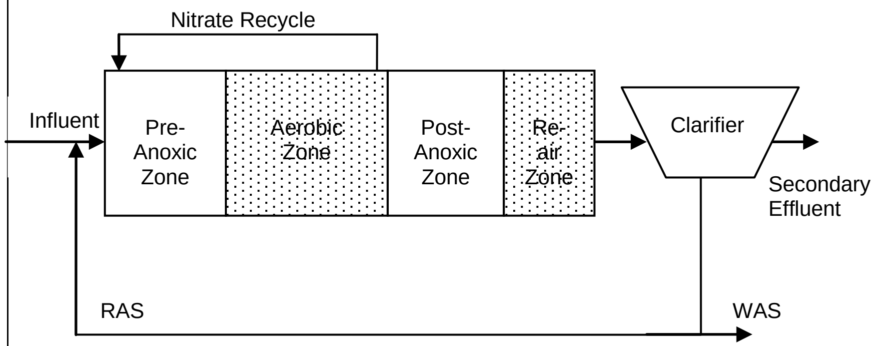
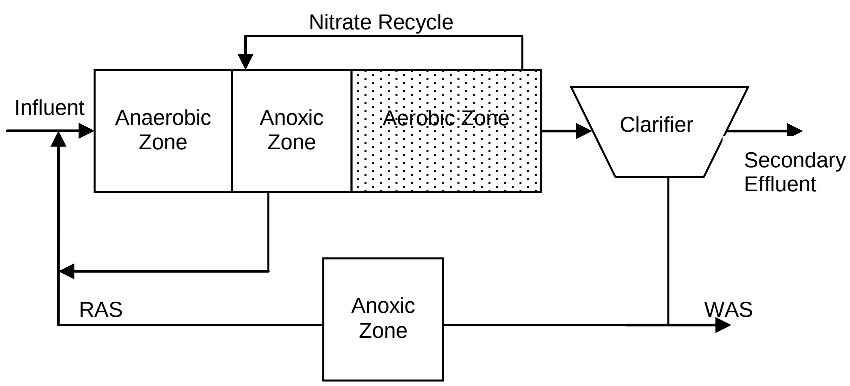
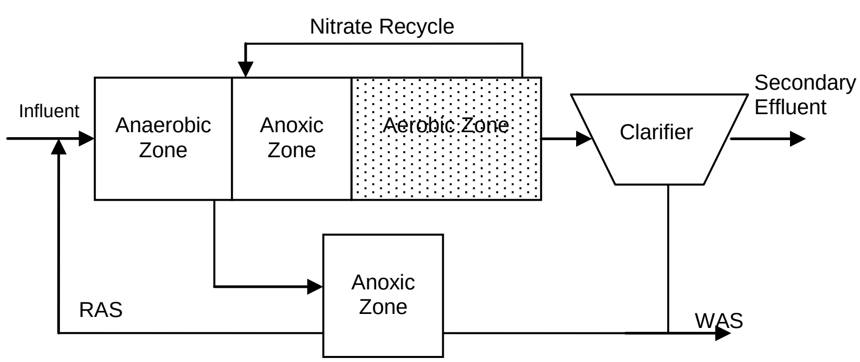
BNR Process	Process Schematic	Process Performance
Virginia Initiative Program (VIP) process(1)		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP < 2 mg/l
Volatile Fatty Acid Induced Phosphorus Removal (VIPR) (1)		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP < 2 mg/l
Carrousel A^2/C^{TM} process(1)		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP < 2 mg/l
4-stage suspended growth activated sludge processes		
Modified University of Cape Town (MUCT) process		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 8 mg/l TP < 2 mg/l

Table A **Long List of BNR Treatment Processes**
Identification of Alternative Treatment Technologies
Orange County Utilities

BNR Process	Process Schematic	Process Performance
Bardenpho™ process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 8 mg/l TP - NA
Modified Johannesburg Process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 8 mg/l TP < 2 mg/l
ISAH process[(1)]		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 8 mg/l TP < 2 mg/l

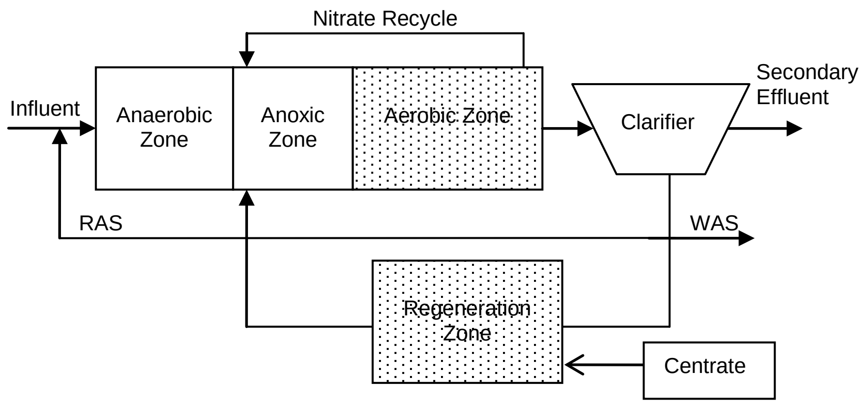
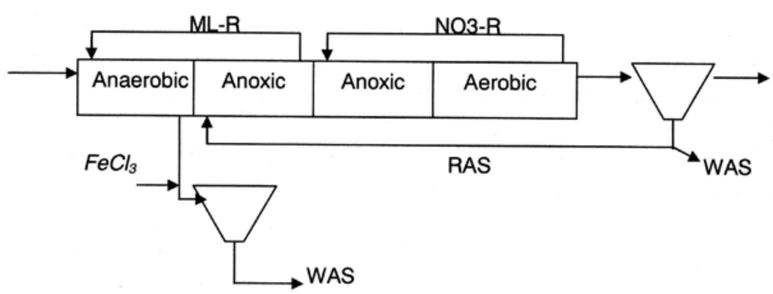
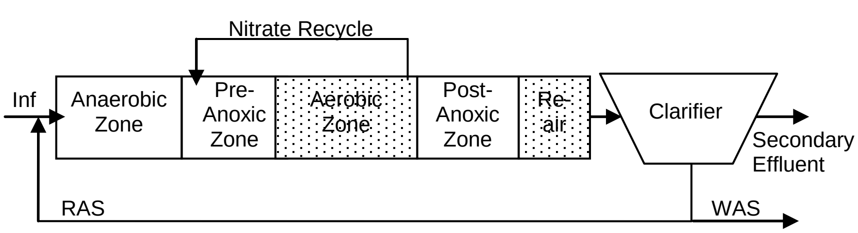
<table>
<tr><td colspan="3">Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities</td></tr>
<tr><th>BNR Process</th><th>Process Schematic</th><th>Process Performance</th></tr>
<tr><td>Regeneration-Denitrification-Nitrification (RDN) process(1)</td><td>
</td><td><u>Typical Effluent</u>
BOD < 20 mg/l
TSS < 20 mg/l
TN < 8 mg/l
TP < 2 mg/l</td></tr>
<tr><td>Biological chemical phosphorus and nitrogen removal (BCFS) process</td><td>
</td><td><u>Typical Effluent</u>
BOD < 20 mg/l
TSS < 20 mg/l
TN < 10 mg/l
TP < 2 mg/l</td></tr>
<tr><td colspan="3"><u>5-stage suspended growth activated sludge processes</u></td></tr>
<tr><td>Modified BardenphoTM process</td><td>
</td><td><u>Typical Effluent</u>
BOD < 20 mg/l
TSS < 20 mg/l
TN < 5 mg/l
TP < 2 mg/l</td></tr>
</table>

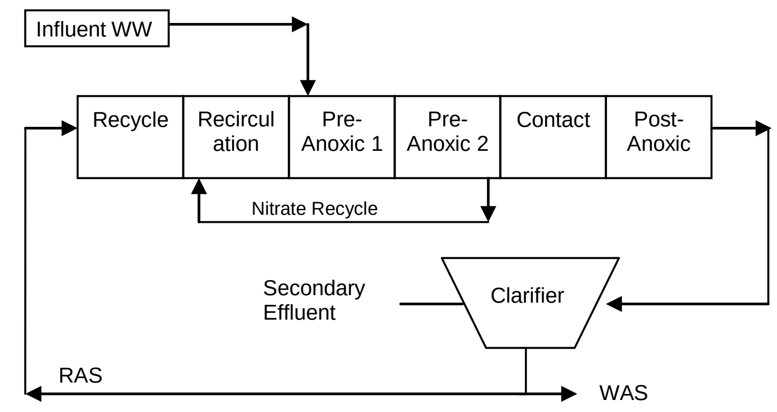
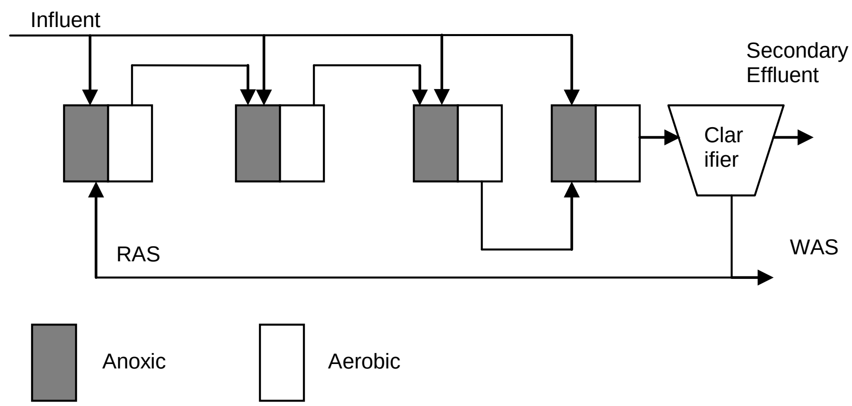
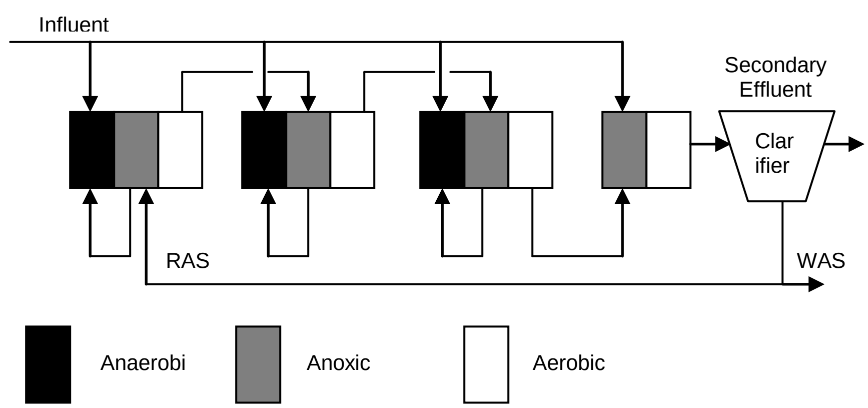
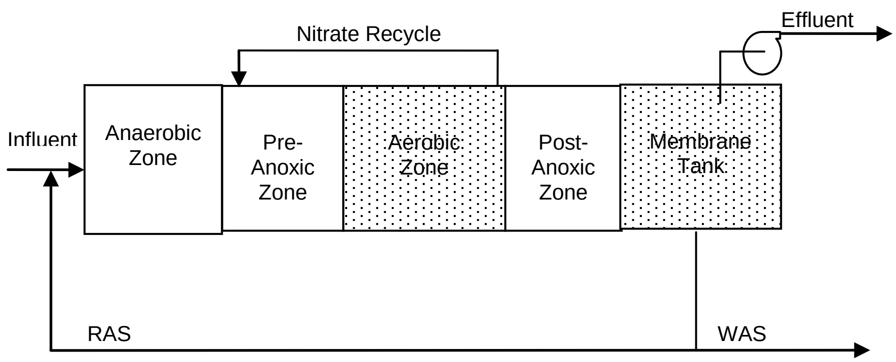
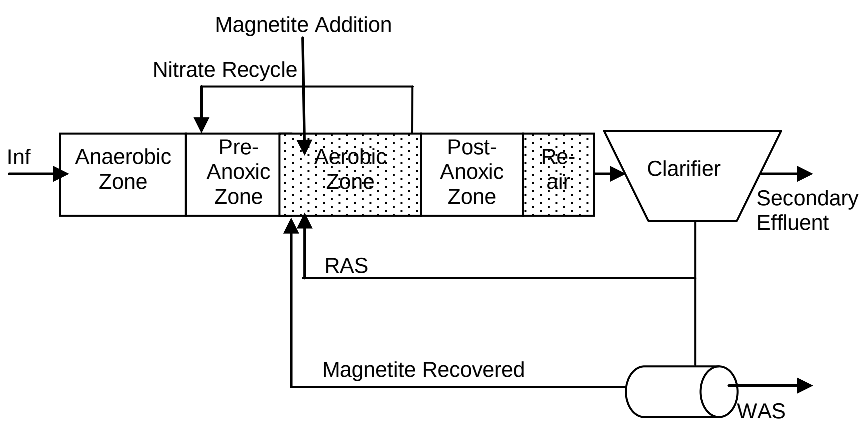
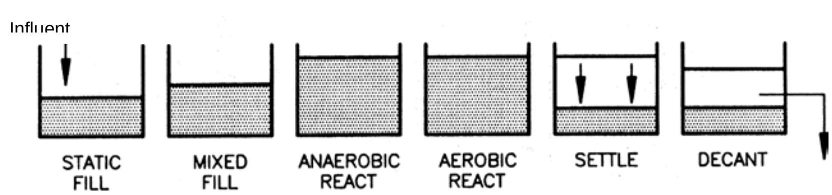
Table A	Long List of BNR Treatment Processes Identification of Alternative Treatment Technologies Orange County Utilities	
BNR Process	**Process Schematic**	**Process Performance**
Partial Nitrification-Complete Denitrification (PN/CD) process(1)		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP - NA
	<u>Step Feed suspended growth activated sludge processes</u>	
Step-feed BNR		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP - NA
Step Bio-P process		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP < 2 mg/l

Table A	Long List of BNR Treatment Processes Identification of Alternative Treatment Technologies Orange County Utilities	
BNR Process	**Process Schematic**	**Process Performance**
Membrane Bioreactor (MBR)		<u>Typical Effluent</u> BOD < 2 mg/l TSS < 2 mg/l TN < 3 mg/l TP < 1 mg/l
BioMag Process(1)		<u>Typical Effluent</u> BOD < 5 mg/l TSS < 5 mg/l TN < 3 mg/l TP < 1 mg/l
Multiple Phases suspended growth activated sludge processes		
Sequencing Batch Reactors (SBRs)		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 6 mg/l TP < 2 mg/l

Effluent

Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

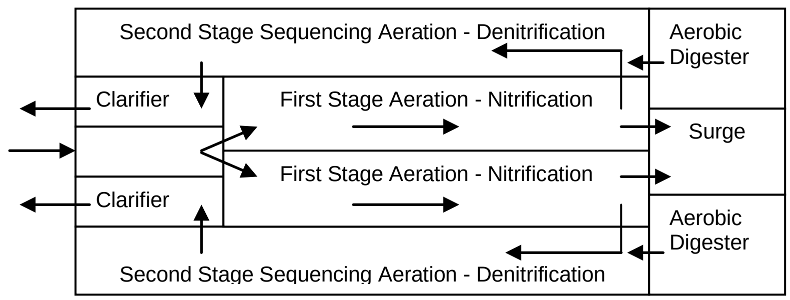
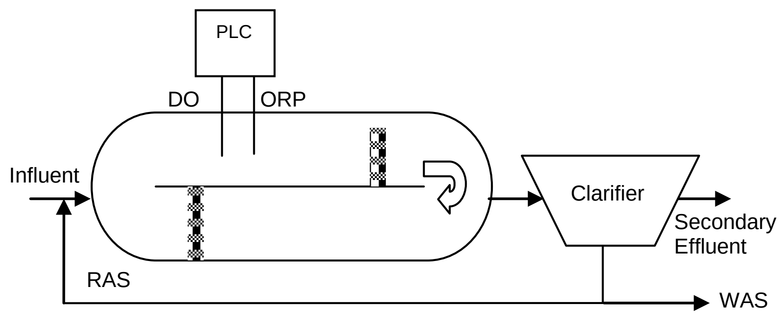
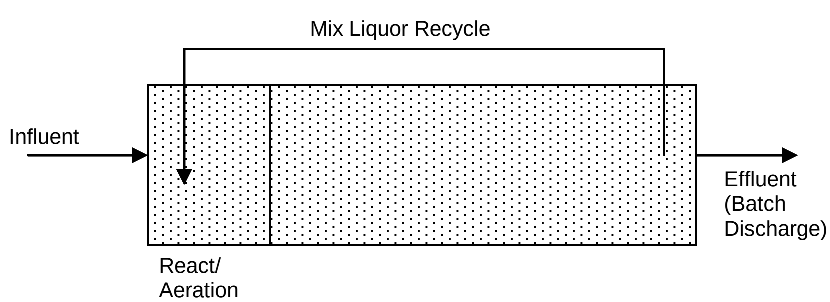
BNR Process	Process Schematic	Process Performance
Sequox® process(1)		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 6 mg/l TP - NA
Nitrox process(1)		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP - NA
Cyclic Activated Sludge System (CAAS™) process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP - NA

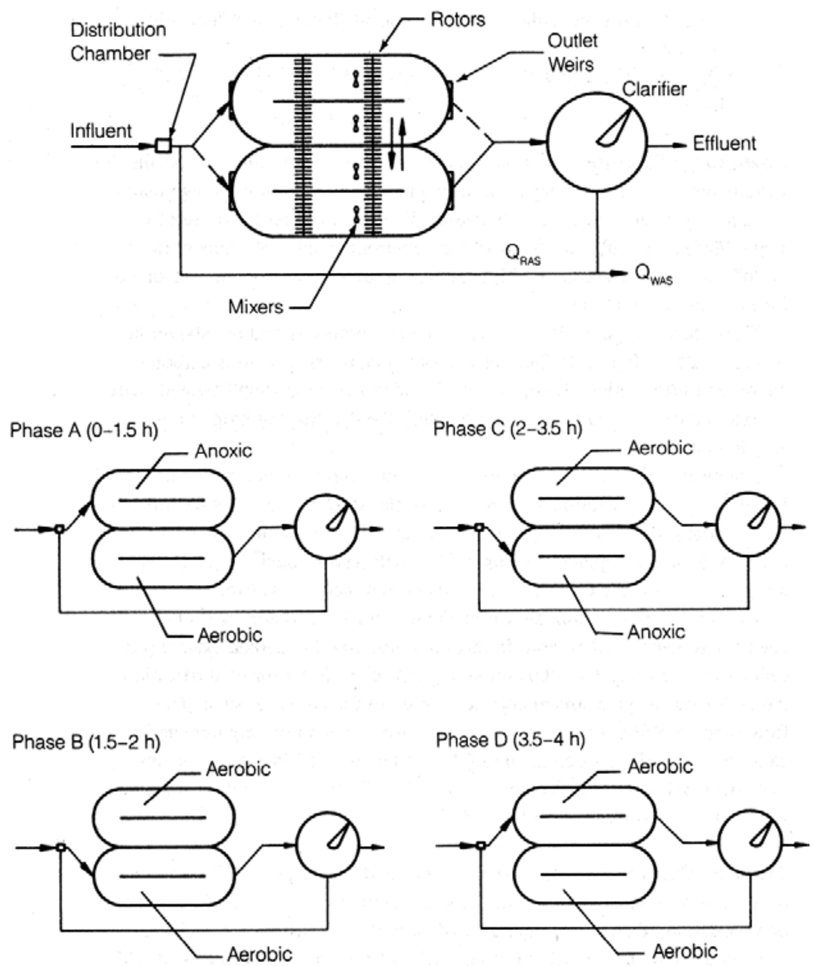
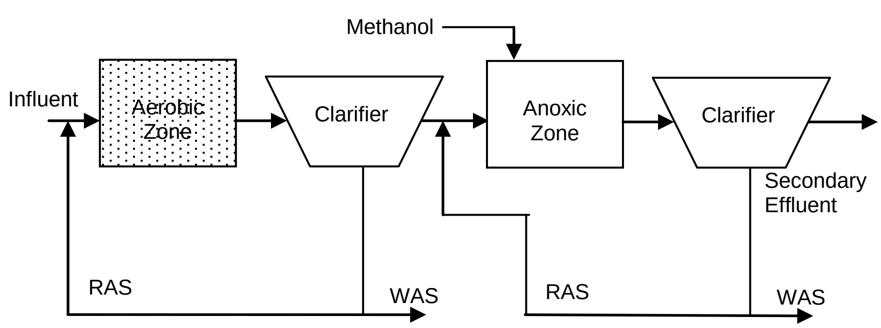
Table A	Long List of BNR Treatment Processes Identification of Alternative Treatment Technologies Orange County Utilities	
BNR Process	**Process Schematic**	**Process Performance**
Phased Isolation Ditches Biodenitro$^{TM(1)}$		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP - NA
<u>Multiple Sludge Single Zone suspended growth activated sludge processes</u>		
Two-Sludge activated sludge process		<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP - NA

Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

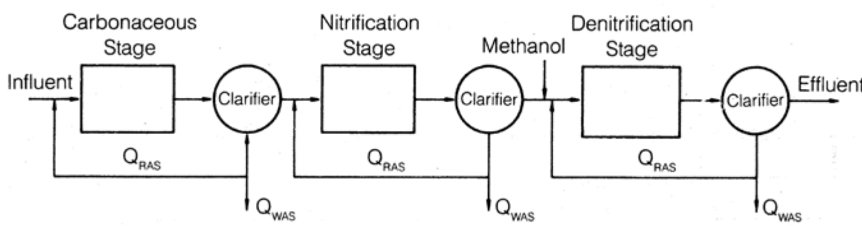
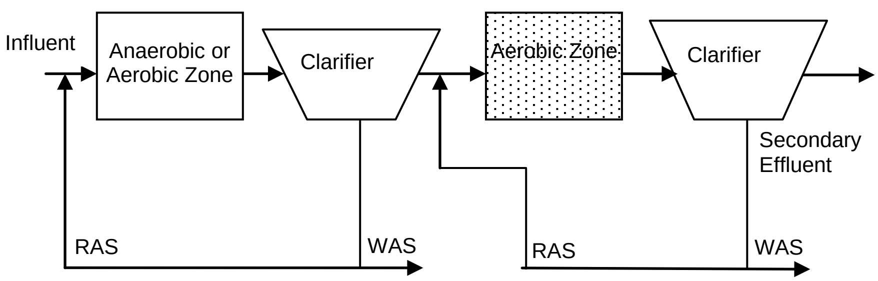
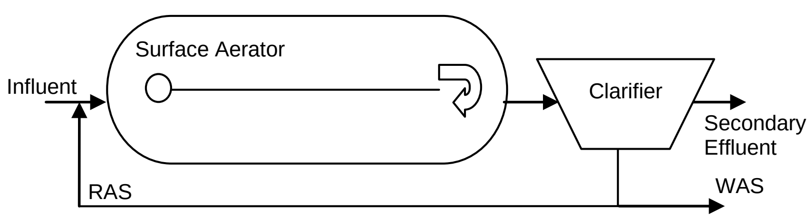
BNR Process	Process Schematic	Process Performance
Three-Sludge activated sludge process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 8 mg/l TP - NA
A-B Process		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TIN ~ 25 mg/l TP < 2 mg/l
Simultaneous Nitrification-Denitrification suspended growth activated sludge processes		
Carrousel™ Oxidation Ditch		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP - NA

Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

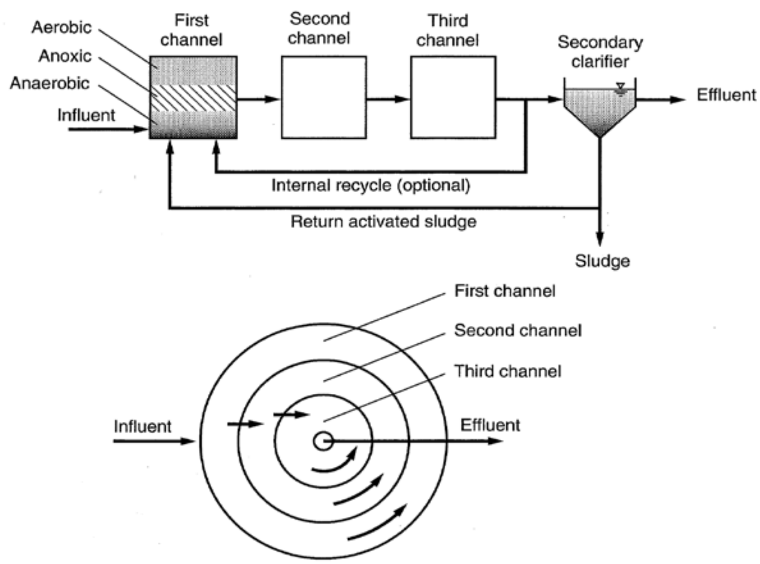
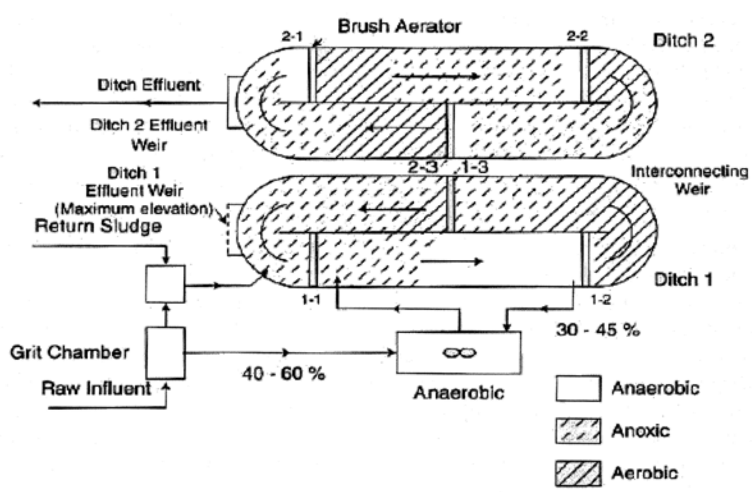
BNR Process	Process Schematic	Process Performance
Orbal™ Oxidation ditch(1)		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 10 mg/l TP - NA
VT2 Oxidation Ditch(1)		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 6 mg/l TP < 2 mg/l

Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

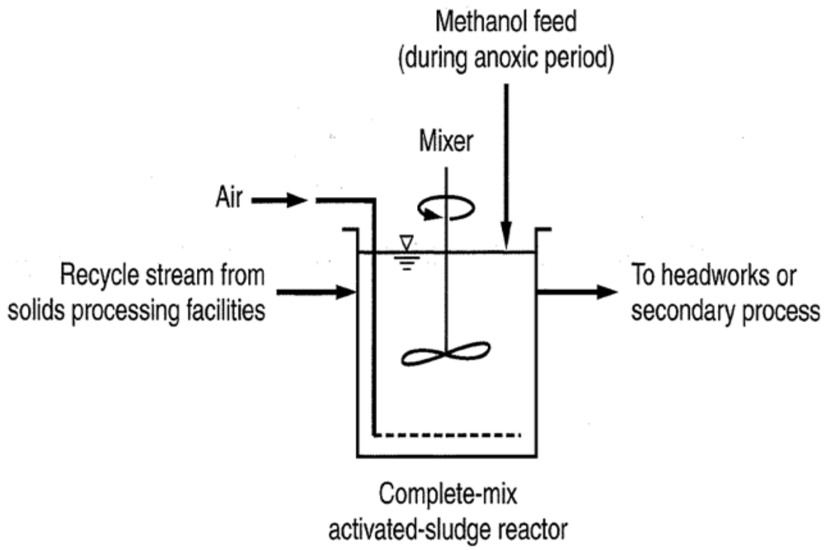
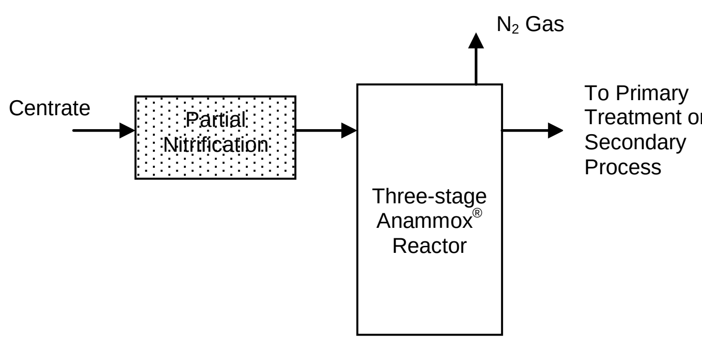
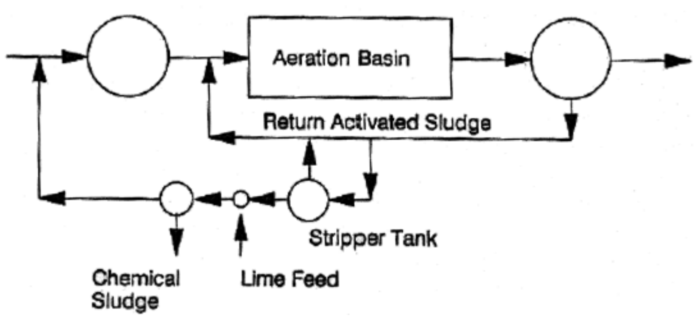
BNR Process	Process Schematic	Process Performance
Sidestream suspended growth activated sludge processes		
AT-3, BABE, SHARON process(1)		Sidestream treatment to remove nitrogen from plant recycle flows such as from anaerobic digesters and dewatering processes.
Anaerobic Ammonium Oxidation (ANAMMOX®) process(1)		Sidestream treatment to remove nitrogen from plant recycle flows such as from anaerobic digesters and dewatering processes.
Phostrip™ Process		Sidestream treatment to remove phosphorus from plant recycle flows such as from anaerobic digesters and dewatering processes.

Table A Long List of BNR Treatment Processes
Identification of Alternative Treatment Technologies
Orange County Utilities

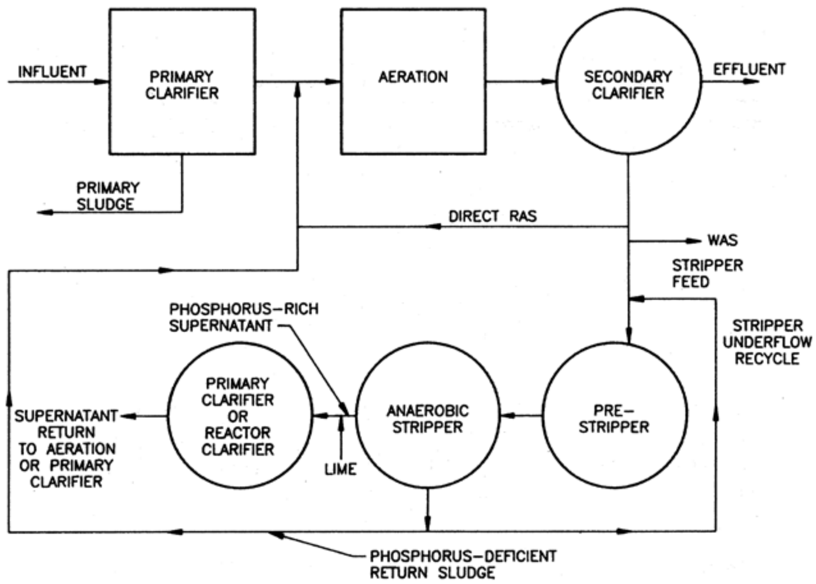
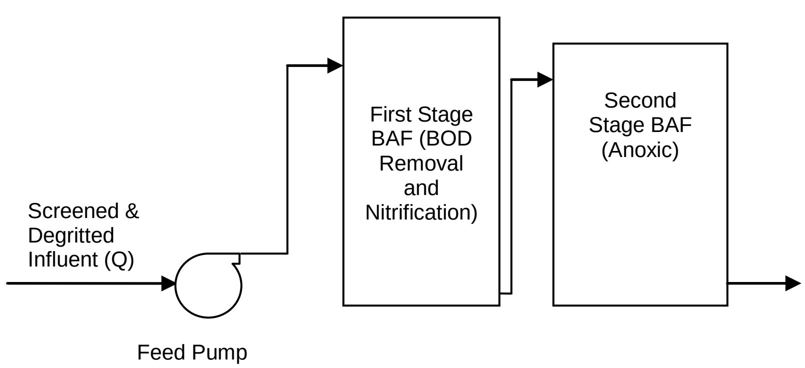
BNR Process	Process Schematic	Process Performance
Phostrip II^{TM} Process		Sidestream treatment to remove phosphorus from plant recycle flows such as from anaerobic digesters and dewatering processes.
ATTACHED GROWTH BIOLIGICAL NUTRIENT REMOVAL PROCESS		
Stationary Bed attached growth activated sludge processes		
Biological Aerated Filters	 Two-Stage BAF	Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP - NA

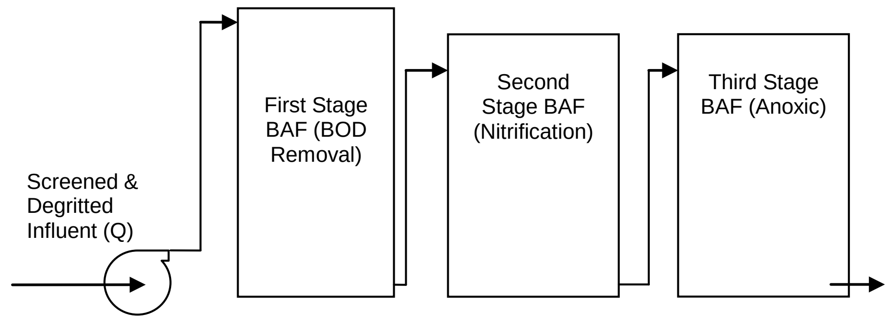
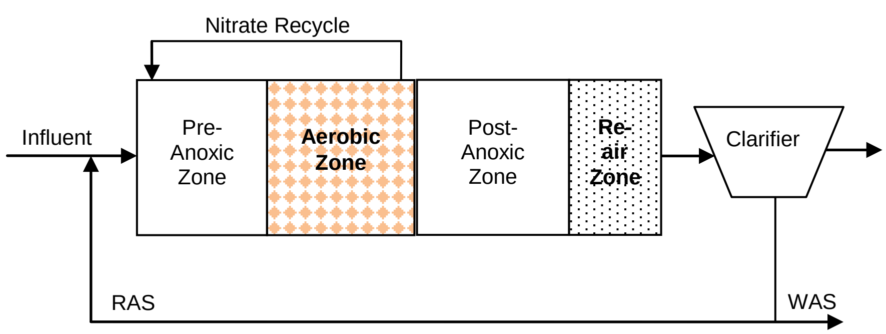
Table A	**Long List of BNR Treatment Processes Identification of Alternative Treatment Technologies Orange County Utilities**	
BNR Process	**Process Schematic**	**Process Performance**
	 Three-Stage BAF	
	Moving Bed attached growth activated sludge processes	
Integrated Fixed Film Activated Sludge (IFAS)		Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP < 2 mg/l

Table A	**Long List of BNR Treatment Processes** **Identification of Alternative Treatment Technologies** **Orange County Utilities**	
BNR Process	**Process Schematic**	**Process Performance**
	 Photo of Sponge media  Media installed in aeration basin with screens on either side to retain the media.	

Table A	**Long List of BNR Treatment Processes Identification of Alternative Treatment Technologies Orange County Utilities**	
BNR Process	**Process Schematic**	**Process Performance**
	 Media with support structure inside an aeration basin  Aeration basin online with attached growth media	

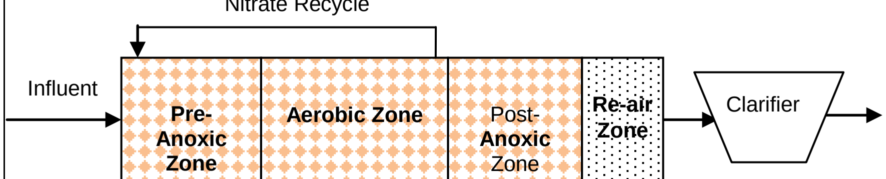
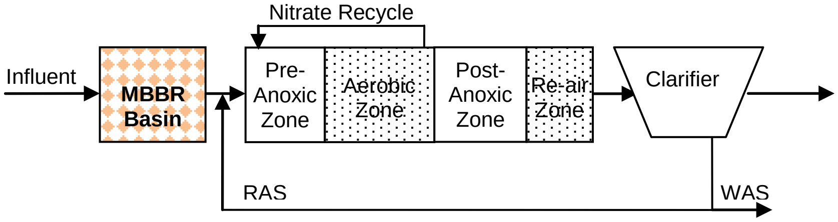
Table A	**Long List of BNR Treatment Processes Identification of Alternative Treatment Technologies Orange County Utilities**	
BNR Process	**Process Schematic**	**Process Performance**
	 Screens to retain media (courtesy of Anoxkaldnes)	
Moving Bed Biofilm Reactor (MBBR)	 Single Pass MBBR  MBBR as a Roughing Process	<u>Typical Effluent</u> BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP < 2 mg/l

Table A **Long List of BNR Treatment Processes**
Identification of Alternative Treatment Technologies
Orange County Utilities

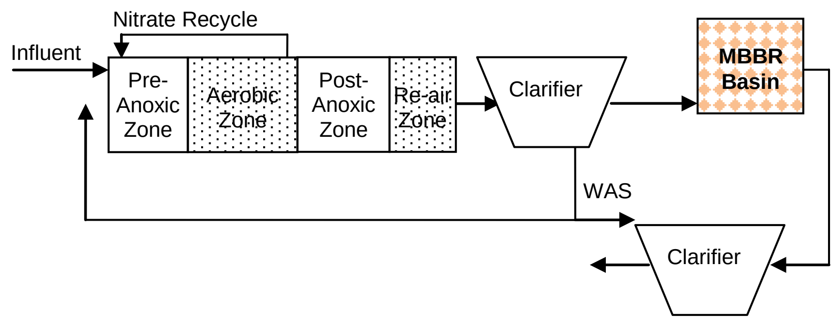
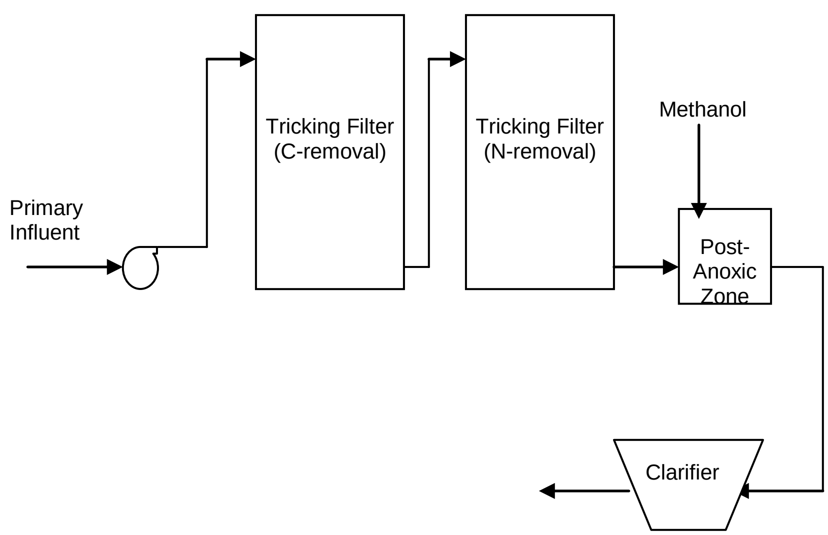
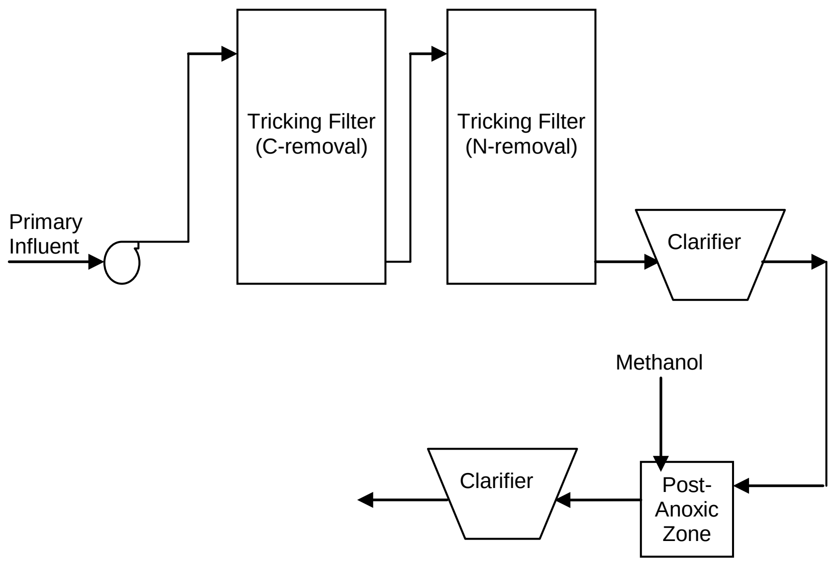
BNR Process	Process Schematic	Process Performance
	 Tertiary MBBR	
	Trickling Filter attached growth activated sludge processes	
Trickling Filter (NTF)	 Two-stage trickling filter with activated sludge	Typical Effluent BOD < 20 mg/l TSS < 20 mg/l TN < 12 mg/l TP - NA

Table A	**Long List of BNR Treatment Processes** **Identification of Alternative Treatment Technologies** **Orange County Utilities**	
BNR Process	**Process Schematic**	**Process Performance**
	 Two stage trickling filter with intermediate clarifier followed by activated sludge	

Notes:
(1) – Proprietary (patented) Process.

DESCRIPTION OF COMMERCIAL FILTRATION TECHNOLOGIES

The following paragraphs describe the various filtration technologies available in the municipal market by filtration mechanism type

1.0 Depth Filtration

There are five different types of depth filtration technologies. Conventional deep bed, continuous backwash, pulsed bed, automatic backwash, and the Fuzzy filter®. A description of the depth filtration technologies is presented below, except the continuous backwash and automatic backwash filters, which are currently being employed by OCU at its water reclamation facilities. The description of the Fuzzy filter® is included in a separate section called “innovative technologies”.

Deep Bed Filters

There are many types of deep bed filters that are commercially available. Deep bed filters can use mono, dual, or multi-media. Typically, the sand depth in deep bed filters ranges from 3 to 6 feet operating at 4 to 9 feet of head loss. In deep bed filters, secondary effluent enters the filter cell, flows through the sand bed by gravity and leaves via an underdrain system. For backwashing, the filtered effluent is pumped back through the underdrain and is evenly distributed in the filter bed. Air scour is also typically applied to help clean the sand. Backwash water is collected in troughs and discharged back to the head of the plant. Three examples of commercially available deep bed filter systems discussed below are the TETRA Deep Bed™ Filter, the Leopold Tertiary Filter System, and the Roberts Deep Bed Filtration System.

<u>TETRA Deep Bed™ Filter (Severn Trent Services)</u>

In TETRA Deep Bed™ Filters, influent to the filter is evenly distributed across the top of the sand by overflowing longitudinal weirs on the influent troughs located along the sides of the filter cells. The water passes through the sand and solids are retained in the voids. As filtration continues, head loss increases to a maximum level and backwashing begins. Simultaneous backwash, air and water, are applied at about 5 cfm/ft^2 and 6 gpm/ft^2, respectively, for 15 minutes. Air is stopped for the last 5 minutes and water continues to purge the air from the sand bed. The backwash water is collected in influent troughs and discharged from the filter basin. The underdrain system consists of concrete filled plastic blocks. These allow filtrate to pass and backwash air and water to be evenly distributed without nozzles, screens, or small orifices that could be clogged.

Figure 1 shows a schematic of the TETRA filter. The sand is typically 4 to 6 ft deep and typical filtration rates range between 2 and 8 gpm/ft^2. Coarse filter sand is used to allow deep penetration of solids into the filter bed and to allow longer filter run times. The sand typically has an effective size of 2 to 3 mm, a uniformity coefficient of 1.4, and sphericity of 0.8. The rounded grains are used to allow a more vigorous scrubbing during backwash. The backwash system effectively cleans the filter bed without sand loss. Support gravel consists of five layers in reverse grade, 18 inches deep.

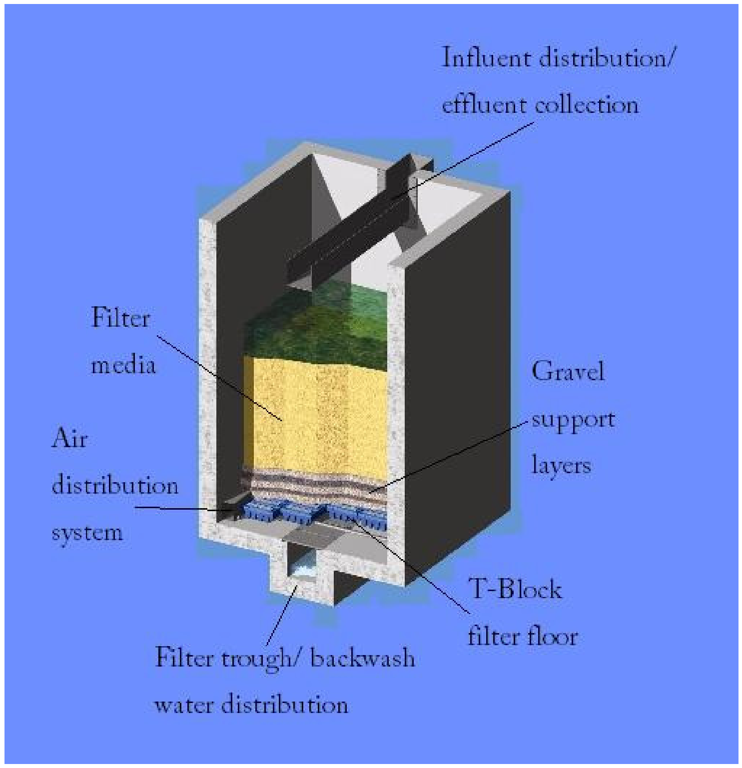


Figure 1. TETRA DeepBed™ Filter (Courtesy of Severn Trent Services)

The filter is automatically operated by a programmable logic controller (PLC) with a human machine interface (HMI). Backwashing is cycled based on time or head loss. The filter valves have pneumatic or electrical controls with optional isolation valves. The manufacturer reports that 2 to 4 percent of the plant flow is used for backwash water. Backwash air is supplied by a positive displacement blower at 3 to 5 cfm/ft^2. Backwash water is supplied by a low head centrifugal pump at 5 to 6 gpm/ft^2 with a 4-inch head loss across the bottom of the filter. Depending on the specific situation, 4 to 9 ft of head is typically required for the filter. Backwash air is introduced to the filter through air headers installed beneath the concrete filled block underdrains.

The filter manufacturer reports that total phosphorus removal to 0.2 mg/L is possible with chemical precipitation and the TETRA filter can provide nitrogen removal to 3 mg/L with supplemental carbon addition. Tanks can be concrete or steel, round or rectangular. The total depth of the filter box is usually 14-22 ft with freeboard. TETRA filters have been in operation since 1960.

Leopold Tertiary Filter System (F.B. Leopold Company)

Leopold tertiary filters are another type of deep bed filter. Influent enters the tank through the center flume and overflows by gravity onto to the filter sand. Suspended particles are removed by depth filtration. Filtered water is discharged through the underdrain system. Backwashing the filter sand is accomplished with water and air scour, and depending on the sand, the filter bed could be fully or partially fluidized. Backwash water is pumped from a holding tank through the sand. The backwash air is introduced through a central flume and is distributed through the underdrains and up through the sand. Backwash water overflows the flume and is discharged from the filter basin. A schematic of the Leopold tertiary filter is presented in Figure 2. Backwash water is reported by the manufacturer to be less than 2 percent of the plant flow. Support gravel is mostly siliceous sand and varies from 1/8-inch to 3/4-inch in size.

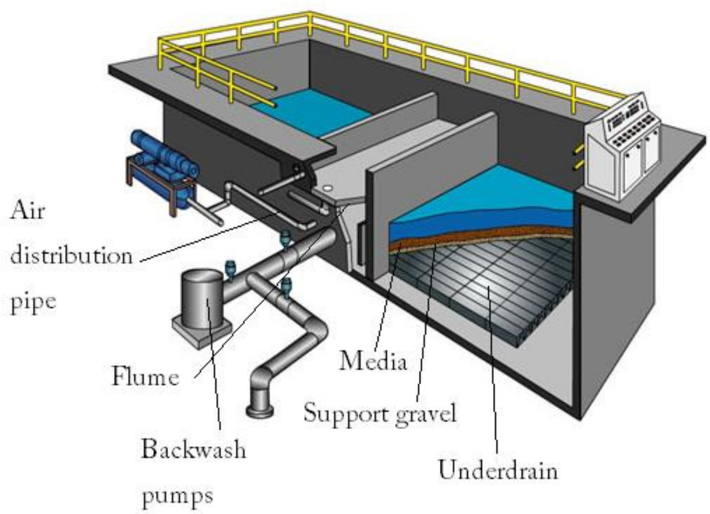


Figure 2. Leopold Tertiary Filter System (Courtesy of F.B. Leopold Company)

Roberts Deep Bed Filtration System (The Roberts Filter Group)

The Roberts Deep Bed filter is typically provided with a 6-feet deep bed of filter sand. Backwashing is accomplished with both air and water. Underdrain systems can be designed with a low profile dual lateral system. This underdrain system is 6-inch in height, custom for the width of the filter tank, and can be greater than 30-feet long without joints. The underdrains can be used with or without a porous plate. Another option for the underdrain is a system that uses passive air scour. This can be used for air and water backwashes or water only backwashes. A third type of underdrain offered does not require a plenum. Optional methods are available for providing air scour including surface agitators, air grids, and managed air systems. The managed air system is located between the gravel and the sand so it introduces air directly to the filter sand, which allows for better cleaning at lower airflow rates.

2.0 Surface Filtration

There are two types of filtration groups in the surface filtration category. These include cloth medium (cloth fiber) and microscreen wire fabric or cloth disks. There are two major differences in these filters. First, the cloth fiber medium filters use a filter medium that is approximately 13 mm thick. The microscreen medium is a wire fabric approximately 150 µm thick. Second, the cloth fiber medium filters flow in an outside to in flow direction, while for the microscreen wire fabric or cloth disk medium the flow follows in an inside to out flow direction. Head loss through these filters will vary depending on configuration. However, total head loss typically does not exceed 3-feet.

Cloth Medium Disk/Lateral Filters (outside in flow direction)

There are two major manufacturers of the cloth fiber medium filters. These manufacturers are Aqua-Aerobic Systems, Inc. and the Parkson Corporation. The AquaDisk filters have been in operation for several years at OCU's South Water Reclamation Facility (SWRF) and hence is not discussed here. OCU is currently in the process of replacing the ABW filters at its Eastern Water Reclamation Facility (EWRF) with a disk filter.

AquaDiamond® (Aqua-Aerobic Systems, Inc.)

The AquaDiamond® was originally designed as a retrofit for automatic backwash filters. This technology uses the same cloth filter medium (nominal pore size of 10 microns) as the AquaDisk® but in a different configuration. Wastewater enters the filter tank over an influent weir and submerges the static diamond laterals. Wastewater passes through the medium on all sides of the laterals and solids accumulate and form a mat. The filtrate is collected in each lateral and discharged to the effluent chamber and over the effluent weir. Backwash is initiated by a rise in the tank level to a set point by an increase in head loss. The solids are vacuumed off the surface of the laterals by backwash shoes that pump filtrate back through the medium. Half of the laterals are backwashed at one time by a drive platform that moves across the basin. The other half of the laterals are backwashed as the platform returns to its starting position. The backwash water is returned to the plant headworks. Filtration can continue while backwashing takes place. Heavier solids that settle to the bottom of the tank are intermittently pumped by suction headers back to the headworks. A schematic of the AquaDiamond® filter is presented in Figure 3.

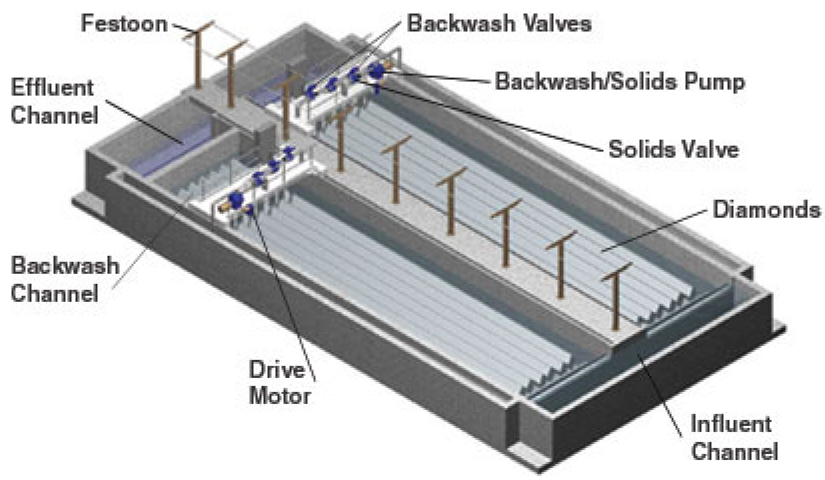


Figure 3. AquaDiamond® Filter (Courtesy of Aqua-Aerobic Systems, Inc.)

The AquaDiamond® is a combination of a traveling bridge and cloth medium filter and is easily retrofitted into an existing ABW traveling bridge filter bed. Use of the AquaDiamond® can double the maximum design hydraulic capacity of an existing ABW style sand filter in the same footprint. Up to eight laterals can be installed per unit, up to 80 ft long. The drive platform and backwash pump have variable speeds for an accelerated response to solids excursions. The drive platform also has four-wheel drive and tracking for better guidance and traction. The operation is fully automatic with a PLC based control system. Filtration requires no moving parts.

Microscreen Cloth and Steel disk (Inside out flow direction)

There are four major manufactures of microscreen wire or cloth fabric disk filters. These manufacturers are Kruger, Nordic Water, Nova Water Technologies, and Siemens. A description of the filters produced by these manufacturers is presented below.

Hydrotech Discfilter (Kruger)

The Hydrotech Discfilter is different from the previous disk filters in that the flow pattern is inside out and the medium is approximately 150 microns thick. The influent enters the center drum and flows by gravity into the filter segments. The medium is a woven cloth and is mounted on both sides of the disks. The disks remain only partially submerged as the filtrate is collected in the filter tank. Solids accumulate on the inside of the cloth medium disks and are backwashed by counter-current flow. Operation of the filter can continue during the backwash cycle. A schematic of the Hydrotech Discfilter is presented in Figure 4.

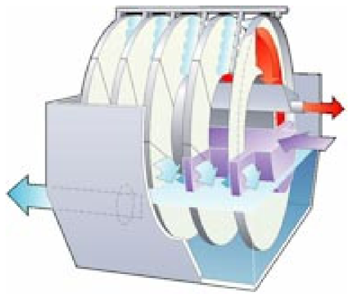


Figure 4. Schematic of the Hydrotech Discfilter (Courtesy of Kruger)

SuperDisc™ Filter (WesTech/Nordic Water)

The SuperDisc™ filter has a microscreen medium covering the filter disks. The fabric is made from stainless steel or synthetic material with 10 micron pores. Influent enters the central shaft of the rotating disks and passes through holes in the shaft to the filter disks. Solids build up on the inside of the filter medium and are backwashed using spray pipes and nozzles. The solids drop into an outlet trough and are discharged from the filter. The backwash process can be continuous or initiated by an increase in liquid level in the tank. A schematic of the SuperDisc™ filter is presented in Figure 5.

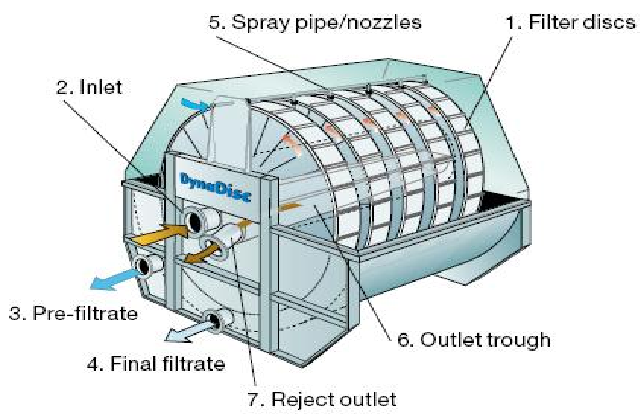


Figure 5 SuperDisc™ Filter (Courtesy of WesTech/Nordic Water)

Forty-X™ Disc Filter (Siemens Water Technologies)

In the Forty-X™ Disc Filter, influent enters a central drum and passes through openings to the panels and out through the filter medium. Backwash is initiated by a rise in the liquid level to a set point. The backwash cycle is a spray cleaning system. Filtration can continue during backwash. A cutaway of the Forty-X™ filter is presented in Figure 6. The cloth medium is made of polyester, has a 10-micron rating, and is pleated to increase the treatment capacity. The pleated design has 40 percent greater surface area than a flat disk. These filters can be installed in new or existing tanks with 1 to 24 disks mounted on a central drum. The structure of the disks can withstand a headloss of 24 inches. Filtrate TSS is typically less than 5 mg/L.

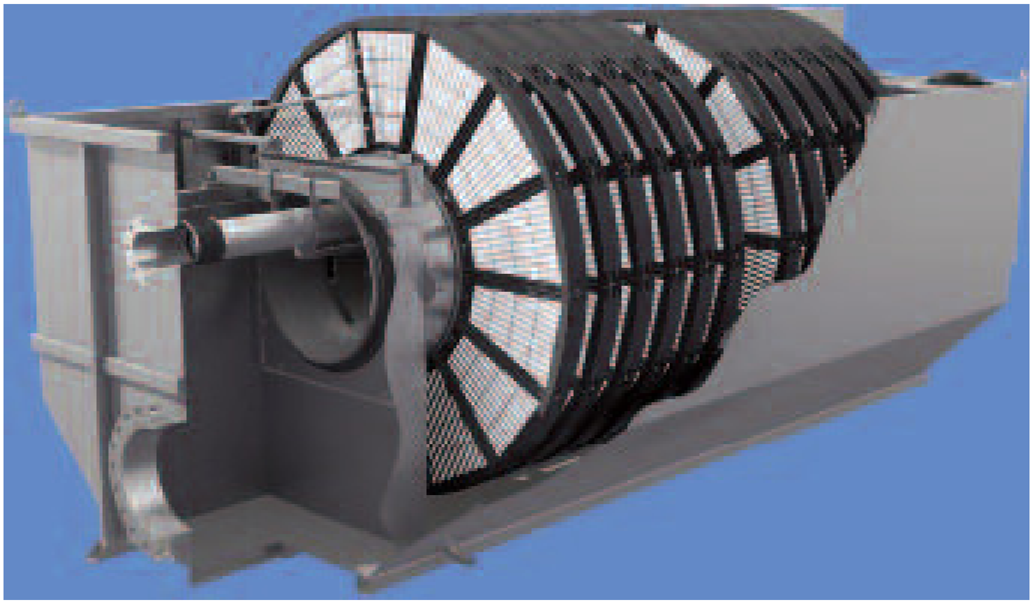


Figure 6 Picture of the Forty-X™ Disc Filter (Courtesy of Siemens Water Technologies)

Low-Pressure Membranes

Low-pressure membranes use microfiltration (MF) and ultrafiltration (UF) membrane materials to separate solids from the wastewater. The commercially available low-pressure membranes can be grouped into two categories: submerged and pressurized. The submerged membranes have cassettes or modules that are placed in a tank. Water flows by gravity into the tank and the filtrate is pulled through the membrane by applying a small vacuum by means of a pump on the membrane. Pressurized membranes use a feed pump, which pushes the water across the membranes. The water is typically applied parallel to the surface of the membrane. The membranes are installed inside a pressure vessel. A small amount of reject is recycled back to the feed tank. Gravity flow through low-pressure membranes is possible if sufficient head is available. Membrane cleaning is accomplished by applying an air scour or reversing flow to the membranes. There are several manufacturers of low-pressure membranes currently serving the municipal wastewater market. However, only a handful have significant full-scale experience with wastewater filtration. A description of the submerged and pressurized membrane systems offered by experienced manufacturers is presented in the following sections.

Submerged

ZeeWeed 1000 (GE Water & Process Technologies)

The ZeeWeed 1000 system consists of a module with thousands of horizontal membrane fibers. Each strand has millions of microscopic pores. The modules are installed in a cassette and the cassettes form the units of the filtration system. A picture of the ZeeWeed 1000 system is presented in Figure 7. A variety of configurations is possible for the ZeeWeed membranes depending on the quantity of water to be treated. Due to the versatility of this system, it can often be easily retrofitted into existing filter boxes.

Influent enters the membrane tank and completely submerges the membrane cassettes. The water is drawn through to the inside of the membrane fibers by applying a vacuum. A backwash cycle is initiated every 20 - 40 minutes. The backwash cycle starts by aerating the membranes for 15-seconds followed by a 30-second reversal of flow where permeate is pumped back through the membrane fibers into the membrane tank. During this backpulse, aeration is maintained to assist in the removal of foulants from the membrane surface. The membrane tank is then drained. Since the membrane system operates in dead-end mode, the tank drain is the only point where solids are rejected by the system. When draining the membrane tank, aeration is maintained at a constant airflow rate regardless of backpressure on the aeration diffuser. The UF membranes are periodically cleaned using a maintenance cleaning (MC) procedure or chemically enhanced backwash (CEB). The membranes can be cleaned using either an oxidizer or an acidic solution. The most common chemicals used are chlorine solution or citric acid. The CEB procedure is performed once per 24-hour period. Chemical concentrations used during the CEB procedure are 50-250 mg/L of chlorine solution and 500-1000 mg/L of a citric acid solution. The total duration of the CEB procedure is generally less than one hour per day. A more extensive cleaning procedure known as a recovery clean is performed when the transmembrane pressure (TMP) level of the membranes rises to a set level (usually once a month). This is similar to a CEB procedure except the concentrations of chemicals used are higher and the soak times are longer. The membrane tank is drained and the membranes are soaked in a cleaning solution for several minutes. Chemical residues are then flushed from the system and normal operation resumes.

The ZeeWeed 1000 membranes are un-reinforced hollow fibers made of polyvinylidene fluoride (PVDF). Each module has a nominal surface area of 450 ft^2. The ZeeWeed 1000 membrane nominal pore size is 0.02 microns and the typical operating TMP is 1 - 10 psig. Typical average flux values when filtering secondary effluent are between 15 - 20 gfd (gallons per day per ft^2).

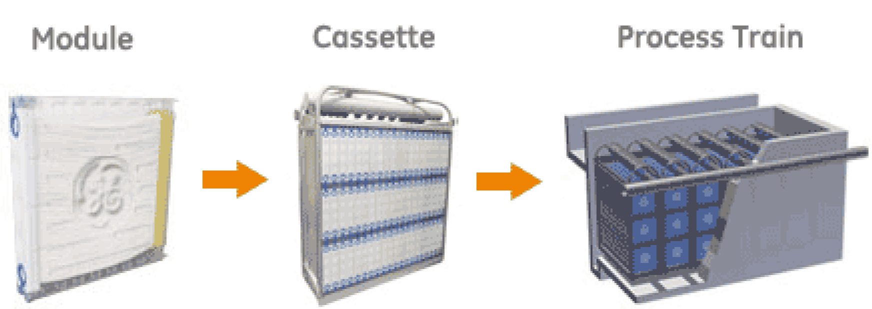


Figure 7. ZeeWeed 1000 (Courtesy of GE Water & Process Technologies)

It should be noted that up until recently (two to three years or so ago), GE/Zenon was offering the ZeeWeed 500D membranes for both membrane bioreactor (MBR) and tertiary filtration applications. However, GE/Zenon now only offers the ZeeWeed 1000 for tertiary applications. Hence, discussion of ZeeWeed 500D membranes has been excluded. There are notable differences between the two membranes. The ZeeWeed 500D membranes are a reinforced membrane, with a nominal pore size opening of 0.04 microns and have been reported to have minimal fiber breakage. On the other hand, the ZeeWeed 1000 membrane is an unreinforced membrane. Studies have shown that the ZeeWeed 1000 membranes have greater virus removal than the ZeeWeed 500D. California Department of Health Testing studies show 3.8 - 5.5 log virus removal for ZeeWeed 1000 membranes compared to 2.5 - 4.5 log virus removal for ZeeWeed 500D membranes. ZeeWeed 1000 membranes have shown greater than 9 log removal of *Cryptosporidium* and *Giardia* cysts.

MEMCOR CS (Siemens Water Technologies)

MEMCOR CS membranes are another submerged system that operates in an open tank design. Influent flows by gravity into the membrane tanks and the water is drawn through the membranes by a suction pump at TMPs up to 12 psi. This UF membrane is fully automated for backwashing, cleaning, and membrane integrity testing. The membranes are isolated into groups of four. A picture of an installation of the MEMCOR CS at the Kranji NEWater plant in Singapore is presented in Figure 8. MEMCOR systems can often be retrofitted into existing tanks thereby significantly increasing the plant capacity without increasing the footprint. Removals down to 0.2 microns are achieved with 6-log removal of *Giardia* and *Cryptosporidium*, silt density index (SDI) less than 2, TSS less than 1 mg/L, and non-detectable total coliform. The membranes can be made of either polypropylene (PP) or PVDF. However, most installations now use PVDF due to its greater tolerance to chlorine.

Figure 8 MEMCOR CS at Kranji NEWater Reclamation Plant, Singapore (Courtesy of Siemens Water Technologies)

Water recovery in the MEMCOR CS systems is typically 93 percent with typical average flux values between 15-25 gfd. A 500-micron strainer is required before the MEMCOR membranes to protect them from large solids. Backwashing lasts for 3 minutes, and includes air scour and reverse filtration. Backwash consists of 15 seconds of liquid backwash with air scour followed by 1 minute of only air scour. Then the dislodged solids are drained from the tank. A chemical CIP (clean-in-place) is required every 30 days and a maintenance wash with acid and chlorine is required every 2 days. The procedure for maintenance washes and CIPs is similar with higher concentrations of cleaning chemicals and a longer duration for the CIP. The cleaning procedure includes a backwash, followed by filling the membrane tank with hot water (40 ºC) and acid or sodium hypochlorite. The solution is then filtered through the membrane followed by a soak with air scour. The tank is then drained and backwashed once more to remove residual chlorine. The membranes then continue filtering, with filtration to waste until the chemical residual has been reduced in the filtrate.

Pressurized Systems

Pall Aria™ System - Microza™ Membranes (Pall Corporation - Asahi Kasei Corporation)

The Pall Aria™ system is a pressurized MF or UF membrane process using Microza™ membranes manufactured by Asahi Kasei Chemical Corporation. The membranes can be MF or UF membranes; however, MF membranes are most commonly used for systems filtering secondary effluent. The Microza™ MF membranes are hollow fiber, PVDF, rated at 0.1 micron with 0.7 mm diameter fibers. A module has 538 ft^2 of membrane surface area. Influent enters the bottom of the modules and passes through the hollow fiber membranes from the outside-in. Filtrate is collected at the top of the module. Solids accumulate on the fiber surface, increasing the TMP over time. Air scouring is applied to remove the accumulated solids at a set TMP increase or a set volume of water throughput. The air is injected at low pressure to the feed side of the module. For backwashing, the filtrate is collected in a tank and pumped in reverse through the module. After backwashing, a forward flush circulates influent at high velocity through the membrane and wasted. This is a fully automated cycle that repeats every 20 to 120 minutes. The filtration process stops for 1.5 to 2 minutes for backwashing. Typical fluxes with secondary effluent are expected to be around 35-45 gfd with a design TMP of 12-15 psi. A photo of the Pall Aria™ system is presented in Figure 9.

Figure 9. Pall Aria™ System (Courtesy of Pall Corporation)

Like many low-pressure membrane systems, the Pall Aria™ system requires fine screening (400 micron) before the membranes to protect them from large particles. There are Pall Aria™ installations worldwide ranging with treatment capacities from 0.3 to 31 mgd. Thirty of these installations are for wastewater applications. The membrane treatment can remove bacteria, pathogens, and suspended solids with an effluent turbidity less than 0.05 NTU and SDI less than 3.

ZeeWeed 1500 (GE Water & Process Technologies)

The ZeeWeed 1500 is a pressure membrane filter that was introduced by GE Water Technologies in 2008. This system appears to be best suited for small and medium sized plants. Both packaged and custom designs are available. Operation is fully automated. A photo of the ZeeWeed 1500 system is shown in Figure 10. The module design is compact with on rack inspection capability. Effluent water quality has TSS less than 1 mg/L, turbidity less than 0.1 NTU 95 percent of the time, and SDI less than 3. Average membrane flux is reported to be about 30 gfd when filtering secondary effluent.

Figure 10. ZeeWeed 1500 (Courtesy of GE Water & Process Technologies)

MEMCOR CP (Siemens Water Technologies)

MEMCOR CP membranes are a pressurized system with the membranes installed in vertically mounted pressure vessels. The influent is typically pressurized at 30-40 psi. The influent pressure can be higher if required for residual pressure. The system is fully automated with backwashing, cleaning, and membrane integrity testing. All modules can be individually isolated for consistent operation. The membranes are UF hollow fibers with a nominal 0.04-micron rating that remove viruses, turbidity, suspended solids, and pathogens. The system is compact and can treat up to 10 mgd in one skid. A photo of a MEMCOR CP installation is shown in Figure 11. This system is reported to achieve 6-log removal of bacteria and protozoa, SDI less than 2, turbidity less than 0.02 NTU, TSS less than 1 mg/L and non-detectable total coliform.

Figure 11. MEMCOR CP at Changi NEWater plant in, Singapore (Courtesy of Siemens Water Technologies)

X-Flow (Norit)

Norit X-Flow membranes are UF hollow fiber membranes made of polyethersulfone (PES). The membrane elements can be installed in two configurations. The first configuration is a series of pressure vessels mounted vertically and connected to a common feed header at the bottom of the skid with one membrane element per vessel. The second configuration is a series of horizontal pressure vessels stacked one above the other with up to four membrane elements per vessel similar to a reverse osmosis skid. A picture of the Norit X-Flow module is presented in Figure 12. This system uses dead end filtration. The backwash process is chemically enhanced and fully automated. The system is reported to remove turbidity and microbes effectively with up to 6-log removal of bacteria, turbidity of less than 0.1 NTU, and SDI less than 3. TMPs are typically 3-9 psi. Backwashing occurs once every 30 minutes for 35-40 seconds. Only permeate is used in backwashing with no air or chemical addition. The membranes require cleaning once per day with a 10-minute soak in caustic and hypochlorite followed by a 10 minute soak in acid. Typical membrane life is seven years.

Figure 12. X-Flow Membrane (Courtesy of Norit)

<u>HYDRAcap® (Hydranautics)</u>

The HYDRAcap® membrane is a pressurized UF membrane with an inside-out flow pattern. Influent enters the fiber and filtrate is collected in the core of the module in a central tube. During backwash, the filtrate is pressurized and reversed through the module so accumulated solids can be removed from the fibers. The fibers are a uniform structure made from hydrophilic PES membranes. They have a high tolerance to chlorine, peroxide, and extreme pH. Filtration is optionally direct or cross-flow for operational flexibility. There is also an option for the diameter of the fibers at 0.8 or 1.2 mm. A schematic of a module is shown in Figure 13.

The nominal molecular weight cutoff of the HYDRAcap® membrane is 150,000 Daltons and the typical flux range of this membrane is from 25 to 35 gfd with a TMP between 2 and 20 psi depending on the feed water quality. Backwash occurs every 15 to 60 minutes for 25 to 60 seconds. Chemical backwash is performed 1 to 2 times per day for a 1 to 30 minute soak, and cleaning occurs every 1 to 6 months.

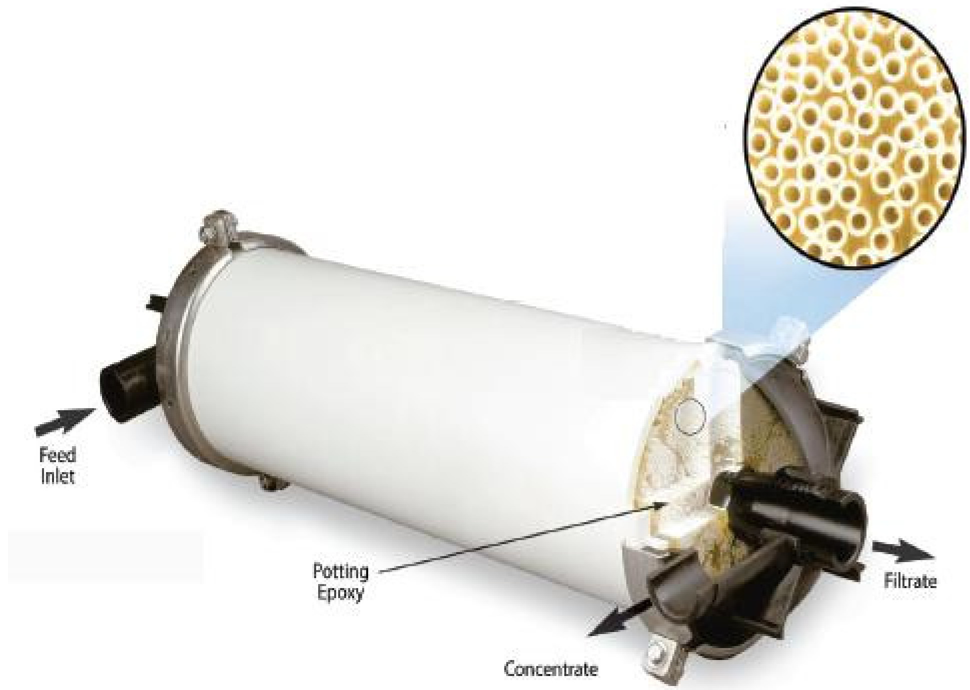


Figure 13. HYDRAcap® Membrane (Courtesy of Hydranautics)

Innovative Technologies

Filtration technologies that are unique or new to the marketplace are considered innovative. Included in this section are the following technologies: the Fuzzy Filter, the DynaSand D2®, the Ultrascreen® Filter, the SpiraSep membrane, and Blue PRO®. The Fuzzy Filter® uses depth filtration with a synthetic medium. The DynaSand D2 is a modification to the continuous backwash filter. The Ultrascreen® Filter is a microscreen filter that is able to handle higher loading rates than other microscreen filters. The SpiraSep membrane is a submerged membrane that makes use a spiral wound configuration rather than hollow fiber. Blue PRO® is a filter with modified sand medium used to meet low-level phosphorus requirements. A more detailed discussion of these innovative technologies is included below.

Fuzzy Filter® (Schreiber)

The Fuzzy Filter® is different from most other filtration technologies in several ways. First, the medium for the Fuzzy Filter® is pink compressible balls made of synthetic fibers. Second, the influent flows through the medium instead of around it. Third, hydraulic loading rates up to 30 gpm/ft^2 are possible. A flow schematic through the Fuzzy Filter® during a typical operational cycle is presented in Figure 14.

During normal operation, water flows up through the Fuzzy Filter® medium which is compressed by a movable plate to a desired compression ratio. As the secondary effluent flows through the medium, the solids are removed. The effluent then passes through the effluent line. After the head loss reaches a certain level, a backwash cycle is initiated. During the backwash cycle, the effluent valve is closed while the influent valve remains open. The moveable plate decompresses the medium, an air scour is introduced, and the filter medium is cleaned with filter influent (secondary effluent) water. After the accumulated solids have been removed from the medium by the backwash process, the moveable plate compresses the medium to the desired compression ratio, and a flush cycle begins. The purpose of the flush cycle is to remove the backwash water from the effluent side of the filter. Once the backwash water has been flushed from the effluent side of the compartment, the effluent valve opens and the filter begins producing effluent. The backwash cycle typically runs one to two times per day. The maximum head loss through the filter is 70 inches and 2 percent of the water is rejected. The medium has been in service for 17 years without replacement and has shown removals down to 5 micron.

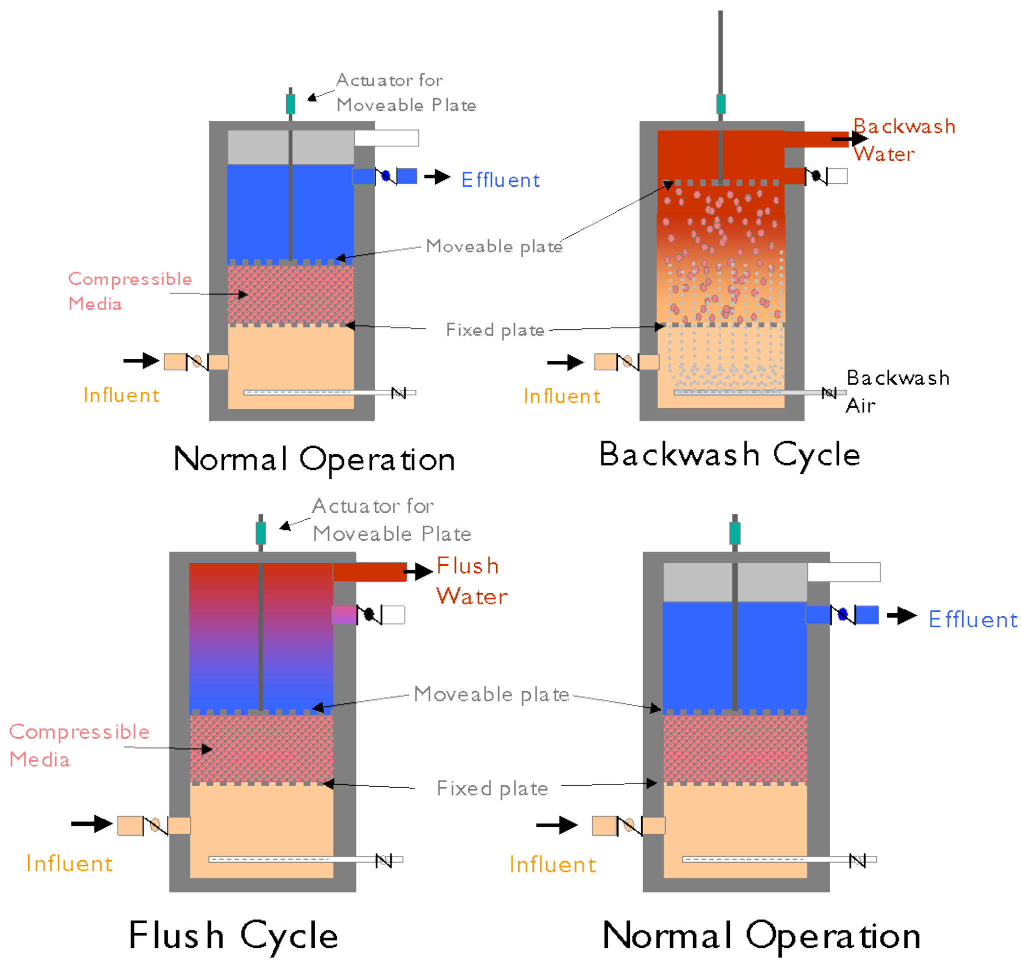


Figure 14. Flow Path through the Fuzzy Filter®

DynaSand D2® (Parkson Corporation)

Similar to the process for continuous backwash filters, the DynaSand D2® advanced filtration system is a patented process that makes use of two continuous backwash filters in series. The first stage has a filter bed 80 inches deep with 1.4 mm silica sand medium, while the second stage has a 40-inch bed depth with 0.9 mm silica sand. Prior to filtration, the influent water is dosed with a coagulant. Chlorine is added as an oxidant and to enhance coagulation. In the filtration system, the first stage removes precipitated phosphorus, while the second stage acts as a polishing step. The reject from both stages is conveyed to an inclined plate separator preceded by rapid mixing and flocculation. The overflow is returned to the filter system feed and the sludge is treated with other plant sludge. The process flow diagram for the DynaSand D2 Process is presented in Figure 15.

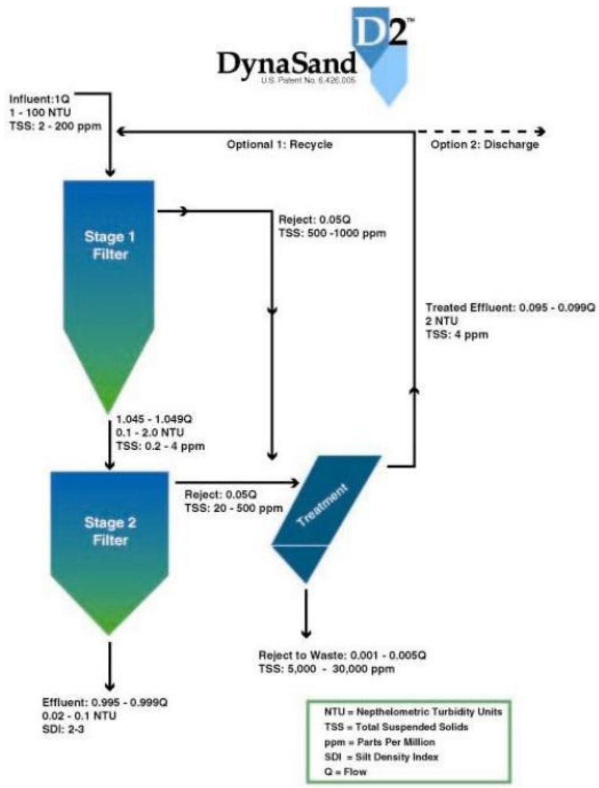


Figure 15 DynaSand D2® Process Diagram (Courtesy of Parkson Corporation)

The DynaSand D2® process has been compared with MF for pretreatment of RO and for tertiary phosphorus removal. Typical effluent quality of full-scale installations are reported to have turbidity values of 0.05 to 0.10 NTU, total phosphorus concentrations of 0.01 to 0.05 mg/L, $cBOD_5$ concentrations of less than 3 mg/L and Cryptosporidium and Giardia removals of 7 log. Side-by-side studies have found the 2-stage DynaSand to have comparable water quality to MF membranes for total phosphorus and fecal coliform (USEPA and NYCDEP/NYSDOH, 1998).

Ultrascreen® Filter (Nova Water Technologies)

Influent enters through the center of each Ultrascreen® Filter disk and passes through the filter medium. The disk rotates continuously so the influent flow always has clean filter medium. The rotation speed causes flow through the pores to occur at less than 90 degrees. Additionally, as solids accumulate, the surface mat strains out finer solids. When the headloss increases the liquid level to a set point, backwashing initiates. Each disk has a spray header that washes the filter medium. The washwater is collected and returned to the headworks of the plant. Figure 16 presents a schematic of the Ultrascreen® Filter. The filter medium is made of woven stainless steel. The speed, wash time, and level before backwash initiates can all be adjusted. Average hydraulic loading rates range from 6 to 16 gpm/ft^2 with backwash water generation of < 1.7 percent of the feed water. Title 22 testing for the Ultrascreen® Filter was recently completed at OCU's SWRF.

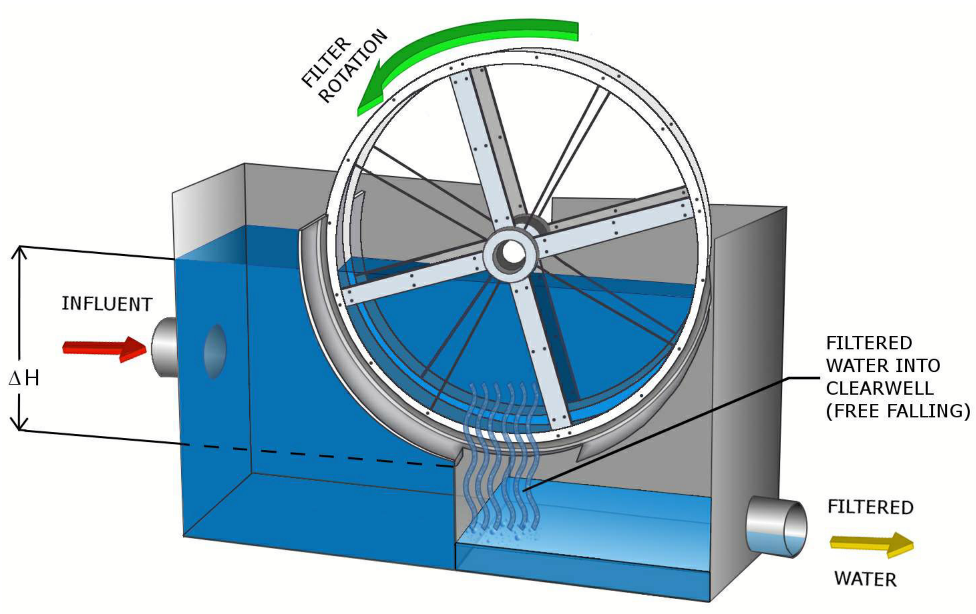


Figure 16. Ultrascreen® Filter (Courtesy of Nova Water Technologies)

SpiraSep (TriSep Corporation)

SpiraSep membranes are submerged UF membranes in a spiral wound configuration that can be backwashed. Flux rates of 25 to 35 gfd are reported with secondary effluent. The system operates with air scour and has discrete feed channels so the air comes in direct contact with the membrane surface. This creates a scrubbing action and promotes cross-flow and turbulence to remove accumulated solids. The membranes are backwashed on a timed basis to remove solids from the membrane surface and maintain flux. Filtrate is backwashed through the membrane with a small amount of disinfectant. A cleaning cycle is also required when the TMP approaches 10 psi. This consists of a 4 to 12 hr chemical soak by draining the membrane tank and filling it with chemical solution. A schematic of the configuration of the SpiraSep membrane is presented in Figure 17.

The membranes have a 0.05-micron absolute pore size rating. Operating pressure is between (-2) and (-5) psi. Chemical cleaning occurs every 3-4 months, the average TMP is 3 psi, permeability is 10 gfd/psi, and backwash frequency is every 15 min. The effluent water quality has a turbidity of less than 0.1 NTU and an SDI of less than 3.

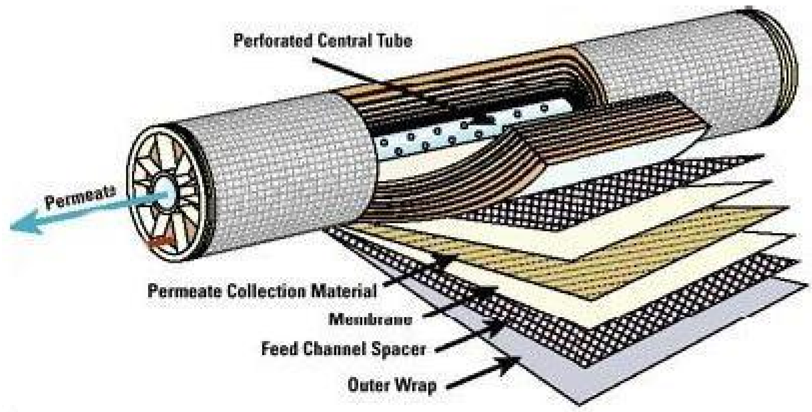


Figure 17. SpiraSep (Courtesy of TriSep Corporation)

Blue PRO® Advanced Phosphorus Removal (Blue Water Technologies, Inc.)

The Blue PRO® Phosphorus Removal Process makes use of a reactive filter medium to reduce phosphorus to very low concentrations. The medium is continuously regenerated with a continuous backwash filter, so no medium replacement or flow interruption for backwash is required. The manufacturer claims phosphorus levels as low as 0.01 mg/L can be attained when using a two-pass system and reject recycle provided the refractory soluble organic phosphorus concentration is less than 0.01 mg/L. The medium is sand that has been coated with hydrous ferric oxide that adsorbs phosphorus. A schematic of the Blue PRO® system is shown in Figure 18. Chemical coagulant is added to the filter influent prior to the Rapid Conditioning Zone to optimize the adsorption. The mixture is added to the filter at the bottom of the filter bed, flows upward, and exits at the top of the filter. The sand moves from top to bottom and is airlifted back to the top of the filter. The sand is separated from excess iron and phosphorus particles at a wash box at the top of the airlift. Ferric chloride or sulfate is used for regeneration of the hydrous ferric oxide medium.

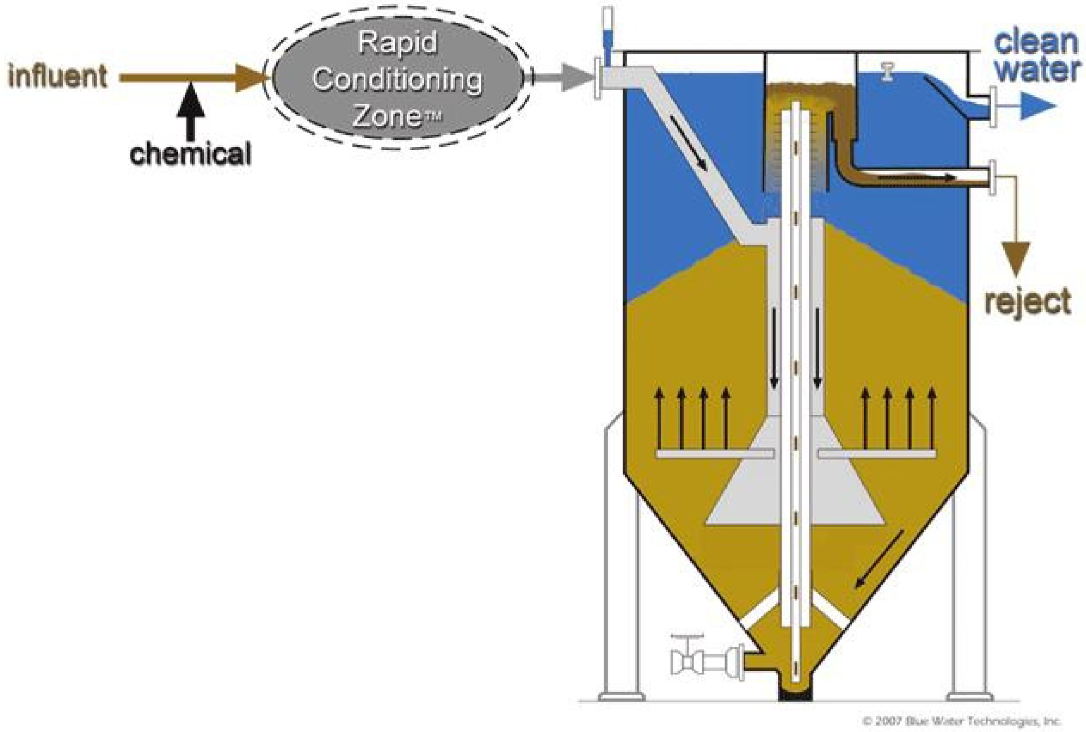


Figure 18. Schematic of Blue PRO® Process (Courtesy of Blue Water Technologies, Inc.)

Summary of Tertiary Filter Technologies

An overall summary of the loading rates, manufacturer reported backwash and/or reject water percentages and years since the first installation for each filtration type as discussed above is presented in Table 1. The loading rates are based on criteria determined by the California Title 22 acceptance requirements.

Table 1	Summary of Filtration Technologies Identification of Alternative Treatment Technologies Orange County Utilities			
Filter	**Loading Rate(1)(2)**	**Reject (%)(3)**	**Years in Market**	**No. of Installations**
Deep Bed				
TETRA® DeepBed™	5 gpm/ft^2	3%	30	>110
Leopold Tertiary Filter System	5 gpm/ft^2	<2%	37	NA
Roberts Deep Bed Filtration System	5 gpm/ft^2	2%	43	NA
Continuous Backwash Filtration				
DynaSand	5 gpm/ft^2	12-25%	24	NA
Automatic Backwash Filters				
AquaABF Automatic Backwash Filter	2 gpm/ft^2	2-3%	34	19
ABW Automatic Backwash Filter	2 gpm/ft^2	5-6%	15	>350
Eimco	2 gpm/ft^2		25	53
Cloth Medium				
AquaDisk	6 gpm/ft^2	<5%	16	33
AquaDiamond	6 gpm/ft^2	<5%	4	10
Microscreen				
Hydrotech Discfilter	6 gpm/ft^2	2-3%	14	111
DynaDisc Filter	6 gpm/ft^2	2-3%	13	NA
Forty-X Disc Filter	6 gpm/ft^2	2-3%	1.5	NA
Submerged Membranes				
ZeeWeed 500D	20.5 gfd	10%	10	30
ZeeWeed 1000	23 gfd	10%	5	13
MEMCOR CS	15-25 gfd	8%	11	3
Pressurized Membranes				
Pall Aria System - Microza Membranes	35-45 gfd	6-10%	12	27
ZeeWeed 1500	30 gfd	10%	1	0
MEMCOR CP	20-30 gfd	5%	23	11
X-Flow	38-41 gfd	10%	10	12
HYDRAcap	25-35 gfd	10%	9	5
Innovative Technologies				

**Table 1 Summary of Filtration Technologies
Identification of Alternative Treatment Technologies
Orange County Utilities**

Filter	Loading Rate(1)(2)	Reject (%)(3)	Years in Market	No. of Installations
Fuzzy Filter®	30 gpm/ft^2	5%	14	NA
DynaSand D2	6 gpm/ft^2	5%	5	NA
Ultrascreen® Filter	12-15 gfd	2%	10	NA
SpiraSep	25-30 gfd	<10%	4	3
Blue PRO®	6 gpm/ft^2	7%	4	NA

Notes:
(1) gpm/ft^2 - gallons per minute per square foot
(2) gfd - gallons per day per square foot
(3) Reject (%) - listed in this table are those that are claimed by the manufacturer. The actual reject rate achievable is highly dependent on the water quality in the influent to the filter and the filter operation of the filter.

COMPARISION OF VARIOUS FILTRATION TECHNOLOGIES

This section presents the inherent differences and performance characteristics of conventional media versus membrane filtration technologies. The objective for providing this section is to present the distinct water quality advantages that membrane filters can provide over the conventional media filters. The general characteristics of the filtration processes can be compared to illustrate the difference between two filtration mechanisms as presented in Table 1 below.

Table 1 Comparison of Conventional, Granular Medium Deep-Bed Filters with MBR
Identification of Alternative Treatment Technologies
Orange County Utilities

Design Parameter	Conventional Deep-Bed Filters	MBR Filters
Type of media	sand	chlorinated polyethylene or polyvinylidene fluoride (PVDF)
Nominal media pore size	10 – 20 micron	0.04 - 0.2 micron(1)
Configuration	gravity	submerged (open tank) or pressure (in vessel)
Typical maximum hydraulic loading rates	2 - 8 gpm/ft^2 (4)	10 - 25 gfd (2)(5)
Average effluent turbidity	< 2 NTU	< 0.1 NTU
Pretreatment	chemical, coagulation/flocculation(3)	fine screening (2 mm)
Backwash or cleaning	air or water only, or both	air scour, relaxation, backpulse and chemical cleaning
Reject stream	2 - 10%	None

Notes:
(1) Nominal pore size for UF and MF membranes
(2) Equates to 0.007 to 0.017 gpm/ft^2
(3) Chemical coagulation/flocculation is only necessary if the effluent turbidity or TSS limits cannot be met by filtration alone.
(4) gpm/ft^2 - gallons per minute per square foot
(5) gfd - gallons per day per square foot

WATER QUALITY

Water quality is the most important performance parameter. Currently, based on full-scale experience here in the state of Florida and elsewhere, well operated biological nutrient removal processes can consistently achieve effluent TP in the range of 0.5 to 2.0 mg/L and TN in the range of 3 to 5 mg/L. Beyond the biological treatment, the ability of the treatment process scheme to separate the biological and other suspended and colloidal matter from the secondary effluent will provide the most effective treatment for further beneficial use of treated effluent. The efficiency or ability of a filtration technology to remove contaminants such as particulates and microbes from secondary effluent is of utmost importance for the safety of the environment and human health depending on the type of disposal. With the recent emphasis on removal of nutrients from wastewater, tertiary filters could play a significant role by removing the portion of nutrients that are associated with particulate matter. Reference is made to low-pressure MF and UF membranes typically used for tertiary filtration application. MBR also use low-pressure MF or UF membranes and its performance is similar to that of a tertiary low-pressure MF or UF membrane for removal of particulate matter and microbiological contaminants.

Particulate Removal

There is a distinct difference in the particulate removal achieved by conventional media filters such as deep bed granular media as compared to MBR. MF or UF membranes have pore sizes that are orders of magnitude smaller than conventional media filters. As a result, membrane filters or MBR provide significantly greater removal of particulate matter with typical effluent turbidities less than 0.1 NTU. Figure 1 shows the particle size distribution for a typical secondary effluent, secondary effluent with physico-chemical treatment, and microfiltration membrane effluent.

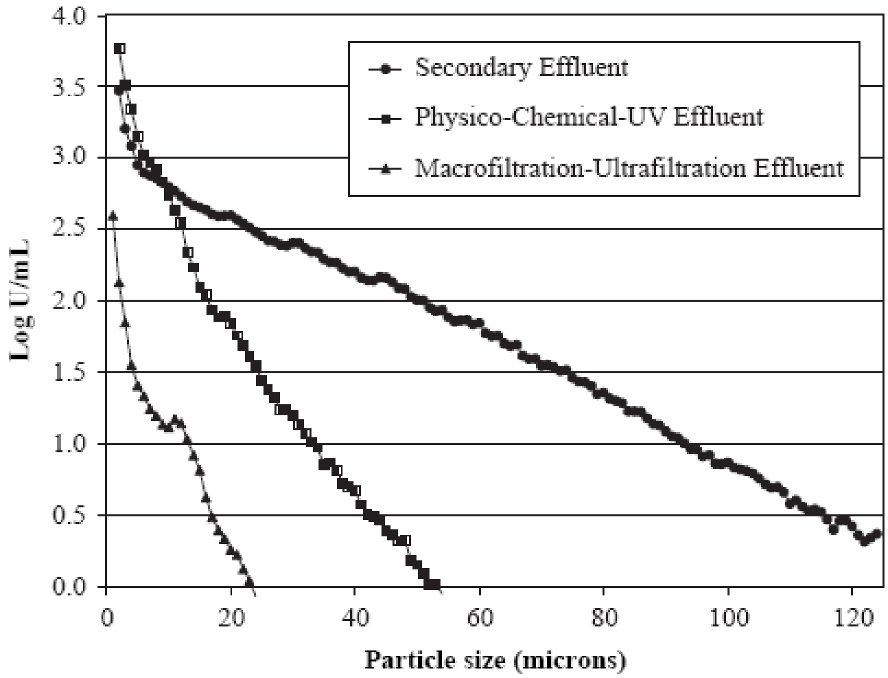


Figure 1. Particle Size Distribution in Effluent from a Coagulation-Sedimentation-GMF-UV Pilot Plant and a GMF-Ultrafiltration Pilot Plant (Gomez et al., 2006)

Microbiological Constituent Removal

As with particulate removal, there is a distinct difference between the conventional media filters and low-pressure membrane filters or MBR for removal of microbiological contaminants as a result of the ability of the membranes to remove nearly all pathogens based on size exclusion. A summary of the relative sizes of some common contaminants and the typical pore sizes for filtration technologies to remove them is shown in Figure 2.

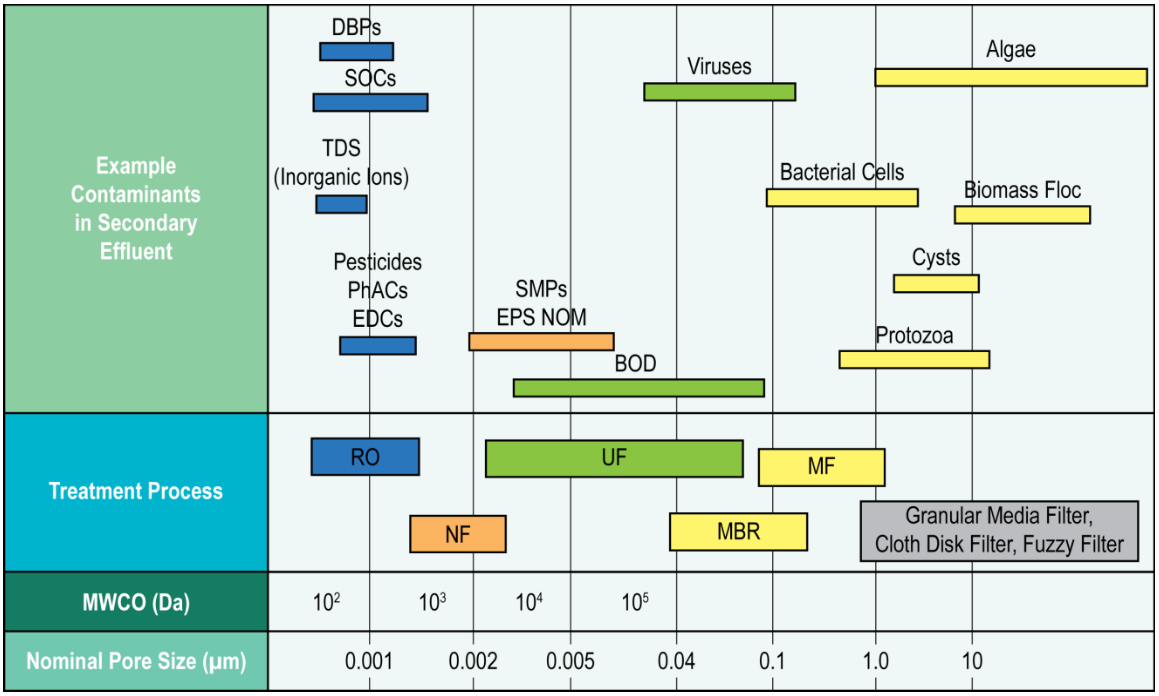


Figure 2. Summary of Contaminants and Treatment Process Size Range

Few studies published in the literature directly compare the performance of deep-bed media filters for the removal of *Cryptosporidium* and *Giardia*. A study conducted by Gomez et al. (2006) compared a disk filter and pressure sand filter with MF and UF membranes. The results of this study are shown in Table 2.

Table 2 Microbiological Removal Comparison (Gomez et al, 2006)
Identification of Alternative Treatment Technologies
Orange County Utilities

Technology	Fecal coliform removal (%)	*E. coli* removal (%)	*E. coli* coliphage removal (%)
Disk filter	31.26 ± 20.98	33.24 ± 31.57	37%
Pressure sand filter	36.88 ± 24.64	34.10 ± 34.23	34%
Microfiltration	99.81 ± 0.33	100	95%
Ultrafiltration	99.998 ± 0.003	100	99.97%

Log-reduction terminology provides a way to express the removal of biological contaminants like protozoan cysts, bacteria, and viruses by factors of 10. Log removal values are easily converted to percent reduction. For example, the log of 10 in the base 10 logarithmic system is 1, the log of 100 is 2, and the log of 1000 is 3, etc. A 1-log reduction removes nine out of 10 pathogens and is equivalent to a 90 percent reduction. A 2-log reduction removes 99 out of 100 pathogens or a 99 percent reduction, and a 3-log reduction removes 999 out of 1000 pathogens or a 99.9 percent reduction. A 99.99 percent reduction is a 4-log reduction.

The size range of the various bacterial species suggests that they should be completely removed by low-pressure MF or UF membranes. Several researchers have reported greater than 6-log removal of total and fecal coliform bacteria by UF hollow fiber membranes (Jacangelo et al. 1989; Cabassud et al. 1991; Madsen 1987). For comparison, typical secondary clarified effluents have fecal coliform in the 10,000 - 1,600,000 MPN/100 ml range. The detection limit for fecal coliform is 2 MPN/100 ml and most of the studies on low-pressure membranes performed have shown effluent fecal measurements at or below this detection limit. MF membrane filters will typically provide up to 6-log removal of Cryptosporidium oocysts and Giardia cysts while an intact UF membrane filter should provide complete removal of the protozoan cysts. The cyst of these protozoa, which range in size from 3 - 14 μm, can be easily removed by either MF or UF membranes.

Various studies have reported virus removal of 0.5 to 4 logs for membrane filters. The typical size of most viruses is in the range of 0.018 - 0.3 μm as compared to the nominal pore size of MF membranes in the 0.1 - 0.4 μm range. Viruses can be removed by MF membranes depending on the foulants (cake or gel) layer that builds over time on membrane surfaces during filtration. UF membranes, with nominal pore sizes in the range of 0.01 to 0.04 μm, are capable of providing significant virus removal without reliance on a foulant layer. Because of differences in pore sizes, UF membranes are considered to provide greater removal of viruses as compared to MF membranes.

The lack of suitable and reliable integrity testing methods for rapid detection of breaches in membrane fibers has limited the acceptance of foulant layers for virus removal in potable water treatment, and for that matter for all microbiological parameters. The wastewater industry has debated the effectiveness of low-pressure membranes as a microbiological barrier, and the allowance of disinfection “credits” for membranes used in wastewater applications. Much research is required; however, for validation and verification of pathogen rejection by membranes similar to what has been done for UV disinfection technology over the last decade. Table 3 below provides summary information on the typical removal of pathogens by the various types of filters.

Table 3	Typical Removal of Particles and Pathogens Reported for Various Types of Tertiary Filters Identification of Alternative Treatment Technologies Orange County Utilities			
Type of Filter	**Minimum Size Particles Removed (1) (μm)**	**Log Removal Fecal Coliform**	**Log Removal Protozoan Cysts**	**Log Removal Virus**
Traveling Bridge ABW	1 – 10	4.0(2)(3)	0.7 – 1.0(2)	0 – 1.2
Deep Bed	1 – 10	2.5(2)(3)	0.4 – 1.5(2)	0 – 1.3
Low-pressure membranes and MBR	< 0.1	3 – 9	6 – 9	0.5 – 4
Cloth medium	1 – 10	3.0(2)(3)	0.4 – 0.5(2)	0 – 0.6

Notes:
(1) The minimum particle size that can be removed depends on the characteristics of the filter medium, and the type and performance of the upstream treatment processes
(2) Levine, et al., 2008.
(3) The influent to the ABW filters was prechlorinated which could have affected the results for fecal coliform. The influent to the other filter types was not pretreated with any chemicals.

Nutrient Removal

As described above, the goal of achieving an effluent TN limit of 3 mg/l and TP limit of 1 mg/l for the initial phase is well within the limits of technology for well operated BNR processes such as the 5-stage Bardenpho treatment process followed by tertiary filtration. Several plants within United States using a 5-stage Bardenpho treatment process followed by tertiary filtration or a similar variation thereof are reported to successfully achieve TN limits at or below 3 mg/l and TP limits at or below 1 mg/l. Without filtration, the biological process will not consistently achieve the TN and TP goal. On the other hand, several of the 3 and 4-stage suspended growth activated sludge processes or some of the attached growth nitrifying processes can be combined with attached growth denitrifying filters to achieve the above effluent nutrient goals. Deep-bed filters provide the most flexibility in this aspect. They perform the role of a tertiary filter by achieving TSS removal to below 5 mg/l and can provide denitrification of NO_3-N to nitrogen gas to achieve the TN limit of 3 mg/l with a feed of supplemental carbon.

On the other hand, in case of the MBR alternative, subsequent treatment in the form of high-pressure membrane such as Nanofiltration or Low-Pressure Reverse Osmosis (LPRO) necessary to produce an effluent amenable for direct aquifer recharge or lake augmentation if required in future, can be easily achieved. Several large treatment plants around the globe use microfiltration followed by reverse osmosis (MF/RO) to produce very high quality reclaimed water for indirect potable use via aquifer or reservoir recharge. MBR/RO can likely meet a total nitrogen limit that is in the range of 1 to 2 mg/L; however, to date this has not been conclusively demonstrated. High-pressure membranes have several very significant disadvantages including production of a high-strength concentrate stream (equal to about 20 percent of the feed flow), high power consumption, and relatively high capital costs. A treatment method that could meet the proposed total nitrogen concentrations without these disadvantages would be very attractive. Alternatively, deep-bed filters can be designed and constructed such that they could be retrofitted with low-pressure membranes in future if advanced treatment of MF/RO is desired to dispose off the treated effluent for beneficial reuse.

There is very little data that shows the speciation of the various organic and inorganic compounds that make up the total nitrogen in the effluent of a typical activated sludge plant. Some published data (Pagilla et al. 2008) suggests that there is a large variation in the dissolved organic nitrogen (DON) content of effluent from a typical nitrifying activated sludge plant effluent. Reported DON concentrations range from 10 to 50 percent of the total nitrogen (0.3 to 2.0 mg/l), and the majority of this is refractory high molecular weight compounds (> 1000 Dalton). The remaining nitrogen is inorganic nitrogen comprised of nitrates, nitrites, and ammonia. The ammonia and nitrates can be removed down to low levels by conventional BNR processes – nitrification and denitrification. Typical UF membrane used in the MBR process can remove compounds with molecular weights > 100,000 daltons, however, very few studies show the effectiveness of a low-pressure membrane to remove additional DON left over from the biological treatment.

REFERENCES

Cabassud, C. Anselme, C. Bersillon, J.L., and Aptel, P. (1991) Ultrafiltration as a nonpolluting alternative to traditional clarification in water treatment. *Filtration and Separation* 28(3), 194-198.

Gomez, M., de la Rua, A., Garralon, G., Plaza, F., Hontoria, E., Gomez, M.A. (2006) Urban wastewater disinfection by filtration technologies. Desalination 190, 16-28.

Jacangelo, J.G., Aleta, E.M., Carns, K.E., Cumming, E.W., and Mallevaille, J. (1989) Assessing hollow-fiber ultrafiltration for particulate removal. *American Water Works Association Journal* 81(11), 68-75.

Levine, A.D., Harwood, V.J., Farrah, S.R., Scott, T.M., Rose, J.B. (2008) *Pathogen and indicator Organism Reduction through Secondary Effluent Filtration: Implications for Reclaimed Water Production*. Water Environment Research, 80(7), 596-608.

Madsen, R.F. (1987) Membrane technology as a tool to prevent dangers to human health by water-reuse. *Desalination* 67, 381-393.

Pagilla, K.R., Czerwionka, K., Urgun-Dermirtas, M., and Makinia, J. (2008) Nitrogen speciation in wastewater treatment plant influents and effluents - the US and Polish case studies. *Water Science and Technology*, 57(10), 1511-1517.

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

TECHNICAL MEMORANDUM NO. 3

WASTEWATER LOAD PROJECTIONS

FINAL
October 2011

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SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

WASTEWATER LOAD PROJECTIONS

TECHNICAL MEMORANDUM
NO. 3

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WASTEWATER LOAD PROJECTIONS

1.0 INTRODUCTION

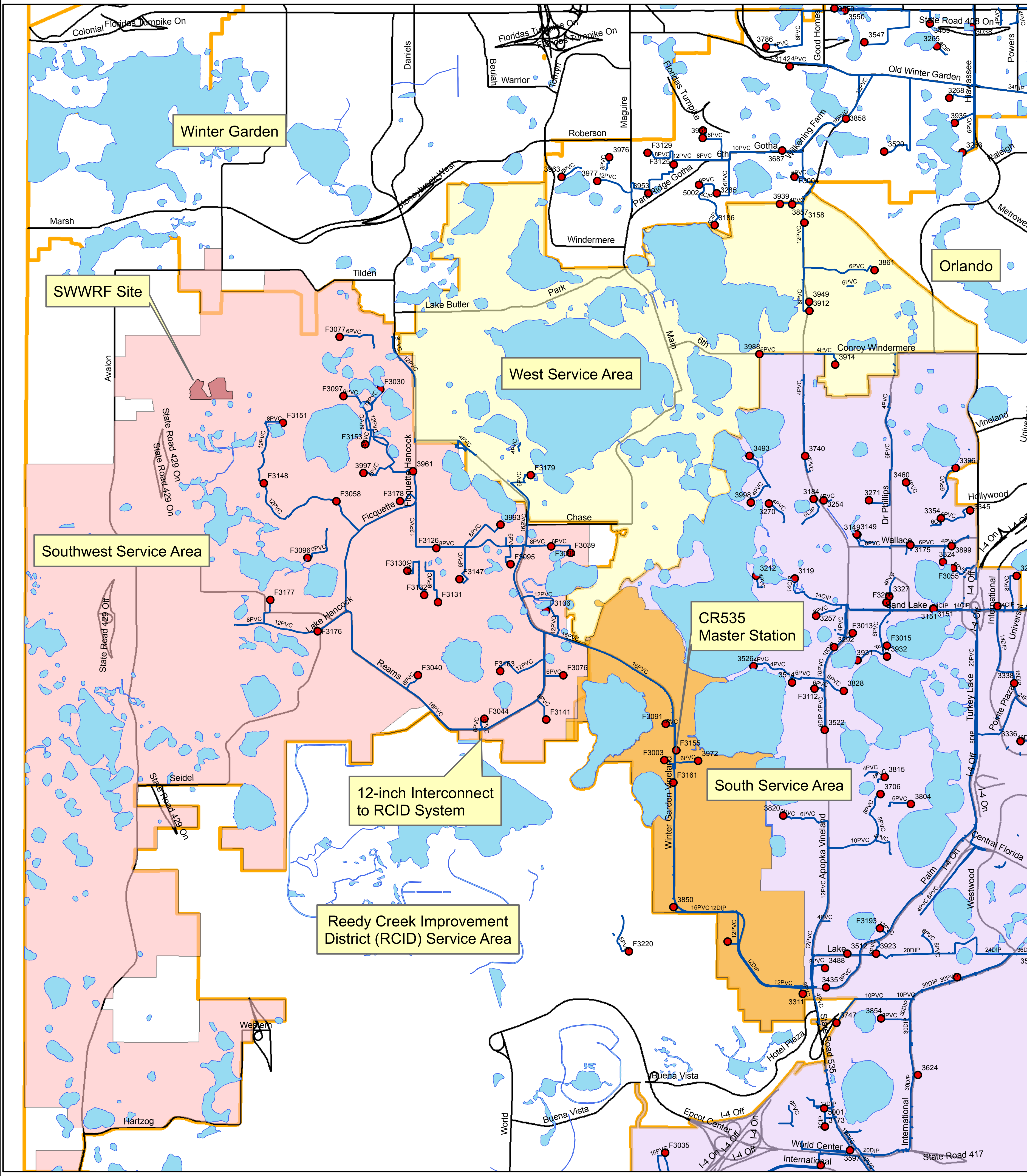
Under Task Authorization (TA) 16 of Contract Y9-901, the Carollo team was retained by Orange County Utilities (OCU) to prepare a conceptual design for the proposed Southwest Water Reclamation Facility (SWWRF). This task includes a review and update of the previous Capital Improvements and Facilities Plan prepared for this facility. The SWWRF conceptual design will update near-term and long-term planning for the SWWRF including the selection of treatment technologies, conceptual design of the plant site, and facility phasing.

1.1 Background

The 2002 Water, Wastewater, and Reclaimed Water Master Plan (PBSJ/CH2M Hill) recommended construction of a new SWWRF serving the Southwest Service Area (SWSA) with an initial treatment capacity of 4.4 mgd, on an annual average day flow (AADF) basis. Later, the 2007 Facilities Plan (PBSJ/CDM) recommended construction of the SWWRF in three phases of 5 mgd each with a build-out capacity of 15 mgd. The 2007 Facilities Plan recommended construction of the first two phases simultaneously by the year 2015 with a total capacity of 10 mgd AADF and assumed a 5 mgd diversion of flow from the South Service Area (SSA) to the proposed SWWRF.

The SWSA is comprised primarily of the Horizon West development. Wastewater collected from the SWSA is currently treated at OCU's South Water Reclamation Facility (SWRF) and at the Reedy Creek Improvement District (RCID) wastewater plant (through an interagency agreement).

Wastewater flow from the SWSA is conveyed via a network of gravity collection systems flowing into pump stations as depicted on Figure 1.1. The various pump stations pump the wastewater via a manifold system of 16-inch force mains to the CR535 Master Station (F3155). The CR535 Master Station re-pumps the flow via a 16-inch force main to Lake Street Master Pump Station (F3512) and ultimately to the SWRF for treatment. The capacity of the CR535 Master Station and the 16-inch force main is estimated to be 1.1 mgd AADF (Reedy Creek Wastewater Transmission Plan, Reiss Engineering, February 2011).



Legend

- OCU Pump Station
- OCU Forcemain
- SSA Interconnect to SWSA
- West Service Area
- South Service Area
- SWWRF Plant Site
- Horizon West Boundary/Southwest Service Area
- OCU Wastewater Service Area Boundaries
- Lakes

N

SCALE: 1 " = 6,500 '

SWSA/SSA Wastewater Service Areas

Figure 1.1

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TM-3 Wastewater Load Projections

ORANGE COUNTY GOVERNMENT FLORIDA

OCU and RCID signed a twenty-year wholesale service agreement in December 2009 for RCID to accept, treat, and provide disposal or reuse for up to 0.5 mgd of wastewater. The agreement is based on short-term service (less than 90 days use per rolling 12 month period) via a 12-inch interconnection at the intersection of Reams Road and Center Drive. In June 2011, the agreement will be amended to allow regular use of the interconnection to transfer flow to the RCID system. According to the Reiss Report, the 12-inch interconnection is hydraulically limited to a capacity of 0.8 mgd AADF from OCU to RCID. Increases above this capacity would require conveyance system improvements within the RCID system.

1.2 Scope/Objectives of this Technical Memorandum (TM)

As part of this task, the wastewater load projections for the SWSA will be updated to reflect the most recently available updates to population and wastewater flow projections developed for OCU. Concentration data for wastewater pollutants from “TM 1 – SWWRF Basis of Design Criteria” will be used along with the updated flow projections to estimate future loads for the proposed SWWRF.

2.0 BUILD-OUT FLOW PROJECTIONS

There is minimal historical wastewater flow data available for the SWSA. However, the build-out flow for the SWSA is assumed to be 13.2 mgd, as derived from the Horizon West build-out flows in the Master Utility Plans (MUP), Specific Area Plans (SAP), Planned Developments (PD), and other relevant documents prepared by the developers. Analysis of recently available wastewater billing records for the SWSA was used to estimate historical unit flows by the Carollo team to develop an independent estimate of build-out flows. Based on this analysis, build-out wastewater flows from the SWSA are estimated at approximately 8-10 mgd AADF.

In addition to the build-out flows from the Horizon West Development/SWSA, hydraulic analyses conducted as part of Carollo TA #11 (SWSA Conveyance Facilities Plan Update) shows that 1.7 mgd AADF from the SSA west of I-4 could be redirected to the SWWRF once constructed. The orange shaded area in Figure 1.1 is the portion of the SSA identified for treatment at the SWWRF. The 1.7 mgd AADF is the projected flow for this portion of the SSA by the year 2030.

In talking with staff, there is a general consensus that at times the OCU system has experienced a hydraulic bottleneck in conveying wastewater from the western portions of the SSA and SWSA (i.e., areas west of I-4) to the SWRF. By redirecting flow or providing flexibility to convey the flows from the CR535 Master Station to the proposed SWWRF, this bottleneck could be avoided in the future. Therefore, based on the anticipated actual development density, review of billing records for the past 5 years (2005-2010), and assuming a diversion of up to 1.7 mgd of wastewater flow from the SSA to the SWWRF, the build-out flows for the SWWRF are estimated to be in the range of 10 to 12 mgd.

3.0 LOAD PROJECTIONS

Current flows in the SWSA previously have been estimated to be around 0.8 mgd AADF (Reedy Creek Wastewater Transmission Plan, Reiss Engineering, February 2011). More recent analysis of available SWSA flow data by the Carollo team indicates that the current (ca. 2010) wastewater flow may be closer to 0.9-1.0 mgd AADF. This equates to a historical growth rate of approximately 0.10-0.12 mgd/year in the SWSA assuming uniform development over the past approximately 8 years. With the recent economic recession slowing growth in the central Florida region, there is a large uncertainty in the expected timing and rate of future growth.

An initial assumption of Phase I SWWRF capacity assumes that the facility will need to be operational when wastewater flows exceed the combined capacity of the RCID interconnect agreement of 0.5 mgd and the transmission and pumping capacity of the CR535 Master Station from the SWSA to the SSA of 1.1 mgd AADF according to the Reedy Creek Wastewater Transmission Plan (Reiss Engineering, February 2011). Given that the current flows through the CR535 Master Station of 0.9-1.0 mgd are approaching capacity, OCU needs to prepare for when flows in the SWSA increase by another approximately 0.5 mgd (the capacity of the RCID agreement). This suggests that OCU should prepare and plan to handle flows in excess of 1.6 mgd, which is estimated to occur in 2016. One option would be to treat all the flows with Phase I of the SWWRF. Additionally, to relieve the hydraulic bottlenecks of the transmission system divert up to 1.7 mgd of wastewater from the SSA west of I-4 to the SWWRF.

Under TA #11, the Carollo team facilitated an updated assessment of the anticipated timing and capacity requirements for the planned SWWRF. TM2 of the TA #11 discusses the timing and capacity assessment and recommended that the SWWRF Phase I should have a capacity of a 5 mgd AADF, sized to accommodate projected SWSA wastewater flow (plus portion of SSA wastewater west of I-4) for approximately 10 years after start-up and to accommodate a transfer of up to 1.7 mgd of wastewater from the SSA west of I-4.

Based on the above discussion and the influent design characteristics for the SWWRF presented in TM 1, the load projections for Phase I (5 mgd) of the SWWRF are presented in Table 3.1.

Table 3.1 SWWRF Influent Wastewater Pollutant Flows and Load Projections SWWRF Conceptual Design and Facilities Plan Update Orange County Utilities

Parameter	Design Parameter	Unit	Phase I
Flow	Annual Average (AA) Influent Flow	mgd	5.0
	Maximum Month (MM) Flow PF	–	1.3
	Maximum Day (MD) Flow PF	–	1.7
	Peak hour (PH) Flow PF		3.0
	MM Influent Flow	mgd	6.5
	MD Influent Flow	mgd	8.5
	PH Influent Flow	mgd	15.0
Carbonaceous 5-day Biochemical Oxygen Demand ($cBOD_5$)	$cBOD_5$, AA	mg/l	290
	$cBOD_5$ Mass Loading, AA	lb/day	12,093
	$cBOD_5$ Mass Loading MM/AA PF	–	1.2
	$cBOD_5$ Mass Loading MD/AA PF	–	1.8
	$cBOD_5$ Mass Loading MM	lb/day	14,512
	$cBOD_5$ Mass Loading MD	lb/day	21,767
Chemical Oxygen Demand (COD)	COD, AA	mg/l	695
	COD Mass Loading, AA	lb/day	28,982
	COD Mass Loading MM/AA PF	–	1.2
	COD Mass Loading MM	–	34,778
Total Suspended Solids (TSS)	Total Suspended Solids, AA	mg/l	300
	TSS Mass Loading, AA	lb/day	12,510
	TSS Mass Loading MM/AA PF	–	1.2
	TSS Mass Loading, MM	lb/day	15,012
Volatile Suspended Solids (VSS)	VSS, AA	mg/l	285
	VSS Mass Loading, AA	lb/day	11,885
	VSS Mass Loading MM/AA PF	–	1.2
	VSS Mass Loading, MM	–	14,261
Total Kjeldahl Nitrogen (TKN)	TKN, AA	mg/l	46
	TKN Mass Loading, AA	lb/day	1,918
	TKN Mass Loading MM/AA PF	–	1.2
	TKN Mass Loading MD/AA PF	–	1.6
	TKN Mass Loading, MM	lb/day	2,302
	TKN Mass Loading, MD	lb/day	3,069
Total Phosphorus (TP)	TP, AA	mg/l	8
	TP Mass Loading, AA	lb/day	334
	TP Mass Loading, MM/AA PF	–	1.2
	TP Mass Loading, MM	lb/day	400

Notes:

(1) PF – Peaking Factor.

(2) Pollutant concentrations and peak factors as described in TM1 – SWWRF Basis of Design Criteria.

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

TECHNICAL MEMORANDUM NO. 4

RECLAIMED WATER UTILIZATION

FINAL
October 2011

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SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

RECLAIMED WATER UTILIZATION

TECHNICAL MEMORANDUM
NO. 4

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ATTACHMENT A
Table A.1. SWWRF Reclaimed Water Utilization Alternatives Assessment Summary

SWWRF RECLAIMED WATER UTILIZATION

1.0 INTRODUCTION

Under Task Authorization (TA) 16 of the Water/Wastewater Program Management Contract (Y9-901), the Carollo team was retained by Orange County Utilities (OCU) to prepare a conceptual design for the proposed Southwest Water Reclamation Facility (SWWRF). The SWWRF conceptual design will update near-term (Phase 1) and long-term planning (Phase 2 and beyond) for the SWWRF including the selection of treatment technologies, conceptual design of the facility site, facility phasing, and related utilization of the reclaimed water produced at the facility. This Technical Memorandum (TM) No. 4 addresses potential water reuse alternatives for the SWWRF as they relate to reclaimed water quality for both the initial phase design and planning for future phases, depending on the type of water reuse practiced.

1.1 Background

The 2002 Water, Wastewater, and Reclaimed Water Master Plan (PBS&J/CH2M JV, 2006) recommended a separate SWWRF by the year 2020 to serve the new Southwest Service Area (SWSA) and portions of the South Service Area (SSA) west of I-4. Subsequently, the 2007 OCU Wastewater Facilities Plan (PBS&J and CDM, 2007) further developed the concepts for a new SWWRF, including an estimate of the required maximum (i.e., build-out) treatment capacity through the year 2050 using the flow projections developed in the 2002 Master Plan. Both the 2002 Master Plan and the 2007 Wastewater Facilities Plan recommended reclaimed water quality based on public access reuse (PAR) requirements, with possible side-stream treatment for direct aquifer recharge options. The 2007 Wastewater Facilities Plan considered biological nutrient removal (BNR) treatment to achieve 3 mg/L of total nitrogen (TN) in anticipation of more stringent treatment requirements.

1.2 Workshop No. 1

As part of this task authorization on March 16, 2011, Workshop No. 1 was held with OCU management staff. The purpose of the workshop was to present to OCU for comment and concurrence the following:

1. Technical Memorandum No. 1 – Southwest Water Reclamation Facility (SWWRF) Basis of Design Criteria.
2. Overview of SWWRF Reclaimed Water Utilization Alternatives and Issues.

The second item above presented for discussion an overview of the most likely options for SWWRF reclaimed water utilization, including PAR, rapid–rate land application, direct aquifer recharge, lake augmentation, and surface water discharge. That overview formed the basis for this TM.

OCU has determined that the initial phase of SWWRF will be designed for reclaimed water quality suitable for use via the existing PAR system in OCU's SWSA and interconnection to the jointly owned Water Conserv II (WCII) system with existing or planned WCII rapid infiltration basins (RIBs) as a backup. Additionally, OCU is requiring the initial phase of the SWWRF to be designed as an Advanced Wastewater Treatment (AWT) plant with effluent meeting a treatment goal of 5:5:3:1 (cBOD5, Total Suspended Solids (TSS), TN, and Total Phosphorus (TP), respectively).

1.3 Technical Memorandum Organization

The main objective of this TM is to present reclaimed water quality requirements for various water reuse options available for the proposed SWWRF. The TM is organized as follows:

Section 1.0 Introduction – This section presents an introduction to the reclaimed water management aspects of the project, provides background information on prior planning in this regard, and summarizes initial OCU guidance decisions from Workshop No. 1 related to SWWRF reclaimed water management and quality.

Section 2.0 Public Access Reuse – This section describes the various aspects of PAR, related compatibility with other reclaimed water systems, and potential capacity limitations of this utilization alternative.

Section 3.0 Rapid-Rate Land Application - This section describes the various types of rapid-rate land application, related compatibility with other reclaimed water systems, and potential capacity limitations.

Section 4.0 Direct Aquifer Recharge – This section describes the various types of direct aquifer recharge, limitations, and related compatibility with other reclaimed water systems.

Section 5.0 Lake Augmentation – This section describes the various aspects of lake augmentation, limitations, potential candidate water bodies, and related compatibility with other reclaimed water systems.

Section 6.0 Surface Water Discharge – This section describes the various aspects of surface water discharge and its limitations.

2.0 PUBLIC ACCESS REUSE

2.1 Description of System

OCU currently has a significant number of PAR residential and commercial customers in the SWSA. The average unit demand for reclaimed water in this area of Orange County is relatively high, likely due to the dominant local soil type (i.e., SCS Type A high-infiltration materials). Because the future SWWRF is not yet constructed, PAR customers in the OCU SWSA currently are served reclaimed water entirely from the WCII reuse distribution system (jointly owned by Orange County and the City of Orlando) via a single turnout along Porter Road. With the development of the SWWRF, it will be possible to serve SWSA PAR customers directly from that facility or to interconnect this new facility with the WCII system.

2.2 Regulatory Issues

PAR includes distribution of reclaimed water for irrigation of areas accessible to the public, such as residential lawns, golf courses, cemeteries, parks, landscape areas, and highway medians. The current reclaimed water rules of the Florida Department of Environmental Protection (FDEP,S) —Chapter 62-610, Florida Administrative Code (F.A.C.), Reuse of Reclaimed Water and Land Application — require a minimum of secondary treatment with high level disinfection and effluent water quality of less than 5 mg/L TSS and 20 mg/L $cBOD_5$.

In addition, the Wekiva Rule (62-600.550, F.A.C., Wastewater Management Requirements for the Wekiva Study Area) also requires the reclaimed water to maintain TN concentrations of less than 10 mg/L on an annual average basis for use in a PAR system located within the identified limits of the Wekiva Study Area. As northern portions of the SWSA and WCII PAR customer service areas are located within the Wekiva Study Area, it is assumed at a minimum that reclaimed water from the future SWWRF would need to maintain TN concentrations below 10 mg/L on an annual average basis. Because OCU is requiring AWT quality water, no restrictions would be placed on the use of SWWRF PAR water in the Wekiva Study Area under normal operating conditions.

2.3 Compatibility with Other Reclaimed Water Systems

Development of the SWWRF to produce PAR quality water makes it compatible with the WCII reuse system, which receives reclaimed water from both OCU's South Water Reclamation Facility (SWRF) on Sand Lake Road and the City of Orlando's Water Conserv II Treatment Facility on McLeod Road. Additionally, SWWRF reclaimed water quality should be or will be generally compatible with several utilities close to or adjoining the SWSA, including Winter Garden and Ocoee, which have interconnections to the WCII system and treat their reclaimed water to meet PAR standards within the Wekiva Study Area. The OCU decision to proceed based on AWT for the initial phase of SWWRF should also make the SWWRF reclaimed water compatible with Reedy Creek Improvement District (RCID) reclaimed water, which already is treated to AWT standards.

It is possible that some farthest eastern portions of the SWSA could potentially be served by the SWRF via the OCU South Service Area (SSA) reuse distribution network. Additional conveyance system improvements may be necessary, however, to provide sufficient pressure for SWRF reclaimed water to be sent as far west as the SWSA.

Additionally, OCU has determined that certain portions of the SWSA, primarily those along southern Avalon Road (County Road 545), south of the SWWRF, will continue to be supplied with reclaimed water from the WCII system. The SWRF is currently under design for expansion and the water quality is proposed to be PAR quality, with average annual TN less than 10 mg/L. Since the SWRF and the SWWRF will produce different qualities of reclaimed water and will both supply water to the SWSA (either directly or via the WCII system), reclaimed water quality in the SWSA will vary depending on location. Consequently, when considering interconnections, reclaimed water in some portions of the SWSA may not be compatible to other portions of the service area that have AWT quality water.

2.4 Capacity Potential

PAR system capacities are often limited by the amount of reclaimed water available to serve customers at required peak delivery rates. Storage is often utilized in these systems to help balance the peak demands with the amount of reclaimed water produced at the treatment facility. As a rule of thumb, with normal storage volumes to balance diurnal reuse demands, PAR systems serving residential reuse customers can only provide a fully reliable service when the annual average daily flow (AADF) demand of the residential customers does not exceed approximately 50% of the AADF supply capacity. This large capacity imbalance occurs because the seasonal supply and demand peaking patterns are out of phase with each other. The highest PAR demands generally occur during the hot, dry weather of April and May, and these same conditions generally produce the lowest reclaimed water supply flows because the lack of rain and lowered water tables minimize inflow and infiltration to the wastewater collection system.

Closer matches between AADF demand and supply capacities can potentially be accommodated with substantially larger seasonal reclaimed water storage, or by using another water source to augment the reclaimed water supply during peak demand periods. In the case of the SWWRF, potential augmentation sources could be: (1) on-site groundwater well(s); (2) connection to the Malcolm Road Water Supply Facility (MRWSF) raw water transmission system; and (3) connection to the WCII reclaimed water transmission main or distribution system. Under Orange County's Integrated Resources Plan (IRP) prepared by PB, several augmentation alternatives were evaluated. The WCII distribution system appears to be the most effective choice for augmentation because WCII already provides reclaimed water to the SWSA through an interconnection located in the vicinity of the proposed SWWRF. That interconnection could be activated to assist in meeting peak reclaimed water demands.

Additionally, OCU is requiring that the SWSA reclaimed water conveyance planning (being addressed as part of another task authorization) be based on the WCII system serving SWSA customers in the County Road 545 corridor south and west of the SWWRF. Based on OCU's hydraulic model and recent non-potable demand projections, approximately one quarter of the 2030 PAR customer demand in the SWSA will be served by the WCII system. This OCU requirement reduces the effective size of the reclaimed service area served directly by the SWWRF, while the facility still will receive all the wastewater generated in the SWSA. For these reasons, the SWWRF should be better able to meet peak non-potable customer demands within the reuse area it serves.

The current (ca. 2010) PAR demand for reclaimed water in the OCU SWSA is approximately 2.5-3.0 million gallons per day (mgd), AADF. Based on developer-provided data for the Horizon West Villages comprising the OCU SWSA, the build-out PAR demand has been estimated at 15 mgd AADF, which is expected to be greater than the build-out wastewater flow treated at the SWWRF. For this reason, the ratio of SWSA PAR demand to reclaimed water available from the SWWRF may be above 100%, which is much greater than the rule-of-thumb limit of 50% required for a reliable system.

Considering the anticipated large PAR demands in this area, significant supplemental sources of non-potable water (as discussed previously) likely will be required for the SWSA PAR system in the long term. The required capacity of other reclaimed water management system alternatives (e.g., RIBs, direct aquifer recharge wells) therefore may be relatively low on an AADF basis. These other alternatives are likely to be needed primarily for management of excess reclaimed water during periods of extended wet weather when seasonal PAR demand is low.

2.5 Cost/Other Considerations

PAR is the best low-cost water reclaimed system for the SWWRF because it can utilize much of the existing reclaimed water infrastructure. In addition to providing cost savings by taking advantage of existing infrastructure, PAR also provides a revenue stream from reclaimed water customer charges. PAR substitutes reclaimed water for demands that might otherwise have to be served by potable water resources, which helps OCU stay within its Consumptive Use Permit (CUP) water allocations. One disadvantage of PAR is that it requires additional expenditures for some form of dry weather augmentation and some form of wet weather disposal (depending on AADF supply/demand balance). Interconnection with the WCII system would allow these expenditures to be deferred by making use of the existing WCII facilities until growth requires a further increase in capacity.

3.0 RAPID-RATE LAND APPLICATION

3.1 Description of System

Rapid-rate land application system technologies include RIBs, spray fields, percolation ponds, and absorption fields. These rapid-rate systems serve several purposes. First, they recharge water into the Floridan aquifer and are thus a key component of the OCU water resource plan. In the case of the WCII system, they also work in conjunction with agricultural and residential irrigation systems and help to balance supplies with irrigation demands by providing an alternative use for reclaimed water when the available supply exceeds true irrigation demand. An extreme example of this use is that the RIBs serve as essential wet weather recharge locations when extended duration wet weather events cause increased reclaimed water production and greatly reduced PAR irrigation demand. Additionally, OCU's projected flows to RIBs have been an important factor in offsetting some of the effects of future increased groundwater withdrawals in groundwater modeling performed in support of OCU's CUP applications. Finally, RIBs can also receive reclaimed water during the rare events when the water being produced at the treatment facilities does not meet PAR water quality standards.

OCU currently utilizes RIBs at the Northwest Water Reclamation Facility (NWRF) and in conjunction with OCU's PAR systems for their facilities in the East Service Area (ESA) and SSA. The WCII RIB system currently provides capacity for management of excess reclaimed water from OCU's SWRF. The proposed SWWRF, being located on WCII RIB Site 6, can be designed to connect directly to the RIBs on Site 6, and can also be designed to provide recharge to the other WCII RIB sites through interconnections with the WCII reclaimed water transmission main and/or the WCII reclaimed water distribution system. Similarly, the SWWRF should also be able to utilize any new RIBs constructed in the SWSA. Use of WCII facilities in this manner will require coordination/discussion between OCU and the City of Orlando. As discussed more in Section 3.2, if new SWSA RIBs are constructed within the limits of the Wekiva Study Area, reclaimed water sent to such RIBs would need to meet more stringent limits on nitrogen (e.g., TN less than 3-6 mg/L). Preliminary SWWRF site layouts indicate that sufficient space would not be available for new on-site RIBs.

The SWWRF should be designed to have a direct connection to sufficient RIB capacity to manage any periods when a process upset may prevent the WRF from producing reclaimed water suitable for PAR. By having a direct RIB connection for off-specification water, the SWWRF would avoid the problems that would otherwise arise from mixing any off-specification reclaimed water from SWWRF with PAR-quality reclaimed water from the other WRFs that serve the WCII system.

3.2 Regulatory Issues

As a reclaimed water management alternative, RIBs normally require secondary treatment with basic disinfection and effluent nitrate-nitrogen less than 12 mg/L, per the current rules of the

FDEP (Chapter 62-610, F.A.C.). However, a substantial area of the northern part of RIB Site 6 falls within the Wekiva Study Area. The RIBs within this part of the site cover portions of the Primary, Secondary and Tertiary Protection Zones defined in the document titled: "Report of Investigations No. 104: Wekiva Aquifer Vulnerability Assessment" (FGS, 2005).

The Wekiva Wastewater Rule (62-600.550, F.A.C.) states that when land application systems are located in two or more protection zones, the more stringent protection zone control measures shall apply to the entire application system. These most stringent control measures would require the reclaimed water applied to the RIBs to have annual average TN concentrations below 3 mg/L. Relief from this requirement can only be obtained through an affirmative demonstration that the discharge of reclaimed water of a different quality is protective of surface and groundwater quality with respect to the target nitrate-nitrogen level of 0.2 mg/L for the Wekiva spring.

Through an affirmative demonstration previously submitted to the FDEP in 2006, the existing WCII RIBs that fall within the Wekiva Study Area have been exempted from the full Wekiva Rule requirements described above; therefore, reclaimed water sent to WCII RIBs does not need to meet the 3 mg/L limit for TN. The latest WCII operating permit (issued in May, 2011) does require, however, that all reclaimed water sent to WCII RIBs meet an annual average limit on TN of 10 mg/L. It is assumed that new RIBs constructed to expand WCII or support OCU's SWWRF would need to meet the full requirements of the Wekiva Rule only if located in the Wekiva Study Area. In practice based on experience, a target of average nitrate-nitrogen concentration less than 8 mg/L in WCII reclaimed water has been adopted in order to assure compliance with groundwater standards while still allowing normal day-to-day variability of nitrogen concentrations in the reclaimed water.

Groundwater samples were collected from the new exploratory wells drilled as part of the ongoing well field investigations for the new MRWSF to be constructed on WCII RIB Site 6 near the SWWRF. These samples showed nitrate-nitrogen concentrations in the range of 4 mg/L in the production zone of the upper Floridan aquifer, diminishing to substantially lower concentrations in the lower Floridan aquifer.

As summarized in Section 1, in Workshop No. 1 OCU decided that the SWWRF would be designed for advanced treatment standards of 5;5;3;1, so it would produce reclaimed water with a TN concentration less than 3 mg/L. This water quality would be suitable for any of the existing WCII RIBs and would also be suitable for any new RIBs, whether they are located in the Wekiva Study Area or not. If new RIBs are constructed within the Wekiva Study Area, they will be permitted only in the Secondary and Tertiary Protection Zones, and not in the Primary Protection Zone. If the reclaimed water from the SWWRF is discharged to the RIBs on Site 6, it could help to reduce the nitrate-nitrogen concentrations that are encountered in the future at the MRWSF well field. In fact, one potential strategy for OCU would be to preferentially utilize SWWRF reclaimed water of AWT quality for loading RIB Site 6 and use more WCII reclaimed water (PAR quality) to serve SWSA reuse customers, with the objective to maximize the water quality in the groundwater at the MRWSF well field.

3.3 Compatibility with Other Reclaimed Water Systems

OCU has chosen to treat wastewater to the more stringent standards of the Wekiva Study Area. Development of the SWWRF to produce PAR-quality water to these more stringent standards makes it compatible with the WCII reuse system including RIBs and potential future RIBs in the northern SWSA which may be located in the Wekiva Study Area. The SWWRF reclaimed water will be compatible with other nearby water reuse systems, allowing interconnection should those systems have excess RIB capacity.

3.4 Capacity Potential

The potential capacity of rapid-rate land application systems in the immediate vicinity of the proposed SWWRF may be limited by the local peaking capacity of the surficial aquifer system. The aquifer system on RIB Site 6 can accept very large peak loads of short duration, but it is less suitable for management of long duration (weeks to months) high flows. Past experience has shown that sustained high loading rates could cause or contribute to unacceptable increases in surface water levels that result in flooding or impacts to adjoining properties and that take many months to recede. If reclaimed water from the SWWRF is applied to the RIBs on WCII Site 6, the RIB management plan must be adjusted to maintain acceptable water levels through adjustment of the amount of water that is currently supplied to this site from WCII.

3.5 Cost/Other Considerations

Rapid-rate land application systems typically are the best low-cost wet weather management alternative for recharging excess reclaimed water. However, another cost consideration is that these systems are land intensive, and the SWSA has high land development potential which typically leads to escalating property values. Accordingly, planning for wet weather alternatives needs to address land needs as soon as possible; preferably while land values are still depressed by the recession, if any new land acquisition is desired by OCU. As part of the separate IRP study for OCU, a comparative cost analysis was completed for various reclaimed water wet weather management options, including new RIBs (PB, 2010). RIB system total unit costs (annualized capital plus O&M) were estimated to be less than $1.00/kgal when land costs are excluded. Depending on local prices per acre, total unit costs for RIBs may increase to $2-$5/kgal or more when land costs are considered. Additionally, related to the WCII system, it may be possible for OCU to acquire greater than their current 50% ownership in the ultimate RIB capacity of the system through an agreement with the City of Orlando. Recharge of reclaimed water to RIBs in the SWRF/WCII area helps to offset drawdown from groundwater withdrawals at OCU well fields, resulting in a larger permittable allocation of groundwater for OCU through the consumptive use permitting process.

Based on analyses performed to date (in various other related studies), it appears that interconnection to WCII and use of excess WCII RIB capacity would be the least cost alternative for wet weather management of reclaimed water from the SWWRF over at least the next 20-year planning horizon. This approach should be less expensive than purchasing new land parcels for new SWWRF-dedicated RIBs. Growth in flows to WCII from the City of Orlando's treatment plant on McLeod Road is projected to be minimal over the next two decades, which means that more capacity at WCII could potentially be available for OCU. To support this approach, it is anticipated that new RIBs at undeveloped WCII Sites 1 and 10 in Lake County may need to be constructed before 2030 to accommodate growth in OCU reclaimed water flows.

4.0 DIRECT AQUIFER RECHARGE

4.1 Description of Systems

Direct aquifer recharge systems include deep injection wells, aquifer storage and recovery (ASR) wells, and aquifer recharge and recovery (ARR) systems using separate wells for injection and withdrawal. Most systems using deep injection wells in Florida discharge to non-potable groundwater which has high total dissolved solids (TDS) concentrations as a form of waste disposal. ASR systems rely on areas of the aquifer with characteristics that allow storage and recovery of injected water, and are often associated with water supply projects. ARR using direct aquifer recharge differs from ASR in that it is readily applicable to zones of the aquifer system that are very hydraulically active, and the water that is recovered is not necessarily the same water that was injected. The stormwater drainage wells and municipal wellfields in the Orlando area are an example of an ARR system. In the case of the SWSA, deep injection wells would most likely be located in the Lower Floridan Aquifer.

4.2 Regulatory Issues

In the SWSA, the underlying groundwater is generally classified as fresh drinking water quality. No high-TDS injection zones are available. Reclaimed water injected into aquifers underlying the SWSA would require "full treatment," which means that the injection water quality must contain no more than 5 mg/L TSS, 10 mg/L TN, 3 mg/L of total organic carbon (TOC), and 0.2 mg/L of total organic halides (TOX). In addition, it would need to meet all primary and secondary drinking water standards (Rule 62-610.560, F.A.C.). For injection into a zone with less than 3,000 mg/L TDS (as would be found in most of the SWSA), a one-year treatment train pilot study would also be required. OCU already has completed a successful one-year nanofiltration membrane pilot study using reclaimed water from the SWRF and the Eastern Water Reclamation Facility(EWRF), which has been accepted by the FDEP and could be considered as part of this requirement in the future. This alternative is not well established in Central Florida and commonly encounters negative public perception issues.

4.3 Compatibility with Other Reclaimed Water Systems

Development of the SWWRF to produce reclaimed water quality suitable for direct aquifer recharge would require treatment to even higher standards than any other systems in the area, making it compatible with all alternatives requiring less stringent standards, including the WCII reuse system and potential future RIBs in the northern SWSA which may be located in the Wekiva Study Area.

4.4 Capacity Potential

Depending on the number of wells installed, direct aquifer recharge could have virtually unlimited capacity. In some parts of the SWSA, an individual recharge well could be capable of recharging 3 to 5 mgd without causing problems with excessive water table elevations. This feature could be of potential value for future applications when other forms of reuse are limited and partial side stream treatment can be considered.

If direct recharge were to be used as the sole wet weather management alternative for the SWWRF in the future (e.g., in lieu of RIBs), the treatment and injection capacity of the system would need to be sufficient to handle peak excess reclaimed water flows during the wettest times of the year. Historically, the WCII system has averaged approximately 50% PAR irrigation and 50% RIB recharge; however, during extreme events the system has experienced days when all available reclaimed water was used to meet PAR demands as well as days when nearly all reclaimed water was sent to RIBs. Considering this, if direct aquifer recharge was the only future wet weather management option available to the SWWRF, the treatment and injection capacity of such a system likely may need to be sized to accommodate the full plant flow.

4.5 Cost/Other Considerations

Treatment to achieve reclaimed water quality suitable for direct recharge has been successfully demonstrated using relatively low pressure nanofiltration and ultraviolet disinfection. While the operating costs of the direct recharge system are higher than those for a comparable capacity RIB system, the capital costs are likely similar, largely because so much less land is required for direct recharge. Concentrate disposal for membrane treatment of reclaimed water also adds to the capital and operating costs of a direct recharge system. As part of the separate IRP study for OCU, a comparative cost analysis was completed for various reclaimed water wet weather management options, including new RIBs and direct recharge systems (PB, 2010). From the IRP, direct recharge system total unit costs (annualized capital plus O&M) were estimated to be in the range of $5-$8/kgal when land costs are excluded, and approximately $6-$10/kgal when land is considered. Overall, direct recharge systems are becoming more cost-competitive with RIB systems as land development increases the cost of land that is suitable for RIBs.

Direct aquifer recharge systems have the advantages that injection wells can be implemented with minimal land area and in locations where the geology is unsuitable for RIBs. However, offsetting this, the proposed SWWRF site is in close proximity to the Malcolm Road WSF, a potential disadvantage for public acceptance of direct recharge wells on the SWWRF site. A way to overcome this issue would be to locate injection wells a suitable distance away from the MRWSF site, although this would tend to increase implementation costs. Direct aquifer recharge has not previously been implemented in Central Florida. It was proposed in the early 1980s by the City of Orlando, and met considerable resistance at that time. Since then, cost-effective advanced treatment technologies have improved greatly, but experience with liberation of arsenic in low concentrations from the aquifer matrix has raised some new concerns.

5.0 LAKE AUGMENTATION

5.1 Description of System

Lake augmentation would involve direct discharge of highly treated reclaimed water into publicly accessible lakes. Potential lake candidates for augmentation in the vicinity of the future SWWRF include Lake Avalon, Lake Ingram, Johns Lake, and Flat Lake.

5.2 Regulatory Issues

Lake augmentation is a possible future component of reclaimed water management. Lake augmentation would require discharged reclaimed water to meet the requirements of surface water discharges with water quality based effluent limitations (WQBELs) and also would likely require the effluent to meet the numeric nutrient criteria (NNC) limits promulgated by the U.S. Environmental Protection Agency (EPA) in 2010. The NNC for lakes includes in-lake limits for TN ranging from 0.51 to 1.27 mg/L and for total phosphorus (TP) ranging from 0.01 to 0.05 mg/L, depending on the color and alkalinity of the lake. National Pollutant Discharge Elimination System (NPDES) permits would also be required for lake augmentation systems. The pending minimum flows and levels (MFL) regulations to be established by the St. Johns River Water Management District (SJRWMD) for Lake Avalon and Johns Lake make a lake augmentation system a potentially attractive option for maintaining OCU's full allocation of groundwater.

5.3 Compatibility with Other Reclaimed Water Systems

Development of the SWWRF to produce lake augmentation quality water would require treatment to even higher standards than other systems, thus making it compatible with all other alternatives that require less stringent standards. Because of its capacity limitations (discussed in Section 5.4), lake augmentation may have some value in future applications in conjunction with other types of systems where partial side stream treatment can be considered.

5.4 Capacity Potential

The potential capacity of a lake augmentation system in the SWSA is expected to be low, possibly less that 1.0 mgd AADF. A relatively small discharge rate is expected to raise average lake water levels sufficiently, and lake stage cannot be increased too much without increasing flooding concerns for surrounding properties. Additionally, seasonal weather variations may limit periods of discharge to lakes. This alternative represents a small fraction of the build-out capacity requirements of the SWWRF.

5.5 Cost/Other Considerations

Due to the limited capacity and the high treatment cost, treatment for lake augmentation would likely be applicable for only a side-stream application with a capacity significantly less than the total SWWRF capacity. This would result in more costly capital and operation and maintenance expenditures than the prior systems. Not only would the treatment be more complex and costly, but the storage and pumping facilities of the reclaimed water with two different qualities and uses would also be more costly and complex. Conveyance of the specially treated reclaimed water to the lakes would also increase the cost of this alternative, and additional space on the SWWRF site would be required for the side stream treatment and storage. Conceptual planning level cost estimates for this alternative were developed as part of the IRP (PB, 2010), and total unit costs were estimated to range from approximately $15-$18/kgal.

On the other hand, lake augmentation of some type could potentially be necessary as a mitigation measure to assist with meeting the pending MFL regulations for Lake Avalon and Johns Lake. The pending MFL regulations, therefore, make lakes Avalon and Johns more attractive candidates for augmentation than other lakes in the area (such as Lake Ingram and Flat Lake). Johns Lake is also a large lake which would translate into a larger capacity than others being considered. Flat Lake is in Lake County, which could make permitting more challenging. Lake Ingram has the drawback that it has a relatively small capacity (identified in a prior study as between 0.1 and 0.15 mgd). From an economic standpoint, using groundwater (rather than reclaimed water) to augment Lake Avalon for MFL mitigation, if necessary, would likely be more feasible because of low treatment and conveyance costs.

6.0 SURFACE WATER DISCHARGE

6.1 Description of System

Surface water discharge would involve direct discharge into streams and/or lakes with outfalls. Potential discharge candidates are generally long distances from the SWWRF and include Lake Apopka (Ocklawaha River system) and Reedy Creek.

6.2 Regulatory Issues

Regulatory issues are similar to those detailed above in lake augmentation. The main issues relate to meeting water quality based effluent limitations and the NNC recently promulgated by the EPA, and the need for NPDES permitting. The NNC for streams and flowing waters in the East Central Florida region include in-stream limits for TN of 1.54 mg/L and for TP of 0.12 mg/L.

Additionally, the FDEP does not favor surface water discharge as a reclaimed water management tool, except as a necessary wet-weather backup, and the RCID would also likely object to reclaimed water discharges into the Reedy Creek watershed. The last 25 years of water management policy development and regulation in Central Florida has been consistently directed towards encouraging and enforcing reclaimed water management alternatives other than consistent discharge to surface waters.

6.3 Compatibility with Other Reclaimed Water Systems

Development of the SWWRF to produce surface water discharge quality water would require treatment to even higher standards than any other Central Florida systems, thus making it compatible with all alternatives requiring less stringent standards.

6.4 Capacity Potential

The potential capacity of a surface water discharge system could be very large, depending on the receiving water body.

6.5 Cost/Other Considerations

Similar to the direct aquifer recharge and lake augmentation alternatives, treatment for a surface water discharge application would result in more costly capital and operation and maintenance expenditures than the prior systems. Conveyance of the reclaimed water to the streams and lakes would also be expensive due to the long distances from the SWWRF to potential discharge points. Another cost disadvantage of surface water discharge is that, unlike the other options, it would not generate any financial return to OCU. The other options all generate direct revenue or compensating cost savings by increasing the amount of groundwater available to OCU, thereby reducing the future need for more expensive forms of alternative water supplies. Surface water discharge would not achieve these benefits.

7.0 CONCLUSIONS AND RECOMMENDATIONS

This memorandum presents various alternatives and associated issues for management of reclaimed water produced from the future SWWRF. A tabular summary of the comparative analysis completed for the identified alternatives is included as Attachment A to this memo. General conclusions and recommendations from this assessment include the following:

7.1 Short Term (Phase 1)

The best short-term options for implementing reclaimed water management for the SWWRF are PAR plus RIBs or just RIBs. None of the other options are especially attractive or easy to permit in the short term. It is recommended that OCU continue the implementation of PAR in the SWSA. It is recommended that OCU plan to use WCII RIBs for SWWRF wet weather management, rather than searching for new land for SWWRF-dedicated RIBs in the SWSA.

Considering the anticipated large build-out demand for PAR in the SWSA, additional sources of non-potable water will likely be required to augment reclaimed water generated from the SWWRF. Based on OCU's decision to serve the County Road 545 corridor developments from the WCII system and to transfer approximately 1.7 mgd AADF of SSA wastewater to the SWWRF, augmentation of PAR will not be as great as would typically be expected for a new facility. The WCII reuse system appears to be the most likely initial choice for augmentation needs for balancing seasonal supply and demand of PAR.

A strategic advantage of prioritizing SWWRF reclaimed water for application to RIBs at WCII Site 6 is having better groundwater quality at OCU's future MRWSF. It is recommended that OCU investigate this water resource strategy and also investigate institutional and operational aspects of the WCII system to implement such a strategy.

The SWWRF should be designed to have a direct connection to sufficient RIB capacity to manage any periods when a process upset may prevent the facility from producing reclaimed water suitable for PAR. WCII existing RIB Sites 3, 4, and 5, or planned future RIB Sites 1 and 10, may be potential candidates for this direct connection. RIB Site 6 is possible, but less desirable due to the presence of the MRWSF. It is recommended that OCU further evaluate handling of off-spec water through the WCII system and implement an operational plan for both SWWRF and WCII to handle at a minimum the Phase 1 maximum day flow to the SWWRF.

With AWT at the SWWRF, the reclaimed water produced from the facility should be generally compatible with surrounding utilities' PAR and RIB systems.

7.2 Long Term (Phase 2 and Beyond)

For the long term, SWWRF Phase 2 and beyond,direct recharge or ARR could be attractive as a means of liberating some of the WCII RIB sites for other uses and selling them to recover their high land values at that time. This may cover much of the capital cost of the required full treatment. Part of the attraction of this option depends on the future course of regulation and its impacts on the current PAR and RIB operations. SWWRF alternative considerations for future phase treatment should therefore focus on alternatives that facilitate (or at least preserve) the option of future direct potable aquifer recharge and recovery facilities.

If direct aquifer recharge is the sole wet weather management option available to the SWWRF in the future, the treatment and injection capacity of such a system likely may need to be sized to accommodate the full plant flow.

The pending MFL regulations to be established by the SJRWMD make lake augmentation a potentially attractive option for maintaining OCU's full allocation of groundwater. If SWWRF reclaimed water were to be used, treatment for lake augmentation would be required only for a side-stream application with capacity significantly less than the total plant flow. From an economic standpoint, however, using groundwater rather than reclaimed water for lake augmentation may be more feasible. It is recommended that lake augmentation only be considered for Phase 2 and beyond if maintaining a full allocation of groundwater becomes an overriding issue.

The lake augmentation option and surface water discharge option have the greatest hurdles for implementation as reclaimed water management options and therefore should not receive detailed consideration for initial SWWRF treatment planning.

REFERENCES

Florida Geological Survey (FGS), 2005. *Report of Investigations No. 104: Wekiva Aquifer Vulnerability Assessment*. June 2005.

PB Americas, Inc. (PB), 2010. *Orange County Integrated Resources Plan Technical Memorandum 4.1.4: Reclaimed Water Wet Weather Management Alternatives*. Report prepared for Orange County Utilities. Orlando, Florida, revised April 16, 2010.

PBS&J and CDM, 2007. *Water Reclamation Facilities Capital Improvements and Facilities Plan ("2007 Wastewater Facilities Plan")*. Report prepared for Orange County Utilities, Orlando, Florida, 2007.

PBS&J/CH2M Joint Venture, 2006. *2002 Water, Wastewater, and Reclaimed Water Master Plan ("2002 Master Plan")*. Report prepared for Orange County Utilities. Orlando, Florida, September, 2006.

ATTACHMENT A

SWWRF Reclaimed Water Utilization Alternatives Assessment Summary

Table A.1	SWWRF Reclaimed Water Utilization Alternatives Assessment Summary				
	Options				
Issues	Public Access Reuse (PAR)	Rapid-Rate Land Application	Direct Aquifer Recharge	Lake Augmentation	Surface Water Discharge
Permittability	Must meet requirements of Part III of Chapter 62-610, FAC. In addition, Wekiva Wastewater Rule requires reuse irrigation in Wekiva Study Area (i.e., northern portions of SWSA) to meet TN<10 mg/L. AWT facility will be superior to regulatory standards.	Meet requirements of Part IV of Ch. 62-610, FAC. Use of WCII RIBs by SWWRF requires TN<10 mg/L. Construction of new RIBs for SWWRF in Wekiva Study Area would require TN<3-10 mg/L (depending on location). AWT facility will be superior to regulatory standards.	Meet requirements of Part V of Ch. 62-610, FAC, and federal UIC rules. Would need "full treatment" of reclaimed water and need to meet primary and secondary drinking water standards. Treatment process(es) beyond AWT would be required. 1-year pilot study required.	Permitted through federal NPDES process. Needs to meet WQBEL and numeric nutrient criteria. Treatment process(es) beyond AWT would be required. Has potential to help meet pending MFL regulations.	Permitted through federal NPDES process. Needs to meet WQBELs and numeric nutrient criteria. Treatment process(es) beyond AWT would be required. Generally discouraged by regulators as a disposal option.
Compatibility with Other Reclaimed Water Systems	SWWRF with AWT will be compatible with any current adjacent reclaimed water PAR system.	SWWRF with AWT will be compatible with any current adjacent reclaimed water RIB system.	Because of the high level of treatment required, the reclaimed water produced would be compatible with all other current reclaimed systems in the area.	Because of the high level of treatment required, the reclaimed water produced would be compatible with all other current reclaimed systems in the area plus other options discussed herein needing less stringent standards.	Because of the high level of treatment required, the reclaimed water produced would be compatible with all other current reclaimed systems in the area plus other options discussed herein needing less stringent standards.
Capacity	Based on most recent projections, it appears that the OCU SWSA will have a significant demand for reclaimed water. On an annual average basis, SWSA PAR may be able to account for a majority of reclaimed water produced at SWWRF.	RIBs in immediate vicinity of SWWRF may be limited in capacity. WCII Site 6 provides approximately 5-6 mgd AADF of total capacity. May wish to re-visit City/County agreement for WCII and RIB loading management plan. Preferential loading of Site 6 with SWWRF AWT water may protect GW quality near new MRWSF.	Potential capacity virtually unlimited. If used for wet weather management in lieu of RIBs, the capacity would need to meet peak flow rates.	Based on previous hydrologic studies, augmentation of area lakes expected to have relatively low capacity--probably much less than 1 mgd AADF. Capacity constrained by need to avoid flooding risk.	Potentially very large capacity depending on receiving water body.
Cost	OCU already has invested in much reclaimed water distribution infrastructure; incremental costs will be minimal. Use of existing WCII pipelines for distribution and interconnection to WCII for dry weather augmentation would further minimize costs.	Generally a low cost wet weather management alternative, but can be land intensive. Land cost for new RIBs in the highly developable SWSA would be high. Interconnected use of WCII system RIBs could prove economical, especially for Phase 1. Total unit costs excluding land estimated at less than $1/kgal, but up to $2-$5/kgal when land is included.	Compared to RIBs, land costs lower, but treatment and operating costs higher, for direct injection systems. Total unit costs estimated at approximately $5-$8/kgal excluding land, or $6-$10/kgal including land.	High unit capital costs and operating costs, due in part to small capacity, handling multiple effluents (i.e., side stream), and conveyance requirements. Total unit costs estimated at approximately $15-$18/kgal.	Costs would be significant due to advanced treatment requirements and due to long conveyance distance to nearest suitable surface water system.
Public Acceptability	Probably the most accepted form of reuse system in Central Florida.	Generally an acceptable option given the benefits of aquifer recharge. Established track record of successful application.	This alternative not well established in Central Florida and may encounter negative public perception issues. A proposal by the City of Orlando in the 1980's met considerable public resistance.	Has potential to have some resistance from land owners around lakes, including concerns over water quality and water levels.	Generally not an option that would receive wide acceptance by the public.
Off-Spec Water	PAR system requires an alternate discharge or sufficient storage to manage off-spec water. RIBs can serve as alternate discharge location, and close proximity to WCII RIBs makes for convenient and economical off-spec water handling.	RIBs are acceptable alternative to manage off-spec discharges.	Would require storage for re-treatment or use of RIBs for off-spec discharge.	Would require storage for re-treatment or use of RIBs for off-spec discharge.	Would require storage for re-treatment or use of RIBs for off-spec discharge.
Groundwater Quality	Compared to secondary treatment, AWT-quality reclaimed water should provide net benefit to groundwater quality in areas of PAR irrigation. AWT-quality water for wet weather discharges to WCII will result in less impact to nitrate-nitrogen levels in groundwater.	Compared to secondary treatment, AWT-quality reclaimed water should provide net benefit to groundwater quality (less nitrogen) in areas of RIB application. OCU could employ a strategy to prioritize SWWRF AWT-quality water for discharges to WCII RIBs in proximity to new MRWSF site.	Because this alternative requires very high levels of treatment, net impact on groundwater quality should be neutral or positive. Close proximity of the MRWSF to SWWRF site is potential concern for public acceptance.	This option only provides a small percentage of capacity needed and would not expect to have any significant effect on groundwater quality.	Would not expect to have any significant effect on groundwater quality.

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

TECHNICAL MEMORANDUM NO. 6

PHASE 1 SWWRF PROCESS ALTERNATIVES EVALUATION
FINAL
November 2011

SWWRF CONCEPTUAL DESIGN AND FACILITIES PLAN UPDATE

PHASE 1 SWWRF PROCESS ALTERNATIVES EVALUATION

TECHNICAL MEMORANDUM NO. 6

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