Optimization of Biological Aerated Filter and Microfiltration Operation for Wastewater Reclamation

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A Wide Range of Potential Reuse Applications

King County (Seattle, WA) is studying whether to implement a water reuse program involving dispersed satellite treatment plants that may operate on a seasonal basis. Potential end uses include urban and agricultural irrigation, and less common applications such as wetlands creation, and direct or indirect streamflow augmentation to improve environmental conditions for fisheries recently listed under the Endangered Species Act. As shown in **Table 1**, the reuse applications have different water quality requirements, ranging from Washington's Class A reuse standards to high levels of nutrient and TOC removal.

TABLE 1

Anticipated Water Quality Requirements for Potential Reuse Applications (Monthly Average)

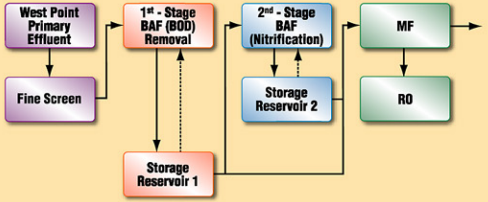
			Groundwater Recharge		Streamflow Augmentation	Lake Discharge	
Effluent Quality Parameter	Class A Reclaimed Water Uses[3]	Wetlands	Surface Percolation	Direct Recharge-Potable	Ultimate Discharge-Marine	Ultimate Discharge-Lake	Anticipated Limits	Worst Case Limits - Match Background
BOD_5, mg/L	30	20	30	5	10	10	10	10
TSS, mg/L	30	20	30	5	10	10	10	10
Total P, mg/L	-	1	-	-	1 - 2	0.1	0.01	0.01
Ammonia-N, mg/L	-	2	-	-	1	1	1	0.02
Total N, mg/L	-	3	10	10	-	-	-	0.6
Turbidity, NTU[1]	2	2	2	0.1	2	2	2	2
TOC, mg/L	-	-	-	1	-	-	-	2
TDS, mg/L	-	-	-	Site Specific	-	-	500	100
Total Coliform, #/100 ml[2]	2.2	2.2	2.2	1	2.2	2.2	2.2	2.2
Metals, Inorganic and Organic Toxics	-	Surface Water Standards	Site Specific	Drinking Water Standards or Background	Surface Water Standards	Surface Water Standards	Drinking Water Standards	Drinking Water Standards or Background

1 - 2 NTU monthly average, 5 NTU maximum (WA Class A), anticipate adoption of CA Title 22 for membranes (0.2 NTU 95th percentile).
2 - Weekly Median
3 - Washington Department of Ecology & Department of Health Class A standards for water reclamation and reuse.

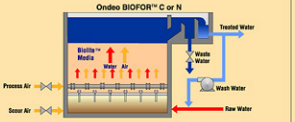
Project Background

At a minimum, baseline processes must meet Class A water quality standards for oxidation, filtration and disinfection. Additional treatment could be required to meet more stringent nutrients, metals, organics, and turbidity levels. Following an in-depth screening of the individual treatment processes, two aerobic biological treatment trains were selected for testing in a nine-month pilot test. One uses a Biological Aerated Filter (BAF) and the other a Membrane Bioreactor (MBR) for wastewater oxidation. Other emerging technologies investigated for their small footprints and enhanced performance include Fuzzy Filter and ballasted flocculation (Actiflo and Densadeg) for primary treatment, Fuzzy Filter and microfiltration (MF) for tertiary effluent filtration, and reverse osmosis for advanced treatment. This poster presents the results of the BAF-MF testing.

Pilot Testing

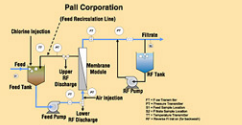


BIOLOGICAL AERATED FILTER (BAF)



In this biological fixed film process, the primary effluent flows upward through a bed of filter media with aeration to create an aerobic environment. The biomass attached to the filter media removes soluble pollutants biologically, and insoluble pollutants are removed physically by filtration.

MICROFILTRATION (MF)



Microfiltration membranes are used for physical separation of small particles from liquids. They are designed to operate in a pressure or vacuum mode. Microfiltration membranes can be designed as hollow fibers or plates depending on the manufacturer and application, and can be used for direct filtration of secondary effluent or as pretreatment for reverse osmosis membranes.

PERFORMANCE GOALS

Parameter	BAF #1	BAF #2
Effluent TSS (90th Percent-e)	<20 mg/L	<10 mg/L
Effluent CBOD (90th Percent-e)	<20 mg/L	<10 mg/L
Effluent NH4-N	N/A	<2 mg/L

Biological Aerated Filter

Microfiltration

- Effluent turbidity <0.2 NTU, 95th percentile, to meet anticipated Class A requirements.
- Effluent TOC <2 mg/L, 50th percentile, to meet anticipated direct groundwater recharge criteria.
- System Recovery >90%.

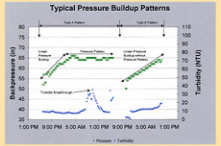
Test Results

BIOLOGICAL AERATED FILTER (BAF)

Performance Optimization

- The BAF performance was optimized by varying the organic and hydraulic loading, and by adjusting the backwash frequency.
- Backwash frequency was adjusted by observing pressure buildup pattern and effluent turbidity. If the pattern exhibited a plateau and a turbidity breakthrough during the filter run (Pattern A), then the backwash frequency was increased. The backwash frequency was deemed optimized when pressure built up linearly (Pattern B) without a turbidity spike during the filter run.

Typical Pressure Buildup Patterns



Summary of Performance After Optimization

	BAF #1 Effluent	BAF #2 Effluent
CBOD, mg/L	29.4 (19)	9.2 (7)
TSS, mg/L	31 (25)	22 (9)
NH4-N, mg/L	12.8 (8.4)	1.57 (0.24)

90th Percent-ile Vs ue and Average Value (= parentheses) from February 3, 2002 to February 19, 2002.

Loading for 1st Stage BAF at Optimized Performance

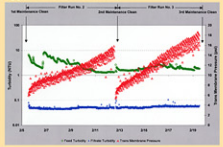
	Pilot Study Conclusion (Temp @ 10˚C)	Manufacturer Suggested Range (Temp @ 25˚C)
Hydraulic Load-ing, gpm/ft²	3.3	1.6 to 8.2
CBOD Loading lbs/kf/d	297	376
TSS Loading, lbs/kf/d	193	313

Loading for 2nd Stage Nitrifying BAF at Optimized Performance

	Pilot Study Conclusion (Temp @ 10˚C)	Manufacturer Suggested Range (Temp @ 25˚C)
Hydraulic Loading gpm/ft²	4.5	1.6 to 8.2
CBOD Loading lbs/kf/d	85	188
TSS Load ng, lbs/kf/d	110	188
NH4-N Loading, lbs/kf/d	35	100

MICROFILTRATION (MF)

Typical Filter Runs



Operating Data

- Filtrate Flow: 6 gpm
- Feed Temperature: 12˚C
- Temperature Corrected Flux (20˚C): 28 gallons per day per sq. ft.

Measured Performance

- Turbidity Removal: 0.06 NTU (95th Percentile)
- Filtrate TOC: 7.5 mg/L (50th Percentile)
- System Recovery: 89.5% (Backwash Frequency 10 min.)

CONCLUSIONS

- The 2-stage BAF without MF cannot meet the Class A requirements. The 2-stage BAF provides level of treatment comparable to activated sludge, but with a much higher loading, hence smaller footprint.
- The 2-stage BAF process provided a consistently low-turbidity (<10 NTU) feed stream to the MF unit.
- The MF unit provided very good filtrate turbidity quality meeting the Class A Reuse requirements and a low-solids feed stream for the reverse osmosis pilot unit.
- The MF unit did not meet the TOC removal goal for direct groundwater recharge (potable).