

City of Riverside

**WASTEWATER COLLECTION AND TREATMENT
FACILITIES INTEGRATED MASTER PLAN**

**VOLUME 4: WASTEWATER TREATMENT SYSTEM
CHAPTER 8: TERTIARY TREATMENT**

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TERTIARY TREATMENT

8.1 PURPOSE

The purpose of this chapter is to analyze the tertiary influent equalization requirement, to evaluate the existing tertiary filters and future expansion alternatives, and to develop tertiary facility layouts that will meet the expansion needs at the Regional Water Quality Control Plant (RWQCP) for a total capacity of 52.2 mgd on an average daily basis.

8.2 CONCLUSIONS AND RECOMMENDATIONS

- The volume of the existing tertiary influent equalization basins is 6.0 MG. It is estimated that an additional equalization volume of 6.1 MG will be required based on the simulated Riverside wet-weather diurnal curves. The additional equalization basins can be built either as tertiary influent equalization basins or as primary effluent equalization basins.
- The existing filters are rated to have a capacity of 28.2 mgd on an average daily flow basis. If Membrane Bioreactors (MBRs) are used for secondary expansion, no tertiary facility expansion is needed. If MBRs are not used, an additional tertiary capacity of 24.0 mgd will be required to meet the 52.2-mgd average influent flow.
- Cloth-disk filters are recommended over conventional dual-media filters because of their lower life-cycle cost and ease of operation.
- The total project cost for the new tertiary filters is estimated to be \$29.9 million for cloth-disk filters.

8.3 BACKGROUND

In Volume 4, Chapter 7 - Secondary Treatment, the alternative of MBRs for secondary treatment is discussed. MBRs of capacity 32 mgd for Plant 1 were chosen for future expansion at the project meeting on November 17, 2006. Because high-quality filtrate from MBRs does not require tertiary filtration, and the existing filters have a capacity of more than 20 mgd, no tertiary expansion is needed for the MBR alternative. Additional tertiary filters and flocculation basins are evaluated for non-MBR secondary treatment alternatives.

8.4 EXISTING TERTIARY TREATMENT FACILITIES

Table 8.1 presents the design information for the existing tertiary treatment facilities. The tertiary influent is equalized in four equalization basins. Flocculation basins are located upstream of Filters 11 through 16. There are 16 dual-media filters, each of which has a 24-inch anthracite layer and a 15-inch silica sand layer. Filters 1 through 10 have a smaller

surface area than Filters 11 through 16. Filters 9 and 10 were built together with Filters 11 through 16 in the early 1990s. They have an air scour blower to improve backwash performance, while Filters 1 through 8 only have water backwash.

Table 8.1 Existing Tertiary Treatment Facilities Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
Description	Value	
TERTIARY INFLUENT EQUALIZATION		
Number of Equalization Basins	4	
Length	240 feet	
Width	140 feet	
Side Water Depth	7.2 feet	
Volume Each	1.5 MG	
Total Existing Volume	6.0 MG	
TERTIARY INFLUENT FLOCCULATION (FOR FILTERS 11 THROUGH 16 ONLY)		
Number of Flocculation Basins	10	
Number of Stages	2 each	
Volume Each	178,000 gallons	
Average Alum Dosage	0.2 mg/L	
TERTIARY INFLUENT PUMPS		
<u>Pump Stations</u>	<u>Plant 1</u>	<u>Plant 2</u>
Number	2 duty + 1 standby	2 duty + 1 standby
Capacity	3 @ 13,050 gpm	3 @ 8,000 gpm
TERTIARY BACKWASH		
Number of Pumps	2 duty + 1 standby	
Capacity Each	3,200 gpm	
Quantity of Storage Tanks	2	
Volume Each	660,000 gallons	
TERTIARY FILTRATION		
<u>Dual-Media Filters</u>	<u>Filters 1-10</u>	<u>Filters 11-16</u>
Number	10	6
Surface Area Each	552 ft ²	650 ft ²
Total Surface Area	5,520 ft ²	3,900 ft ²

8.5 DESIGN CRITERIA

The tertiary peaking factor is 1.5. The maximum and the average loading rate for the tertiary filters is 5.0 gpm/ft² and 3.33 gpm/ft² at the tertiary peak flow and average flow rates, respectively. For cloth filters, the Title 22 maximum allowance is 6.0 gpm/ft². However, for this analysis, 5.0 gpm/ft² is used, the same as conventional dual-media filters, based on recent experience with cloth-filter loading rates at other plants.

The detention time for the tertiary flocculation basins is 15 minutes at the average daily flow, including the filter backwash flow.

8.6 TERTIARY INFLUENT EQUALIZATION SYSTEM

The purpose of the equalization system is to balance fluctuating flows from upstream, and reduce the surface area requirements for tertiary filters. Assuming the equalization basins are emptied every day, the necessary volume should be the accumulated volume above the capacity of the tertiary filters during a wet-weather peak day. The filter capacity will match or exceed the average influent flow in a wet weather day.

To determine the average daily influent flow during a wet-weather peak day, the RWQCP influent flow data for the last 6 years was used as presented on Figure 8.1. The figure shows that the average daily flow for the highest peak day occurred in February 2005, at 46.5 mgd. During the entire 6-year data timeframe, the average daily flow was 31.2 mgd. The ratio of the maximum average daily flow (46.5 mgd) to the overall average daily flow (31.2 mgd) is approximately 1.5. Applying the 1.5 ratio to the projected 2025 annual average daily flow of 52.2 mgd results in a peak wet-weather average daily flow of 78.0 mgd. The accumulated volume above this value in a diurnal flow curve is used to calculate the maximum necessary volume of the equalization basins.

Since there is no diurnal flow curve available for the RWQCP, the diurnal curves from the City's Collection System Master Plan were used. Data from the two flowmeters (Meters 7 and 8), located close to the RWQCP, as discussed in Volume 4, Chapter 12 - Primary Effluent Equalization, were used to simulate the RWQCP diurnal curve, as shown on Figure 8.2. The equalization volume is equal to the area below the simulated diurnal flow curves and above the peak wet-weather average daily flow line (78.0 mgd). The required volumes are 10.1 MG and 8.8 MG for the two curves, respectively. Using the larger required volume from the adopted curves and including a 20-percent safety factor as an operational contingency, the total designed equalization volume is 12.1 MG. This total volume can be built as either tertiary influent equalization or primary effluent equalization.

If primary effluent equalization basins are not used, two new tertiary influent equalization basins would be needed for the additional volume of 6.1 MG, as presented in Table 8.2. The final design of the equalization basins should use the actual diurnal curve for the RWQCP, which will be available after completion of the influent metering project. The dimensions of the new basins should be determined during the preliminary design based on a geotechnical investigation. A cursory review of the existing geotechnical boring logs from past geotechnical reports completed for the adjacent area indicates a groundwater level of approximately 15 feet below ground level. For this reason, the depth of the equalization basins is limited to 8 feet for this Integrated Master Plan.

Table 8.2 Tertiary Influent Equalization Basin Volume Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside			
	Quantity	Size	Total Volume
Required Volume			10.1 MG
Total Volume ⁽¹⁾			12.1 MG
Existing Basins	4	240 x 140 x 7.2 ft. (1.5 MG)	6.0 MG
New Basins ⁽²⁾	2	330 x 250 x 8 ft. (4.4 MG)	6.1 MG
Notes:			
(1) Includes 20-percent operational safety factor.			
(2) Assume 2:1 sloped side; dimensions depended on geotechnical conditions.			

8.7 TERTIARY FILTERS

For this Integrated Master Plan, two expansion alternatives, conventional dual-media filters and cloth-disk filters, are evaluated for tertiary filtration. They are assessed based on a life-cycle cost analysis as well as other non-economic factors.

8.7.1 Alternative 1 – Conventional Dual-Media Filters

The conventional filters are designed to filter water by gravity and the filters are removed from service intermittently for backwash, which usually uses water accompanied by air from the bottom to loosen particles adhering to the sand grains. Based on one backwash filter for each filter system and one standby filter for every six filters, Table 8.3 lists the existing capacity and the required tertiary treatment capacity for non-MBR expansion alternatives for both conventional and cloth filters.

Table 8.3 Tertiary Filters Capacity (Tertiary Peaking Factor = 1.5) Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
Existing Dual-Media Filters	Filters 1-10	Filters 11-16
Designed Loading Rate	3.3 gpm/ft ²	3.3 gpm/ft ²
Wet-Weather Peak Loading ⁽¹⁾	5.0 gpm/ft ²	5.0 gpm/ft ²

Table 8.3 Tertiary Filters Capacity (Tertiary Peaking Factor = 1.5) Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
Quantity	10 (7 duty, 2 standby, 1 backwash)	6 (4 duty, 1 standby, 1 backwash)
Surface Area for Each Filter	552 ft ²	650 ft ²
Total Area	5,520 ft ²	3,900 ft ²
Total Effective Area	3,864 ft ²	2,600 ft ²
Tertiary Flow Including Backwash ⁽²⁾		31.0 mgd
Existing Capacity		28.2 mgd
New Filters	Alternative 1: Conventional (Dual-Media)	Alternative 2: Cloth-Disk (AquaDisk®)
Designed Loading Rate	3.3 gpm/ft ²	3.3 gpm/ft ²
Wet-Weather Peak Loading ⁽¹⁾	5.0 gpm/ft ²	5.0 gpm/ft ²
Quantity	12 (9 duty, 2 standby, 1 backwash)	10 (8 duty, 2 standby)
Surface Area for Each Filter	620 ft ²	646 ft ²
Total Area	7,440 ft ²	6,460 ft ²
Total Effective Area	5,580 ft ²	5,168 ft ²
Tertiary Flow Including Backwash ⁽²⁾	26.4 mgd	24.7 mgd
Expansion Capacity	24.0 mgd	24.0 mgd
Total Capacity (Existing + Expansion)	52.2 mgd	52.2 mgd
Notes:		
(1) Maximum Title 22 Loading Rate: 5.0 gpm/ft ² for conventional filters, 6.0 gpm/ft ² for cloth-disk filters.		
(2) Backwash for dual-media filters: 10 percent; backwash for cloth-disk filters: 3 percent.		

8.7.2 Alternative 2 – Cloth-Disk Filters

Figure 8.3 shows a section of a typical AquaDisk® cloth-disk filter unit. Each AquaDisk® unit has 12 cloth-disk filters that are completely submerged. By gravity, liquid passes through the cloth media with an outside-in mode. The backwash cycle is initiated at a predetermined level or time, and the solids are removed by a stationary backwash suction head, as shown on Figure 8.4. The suction head behaves similar to a vacuum cleaner, through a manifold that creates suction to force filtrate back through a small portion of the filter panels from both sides of each disk. The disks rotate at 1 rpm to allow the entire surface of the filter panels to be cleaned. The disks are cleaned in multiples of two, and one backwash cycle takes 6 minutes. During the backwash cycles, filtration is continuous. The cloth disks are stationary except during the backwash cycle. There are two 2-hp backwash pumps and one 0.75-hp shaft driver for each unit, and the backwash valves and motors are automatically controlled.

8.7.3 Non-Economic Comparison

A comparison of non-economic factors for the two alternatives is presented in Table 8.4. In general, cloth-disk filters have a simpler mechanism and require less maintenance, but cloth media have a lower resistance to chemicals. If chlorine is used to control algae and slime, the concentration should not exceed 1 mg/L for the cloth-disk filters. The cloth media are also sensitive to polymer concentrations. Therefore, polymer dosage needs to be carefully controlled to avoid blinding the filters.

Table 8.4 Non-Economic Comparison of Conventional and Cloth-Disk Filters Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
	Alternative 1: Conventional (Dual-Media)	Alternative 2: Cloth-Disk (AquaDisk®)
Operating Filter Head Loss	10 feet	3 feet
Long-Term Equipment Reliability	+	0
Resistance to Chemical Addition	+	-
Flocculation Basin Required	0	0
Backwash Downtime	-	+
Backwash Horsepower Requirement	-	+
Maintenance Requirement	-	+
Air Scour Blower Requirement	-	+
Ratings:		
+ = Positive comparative characteristic.		
- = Negative comparative characteristic.		
0 = Neutral comparative characteristic.		

8.7.4 Flocculation Basins

Based on experience from other installations, flocculation basins may be needed to meet Title 22 standards consistently. For this evaluation, it is assumed that flocculation basins are required. Pilot or bench-scale testing can help determine this. The dosage requirement for the alumer (or alum and polymer) would be affected by the particle distribution of the tertiary influent, and the dosage should be determined based on pilot or bench-scale testing. The capacity and costs of the flocculation basins are based on the average tertiary flow for the new filters, including the filter backwash at a detention time of 15 minutes.

8.7.5 Site Layout

A proposed layout for a tertiary influent pump station, new flocculation basins, and new filters is shown on Figure 8.5, near the existing filters and chlorine contact basins. The footprint for the filters on Figure 8.5 includes room for either the cloth-media or the dual-media filter alternatives.

8.7.6 Life-Cycle Cost Analysis

The total project costs are \$40.0 and \$29.9 million for conventional filters and cloth-disk filters, respectively. The Operations and Maintenance (O&M) costs for conventional filters are also higher than the cloth-disk filters. Life-cycle costs for the two alternatives are shown in Table 8.5. At the project meeting on November 17, 2006, it was decided to use cloth-disk filters because of the lower life-cycle cost and simplicity of operation.

Table 8.5 Life-Cycle Cost of Conventional and Cloth-Disk Filters Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
	Alternative 1: Conventional (Dual-Media)	Alternative 2: Cloth-Disk (AquaDisk®)
Filter Facility ⁽¹⁾	\$10,390,000	\$7,300,000
Flocculation Basins ⁽¹⁾	\$1,090,000	\$1,020,000
Tertiary Influent Pump Station ⁽¹⁾	\$1,160,000	\$1,110,000
Total Project Cost	\$40,000,000	\$29,900,000
Yearly O&M Cost ⁽²⁾	\$153,000	\$86,000
Replacement Cost ⁽³⁾	\$199,000	\$91,000
Life-Cycle Cost⁽⁴⁾	\$42,800,000	\$31,500,000
Notes:		
(1) Total direct costs.		
(2) Includes the chemical cost and backwash pumping cost. The required media refill and the influent pumping power cost for the 7-foot head loss difference is also included for conventional filters (see the first item in Table 8.4).		
(3) Conventional dual media will be replaced every 10 years, and cloth media will be replaced every 5 years.		
(4) As present value, assuming a life-cycle period of 19 years, a discount rate of 6 percent, and an escalation rate of 6 percent for the first 5 years and 4 percent thereafter.		

