Project 2

Recycled Water Enhancement Project

Project Supporting Documents

City of Santa Barbara

Urban Water Management Plan

2010 Update – Adopted June 2011

(Including Addendum Dated June 12, 2012)

Prepared by the City of Santa Barbara, Water Resources Division,
pursuant to California Water Code, Section 10631

Adopted by the Santa Barbara City Council on June 14, 2011
as Agenda Item No. 15

City Council:

Helene Schneider, Mayor
Grant House, Councilmember
Dale Francisco, Councilmember
Frank Hotchkiss, Councilmember
Michael Kathleen Self, Councilmember
Harwood "Bendy" White, Councilmember
Randy Rowse, Councilmember

Board of Water Commissioners:

Landon Neustadt, Chair
Barry Keller, Vice-Chair
Russell Ruiz, Commissioner
James Smith, Commissioner
Bill Thomas, Commissioner

Table 9

Demand & Urban Water Use Projections

Volumes in AF, except as noted

Input assumptions:

300 = Planned Potable Demand Reduction from New Recycled Water Connections
Row 27 = Projected "Program B" demand reductions, including plumbing codes & conservation program
0 = Additional 20-year demand reductions from conservation above "Program B"
275 = Target Blending Amount After Secondary Improvement (starting 2015)

Summary Information:

300 = Total Demand Reductions from New Recycled Water
1320 = Total Demand Reductions from New Water Conservation
150 = Demand reductions from incr. recycled water by 2020
802 = Conservation reductions projected by 2020

Service Area Growth Projection - Per Plan SB Final EIR:

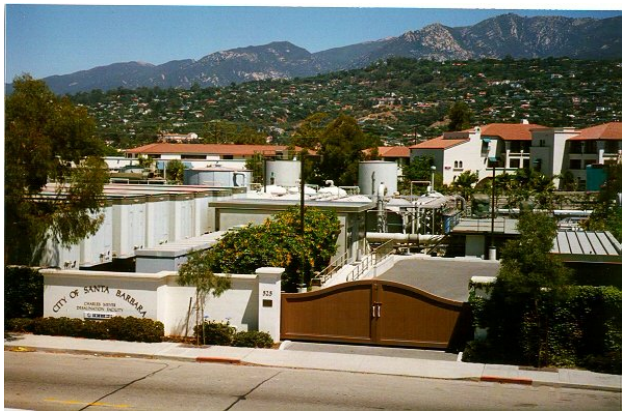
20-Year Breakout by Sector:	20-year Total	Annual Amount
Single Family Residential	166	8.31
Multi-Family Residential	445	22.26
Non-Residential	283	14.16
Total:	**895**	**44.73**

0 = Calculated average annual required conservation demand reductions in excess of "Program B"

6,700 = 20-year Population Growth Projection (from Plan SB Final EIR)
335 = Annual average population increase

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Starting Potable Production		12,731	12,669	12,614	12,557	12,497	12,436	12,397	12,352	12,314	12,270	12,226	12,195	12,166	12,140	12,115	12,093	12,072	12,053	12,036	12,020
Demand from New Devel.																					
SFR		8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31
MFR		22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26	22.26
Non-Resid.		14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16	14.16
Demand Reductions																					
New Recyceld Water Use		-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15
New Conserv. - Prog B		-92	-84	-87	-90	-91	-69	-74	-68	-73	-74	-61	-59	-56	-54	-52	-50	-49	-47	-46	-44
New Conserv. > Prog B		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ending Potable Production	12,731	12,669	12,614	12,557	12,497	12,436	12,397	12,352	12,314	12,270	12,226	12,195	12,166	12,140	12,115	12,093	12,072	12,053	12,036	12,020	12,005
Plus Blend Water to Recycled	651	600	600	300	300	300	275	275	275	275	275	275	275	275	275	275	275	275	275	275	275
Less Agriculture Deliveries	-106	-105	-105	-104	-104	-103	-103	-103	-102	-102	-102	-101	-101	-101	-101	-101	-100	-100	-100	-100	-100
Gross Water Use:	**13,276**	**13,164**	**13,109**	**12,752**	**12,693**	**12,632**	**12,568**	**12,524**	**12,486**	**12,443**	**12,399**	**12,369**	**12,340**	**12,314**	**12,289**	**12,267**	**12,246**	**12,228**	**12,210**	**12,195**	**12,180**
Service Area Population:																					
Starting Amount		91,416	91,751	92,086	92,421	92,756	93,091	93,426	93,761	94,096	94,431	94,766	95,101	95,436	95,771	96,106	96,441	96,776	97,111	97,446	97,781
Added Population		335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335
Ending Amount	91,416	91,751	92,086	92,421	92,756	93,091	93,426	93,761	94,096	94,431	94,766	95,101	95,436	95,771	96,106	96,441	96,776	97,111	97,446	97,781	98,116
Per Capita Use (GPCD):	**130**	**128**	**127**	**123**	**122**	**121**	**120**	**119**	**118**	**118**	**117**	**116**	**115**	**115**	**114**	**114**	**113**	**112**	**112**	**111**	**111**
Recycled Production:	696	815	830	845	860	875	890	905	920	935	950	965	980	995	1,010	1,025	1,040	1,055	1,070	1,085	1,100
System Production:	**13,427**	**13,484**	**13,444**	**13,402**	**13,357**	**13,311**	**13,287**	**13,257**	**13,234**	**13,205**	**13,176**	**13,160**	**13,146**	**13,135**	**13,125**	**13,118**	**13,112**	**13,108**	**13,106**	**13,105**	**13,105**

filtration capacity was subsequently sold, leaving current capacity of 3,125 AFY. This capacity is entirely dedicated to City use, though it is currently in a long-term storage mode to reduce maintenance costs and would require approximately one year to recommission. This time frame is consistent with the anticipated use of the facility during drought, a water shortage condition that develops rather slowly.



Annual Capacity: With the departure of the co-participants and sale of a portion of the capacity, the desalination facility now has a production capacity of up to 3,125 AFY, subject to time and costs to recommission as noted below.

Operating Criteria: Relatively high variable costs for desalination make this supply the last to be used during periods of shortage. Recently updated water supply policies identify a key goal of deferring reactivation until at least the sixth year of a critical drought period.

Cost Information: A 2009 study by Carollo Engineers estimated variable costs at $1,470/AF and a capital cost of $17.7 million for reactivation. The original capital cost for construction of the facility was $34 million. Approximately $3 million is set aside as a reserve for this purpose. The balance would be budgeted as a part of the Water Fund Capital Program.

Recycled Water

Description: The City initiated planning for a water reclamation project in the early 1980's. Phase I was completed in 1989. It included addition of tertiary treatment with carbon filtration and disinfection at El Estero Wastewater Treatment Plant, a 600,000 gallon distribution reservoir and pumping station, and 5.1 miles of distribution main. Phase II was completed in 1992, adding an additional pumping station, a 1.5 million gallon reservoir, and 8.3 miles of distribution main. The system now provides recycled water to 80 accounts that serve 440 acres of landscaped area at parks, schools, golf courses, and other large landscaped areas. Several public restrooms have been retrofitted to use recycled water for toilet flushing. Water is provided at 80% of the potable water irrigation rate as an incentive for using recycled water and to compensate for additional irrigation requirements associated with salt leaching. Monitoring of salt levels in the soil was conducted twice per year from 1993 through 2003. No long-term build-up of soil salt was indicated.

Annual Capacity: The system has the capacity to treat and deliver 1,400 AFY; current demand is approximately 800 AFY, plus approximately 300 AFY of process water for use at EEWTP.

Future Uses: Optimization of the use of recycled water has been mostly accomplished with the completion of Phase II. Distribution pipelines have been constructed to all cost effective use areas, and most existing potential user sites are now connected. Use of recycled water for toilet flushing has been implemented in selected public restrooms and others are being added. New development in proximity to the recycled water main is required to utilize recycled water for landscape irrigation. Conversion or remaining potable use at current user sites, addition of new users along the existing distribution, and some limited expansion of the distribution system are expected to allow an additional 300 AFY of new usage. Recycled water users enjoy a rate that is 20% below potable irrigation for recreational sites and 60% below rates for commercial customers.

Operating Criteria: Recycled water is a non-variable supply in that it can only be supplied to those customers that are connected to the recycled water system. Usage is relatively constant regardless of drought conditions. Some potable water is blended with recycled water as a means of maintaining acceptable recycled water quality.

Cost Information: Variable costs, including pumping and treatment, range from $157/AF for the Phase 1 zone to $247/AF for the Phase 2 zone. The capital cost for the construction of Phases I and II was approximately $15.2 million. The annualized unit cost, including amortized capital costs and variable costs, is approximately $1,450/AF.

City of Santa Barbara
Long-Term Water Supply Plan
2011

Prepared by Water Resources Division,
Public Works Department

Adopted by the Santa Barbara City Council on June 14, 2011,
as Agenda Item No. 15

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City of Santa Barbara

Long-Term Water Supply Plan
2011

Introduction

The City of Santa Barbara provides water service to most properties within the City limits, as well as several unincorporated areas, including Mission Canyon and the Barker Pass. The service area is approximately 20 square miles with a population of approximately 91,416. The water utility is administered by the Water Resources Division of the Public Works Department. The City's potable water supply sources include surface water from Gibraltar Reservoir, Devils Canyon Creek, and Lake Cachuma; groundwater from City production wells and Mission Tunnel infiltration; State Water; and desalination. A separate recycled water system supplies treated wastewater, primarily for irrigation, to offset the need to use potable water. In addition, water conservation is a key component of water supply management due to its role in offsetting the need to develop new water supplies and reducing the demand on existing water supplies. The Water Fund budget for FY 2011 includes an Operating Budget of $31,301,242 and a Capital Program of $3,349,702, for a total budget of $34,650,944.

For the past 17 years, the water supply has been managed under the 1994 Long-Term Water Supply Program (1994 LTWSP). Important events at the time of the program's adoption included the recent end of the severe drought of 1987 to 1991, an extensive inventory and analysis of water supply alternatives, and the addition of recycled water, State Water, and desalination to the City's water supply portfolio. The program incorporated water demand estimates derived from the City's 1988 General Plan Update process and water conservation savings anticipated from a rapidly developing City Water Conservation Program. During the two decades since the drought, the City's normal year water system demand (including potable and recycled water demand) has dropped from a pre-drought amount of 16,300 AFY to 14,000 AFY, despite a population increase of approximately 5%. This is a significant consideration in the development of this updated plan and is discussed in detail in later sections.

The fundamental challenge for the City's water supply continues to be the ability to provide adequate water during an extended drought. However, the water supply situation may also be affected by potential climate change impacts on hydrology and sea level, new constraints on deliveries of State Water through the Sacramento-San Joaquin Delta, a statewide water supply deficit with an accompanying legislative mandate for water use reduction, new technologies and practices for conserving water, and increasing costs for water supply and operation of the water system.

The City has recently certified an Environmental Impact Report (EIR) for the *Plan Santa Barbara* process to update the City's General Plan. The document included an analysis

of the City's water supply, which was developed in conjunction with the City's Water Commission in preparation for a recommendation to update the 1994 LTWSP. On June 14, 2011, the City Council adopted this Long-Term Water Supply Plan as Agenda Item No. 15.

Terms and Concepts

A number of key terms and concepts play a role in water supply planning and are discussed below:

Planning Period: The period covered by this plan is from 2011 through 2030, intended to roughly correspond with the term of the anticipated General Plan update.

Water Production: Production is the amount of water treated and put into the City distribution system in order to serve City water customers, net of deductions for water that leaves the distribution system as transfers for other purposes. As such, production is a measure of the amount of water supply needed to serve City customers. Production is tracked separately for the potable and recycled distribution systems. The sum of these two is referred to as "system production."

Metered Sales: The City maintains 26,513 retail water meters that measure the water used from the distribution system by City water customers. The sum of usage on these meters is referred to as "metered sales." Due to system losses, distribution system flushing, and normal meter inaccuracy, this number is generally about 90% to 92% of the production amount.

Cloud Seeding: Clouds can be seeded with certain compounds that enhance the amount of precipitation generated. The City participates, with other Santa Barbara County agencies, in an annual cloud seeding program to augment precipitation and runoff into local reservoirs.

Marginal Cost: To evaluate the economic benefits of ordering more water from one supply over another, only those costs that vary with the amount of water delivered are considered. These are called the "marginal" costs, also referred to as "variable" costs. Fixed or "sunk" costs are not included since they are the same regardless of whether more water is taken from a given source. For example, State Water has substantial costs for debt service and fixed operation and maintenance, but it is only the variable costs for chemicals and electricity that influence the economics of ordering additional State Water.

Avoided Cost: The cost effectiveness of a water conservation measure is evaluated by comparing the cost of the measure to the marginal cost that is avoided as a result of implementing the conservation measure and reducing the amount of water supply required.

Critical Drought Period: A water supply is evaluated by how well it performs in meeting the target level of demand during the expected worst case water supply situation. For the Santa Barbara area, this worst case is an extended drought, characterized by multiple years of below average rainfall, resulting in minimal inflow to Lake Cachuma and declining reservoir levels. The historical critical drought period for Santa Barbara is the 5-year period of 1947 to 1951. The most recent drought of 1987-1991 was somewhat less severe. Importantly, any year following the filling and spilling of Lake Cachuma could be the first year of a critical drought period, but this generally doesn't become apparent until about the third year.

Conservation: The City's Water Conservation Program promotes ongoing efforts to improve water efficiency and reduce waste in ways that don't require lifestyle sacrifices on the part of customers. Examples include using a high efficiency clothes washer to do the job with less water, fixing leaks, replacing a conventional irrigation controller with a smart irrigation controller, and replacing lawn with water wise plants. This type of conservation can be counted on for long-term reduction in demand, which avoids the need to procure more water supplies with high marginal cost. For water supply planning, it is important to distinguish between these ongoing efforts, and planned short-term extraordinary demand reductions employed during an extended severe drought or other catastrophic water supply interruption.

Safety Margin: In addition to quantifiable estimates of water supply yield and projected water demand, there is the potential for unplanned and unquantifiable shortages in supply or increases in demand. The approach used in this plan is to make reasoned estimates of supply and demand for the planning period and then add a safety margin on top of the projected demand target to recognize that unexpected events will occur.

Planned Demand Reductions During Severe Drought: A water supply can be planned for 100% reliability (i.e., able to meet full demand under all circumstances). However, meeting this reliability standard can result in significant additional cost. Because there is short-term flexibility in water demand during extraordinary conditions, it is reasonable to count on such short-term reductions to some extent to reduce the cost of operating the water system. During the most recent severe drought of 1987-1991, it became necessary to seek extraordinary reductions of up to 50%, which came at some considerable expense to the community. This level of planned reduction was deemed excessive during the development of the 1994 LTWSP and an amount equal to 10% of target demand was adopted at that time. This percentage was referred to as the "acceptable shortage" in the 1994 LTWSP.

Water Supply Performance: A water supply plan is evaluated by whether it meets the established technical and policy goals during the planning period. Performance of the water supply is based on assumptions for anticipated deliveries from the various sources. For the City's plan, much of this information comes from the Santa Ynez River Hydrology Model (SYRHM), a computer model developed by the Santa Barbara County Water Agency. The model covers a 76-year period from 1918 to 1993. It uses historical weather and river flow data, along with current water supply facilities and

operational strategies, to simulate the long-term yield of the river in its current state. The purpose is to illustrate how our current water supply portfolio might perform over a future period that is similar to the past. This explains why, for example, the model results include yield from Lake Cachuma in years before the reservoir actually existed.

A second important element of the performance analysis is to evaluate the relative costs of various options for meeting the supply goals. The focus is on marginal costs for the supplies that are part of the various alternatives evaluated.

Current Water Supply Portfolio

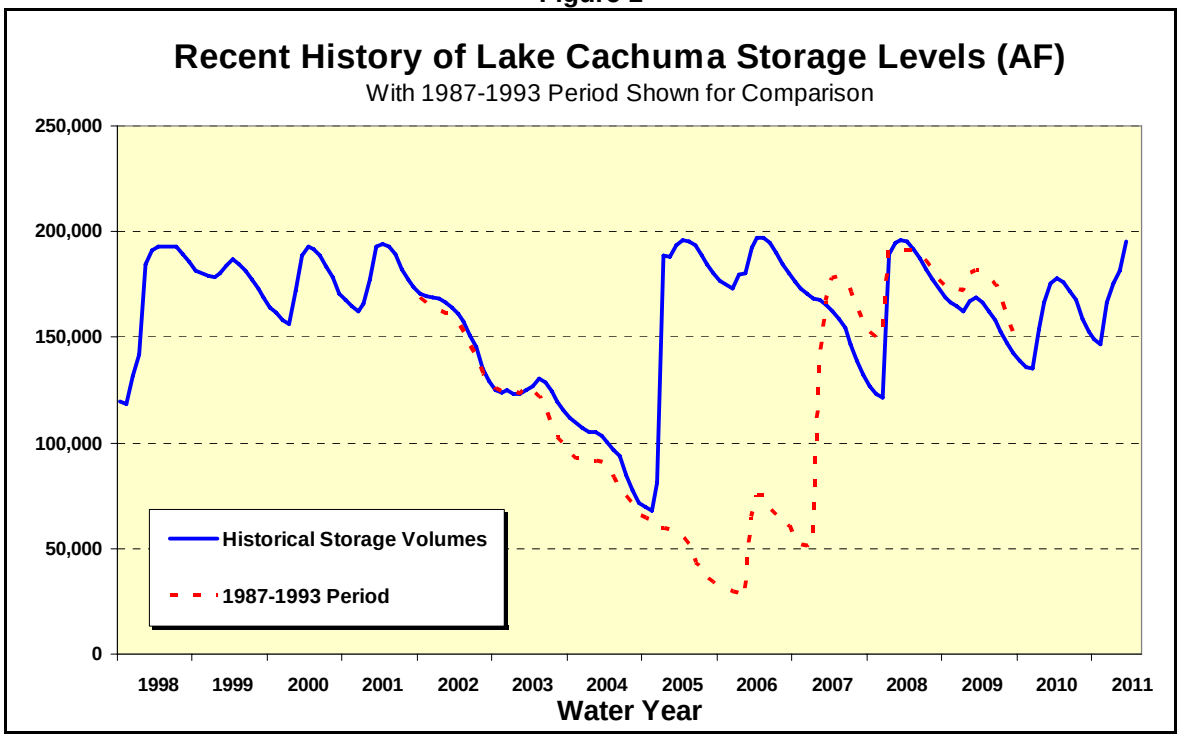
The City operates a diverse water supply. The various supply sources are summarized below. Additional discussion is included in the Final EIR for the *Plan Santa Barbara* process to update the City's General Plan.

Lake Cachuma

The federally-owned Cachuma Project on the Santa Ynez River supplies water to the City and four other member agencies. The most recent capacity survey (2008) estimated the storage capacity at 186,636 AF. The reservoir is currently operated to supply a total yield of 25,714 AFY to the five member agencies in most years. The City's current share of this annual yield is 8,277 AFY. In later years of extended dry periods (characterized by consecutive years of below average rainfall), storage typically drops below 100,000 AF and deliveries to member agencies are reduced. Historically the reservoir has filled and spilled an average of once every three years, but there occasionally are longer dry periods, the longest of which defines the critical drought period for planning purposes. Lake Cachuma is the City's primary water supply and the multi-year storage capacity provides an important buffer against dry periods. Figure 1 illustrates the recent history of storage levels at Lake Cachuma.

The lake is operated by the U.S. Bureau of Reclamation pursuant to orders of the State Water Resources Control Board (SWRCB) and in compliance with a Biological Opinion issued by the U.S. Fish and Wildlife Service (USFWS) for protection of steelhead trout, which were designated as endangered in the Lower Santa Ynez River in 2003. SWRCB is considering Lake Cachuma and Santa Ynez River water rights following a major hearing on the Cachuma Project conducted in November 2003. This was a continuation of SWRCB's long-standing review of the Cachuma Project in terms of its effects on downstream water users and on Public Trust resources (i.e., steelhead trout). The SWRCB ruling has been delayed pending completion of the necessary environmental documents.

Figure 1



For estimating future deliveries from Lake Cachuma during the planning period, the following assumptions were used:

- Alternative 3-C of the 2003 Cachuma Water Rights hearing Draft EIR, as modeled by the SYRHM was assumed. This includes a reservoir surcharge of 3-foot elevation (now in place) to provide additional water for fish releases and operation of the reservoir in compliance with the above mentioned Biological Opinion.

- Siltation has historically averaged about 332 AFY from the time of dam construction in 1953 until the most recent reservoir survey in 2008. Though options to control such siltation will be important, it should be assumed that this rate of siltation will continue, and would result in a 5% reduction in the reservoir capacity, and a roughly similar reduction in yield, by the end of the planning period. As a result, it could be estimated that normal year deliveries would be reduced from the current amount of 8,277 AFY to 7,863 AFY by the year 2030.

- Deliveries of Cachuma water during surplus (spill) conditions are not deducted from member agency annual entitlements, meaning that spill years usually result in some accumulation of water in excess of entitlement. The excess becomes "carryover" water that continues to be available until lost to spill or evaporation. This provides increased flexibility for members, but can not necessarily be expected to increase project yield above the amount modeled. Therefore, delivery estimates do not assume increased yield as a result of the carryover accounting of water accumulated during a spill condition.

Gibraltar Reservoir

In 1920, the City completed construction of Gibraltar Dam on the Santa Ynez River upstream of where Lake Cachuma was subsequently constructed. The dam formed Gibraltar Lake, with an initial storage capacity of 15,793 AF. Water is conveyed from Gibraltar Reservoir to the City through Mission Tunnel. From the beginning, siltation has been an issue, particularly following wildfires. In 1948, siltation had reduced the volume by about half and the dam was raised 23 feet to its current height of 1,400 feet above sea level. Prior to the 2007 Zaca Fire, which burned 60 percent of the Gibraltar watershed, the volume was 6,786 AF. Erosion since the fire, particularly the heavy rainfall of January 2008, has reduced the reservoir volume to 5,251 AF as of the June 2010 lake survey.

Since before the completion of Gibraltar Dam, the City has also diverted water from Devils Canyon Creek just downstream of the dam, with long-term average annual diversions of approximately 100 AFY. The City counts Devils Canyon diversions as part of its total allowable Gibraltar diversions.

As a result of the sale of the Juncal Dam site upstream of Gibraltar Reservoir and associated water rights in the early 1900's, the City receives an annual transfer of 300 AFY from the Montecito Water District. The water is transferred to the City's account at Lake Cachuma.

Current Gibraltar Reservoir operations are based on the 1989 Upper Santa Ynez River Operations Agreement (also known as the "Pass Through Agreement") by which the City agreed to defer a second enlargement of the reservoir in exchange for the right to receive a portion of its Gibraltar water through Lake Cachuma. The intent of this arrangement was to allow the City to stabilize the yield of Gibraltar so it would be consistent with the 1988 reservoir volume, while recognizing the interests of the Cachuma Project and other downstream users.

The City and other signatories to the Pass Through Agreement are currently working to implement the Pass Through mode of the agreement, which tracks the yield of a hypothetical "Base Reservoir" that is equal to the 1988 storage capacity of 8,567 AF, and operated under the procedures defined in the Pass Through Agreement. The Pass Through mode allows Gibraltar Reservoir diversions (including diversions to Mission Tunnel and the portion taken through Cachuma) up to the amount that could have been diverted under the "Base Reservoir" operations. Modeling done in 1989 indicated that long-term average yield of the Base Reservoir would be 5,160 AFY. Yield under the actual Pass Through operations can be expected to be somewhat less on average, due to potential losses associated with conveyance of water between Gibraltar and Cachuma, and spill and evaporation of Pass Through water at Cachuma.

Mission Tunnel

Mission Tunnel conveys water from Gibraltar Reservoir through the Santa Ynez Mountains to the City and was completed in 1910. Infiltration into the tunnel from watersheds on both sides of the mountains contributes to the City's water supply. Water supplies from infiltration to Mission Tunnel have varied from a low of 500 AFY in 1951 to a high of 2,375 AFY, with an average annual yield of 1,125 AFY based on analysis in the DEIR for the Cachuma Project water rights hearings.

State Water Project

The City is a participant in the State Water Project (SWP). Deliveries to Santa Barbara County participants are administered by the Central Coast Water Authority (CCWA). Project water is delivered into Lake Cachuma through the Coastal Branch of the State Aqueduct and two locally-operated pipeline extensions. The SWP contract defines the maximum amount each project contractor is entitled to request each year, which is referred to as the "Table A" amount, referring to the table of that name in the contract. The City's SWP Table A amount is 3,300 AFY and the City has a share of pipeline capacity to deliver that amount. However, deliveries of Table A amounts are subject to availability and delivery constraints.

The California Department of Water Resources produces the State Water Delivery Reliability Report every two years to assist project participants in estimating anticipated deliveries. The 2009 version (published August 2010) is the most recent. The report is based on analysis using the CALSIM II computer model developed by DWR and USBR to simulate Delta flows and predict available deliveries.

Deliveries are estimated for "current conditions" (2009) and "future conditions" (2029). Projections for this plan are based on the "future" conditions, but it is important to note that "future" conditions do not assume improvements in the ability to deliver water through the Delta. Key assumptions are listed below:

- Despite substantial efforts being made to address Delta delivery constraints, DWR's modeling assumes no improvements to the current conveyance system through the Delta. For example, there is no assumption that a Peripheral Canal or other form of "isolated facility" to convey water around or under the Delta will be in place.

- The beneficial effects of planned increases in SWP reservoir capacity are not assumed as a part of the analysis.

- Current constraints on exports, including federal biological opinions of December 2008 (Delta smelt) and June 2009 (salmon, steelhead, green sturgeon, and killer whale) are assumed to remain in place.

- The model does not assume any easing of delivery constraints associated with potential habitat improvements related to the ongoing development of the Delta Habitat Conservation and Conveyance Program, which targets the co-equal goals of ecosystem restoration and water supply conveyance.

- The model has been modified to include the projected future hydrological effects of climate change. The most important of these effects are the assumed continuation of sea level rise and a reduction in the amount of precipitation that falls as snow. The latter reduces the "storage" effect provided by snowpack and results in more concentrated runoff during winter and early spring, versus late spring and summer, which has the effect of reducing the amount of water available for delivery to SWP contractors.

Based on the above assumptions for future conditions, the 2009 report projects 6-year average annual dry period deliveries of 32% to 36% of Table A amount, median deliveries of 63%, and long-term average annual deliveries of 60%. The estimated long-term average continues a downward trend in DWR's previous biennial reports, as shown in Figure 2, reflecting the restrictions of the biological opinions and the projected effects of climate change. Given the number of variables associated with State Water Project deliveries, staff analysis for this plan assumes annual deliveries would be limited in all years to no more than 50% of Table A amounts, reflecting experience during 2008 and 2009. This results in an average annual predicted delivery of 46% of Table A amount (also shown in Figure 2).

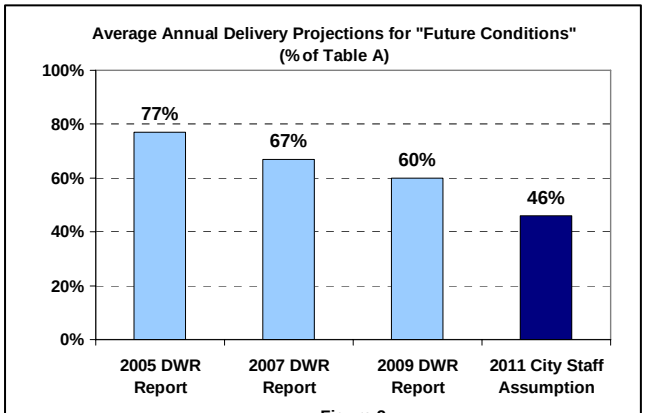


Figure 2

For comparison purposes, actual Table A availability for the past 5 years is shown in Figure 3. This period of 2005 to 2010 includes the recent statewide drought. Three of the five years were classified as "dry" or "critically dry." The period also includes significant new restrictions in SWP deliveries due to environmental and endangered species issues. The 57% average delivery amount for this period suggests that the assumption of 46% average annual deliveries is reasonably conservative.

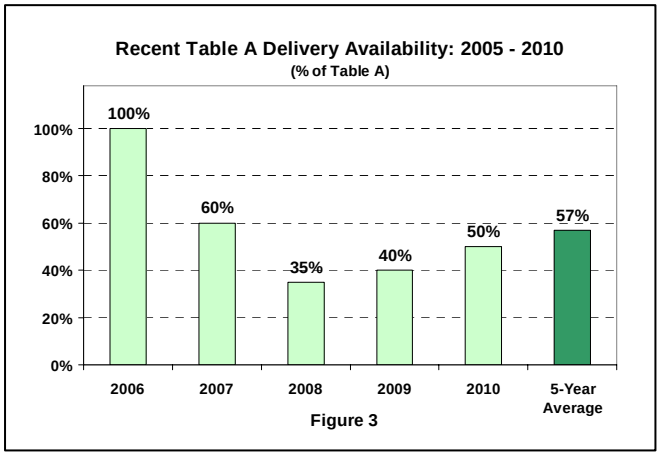


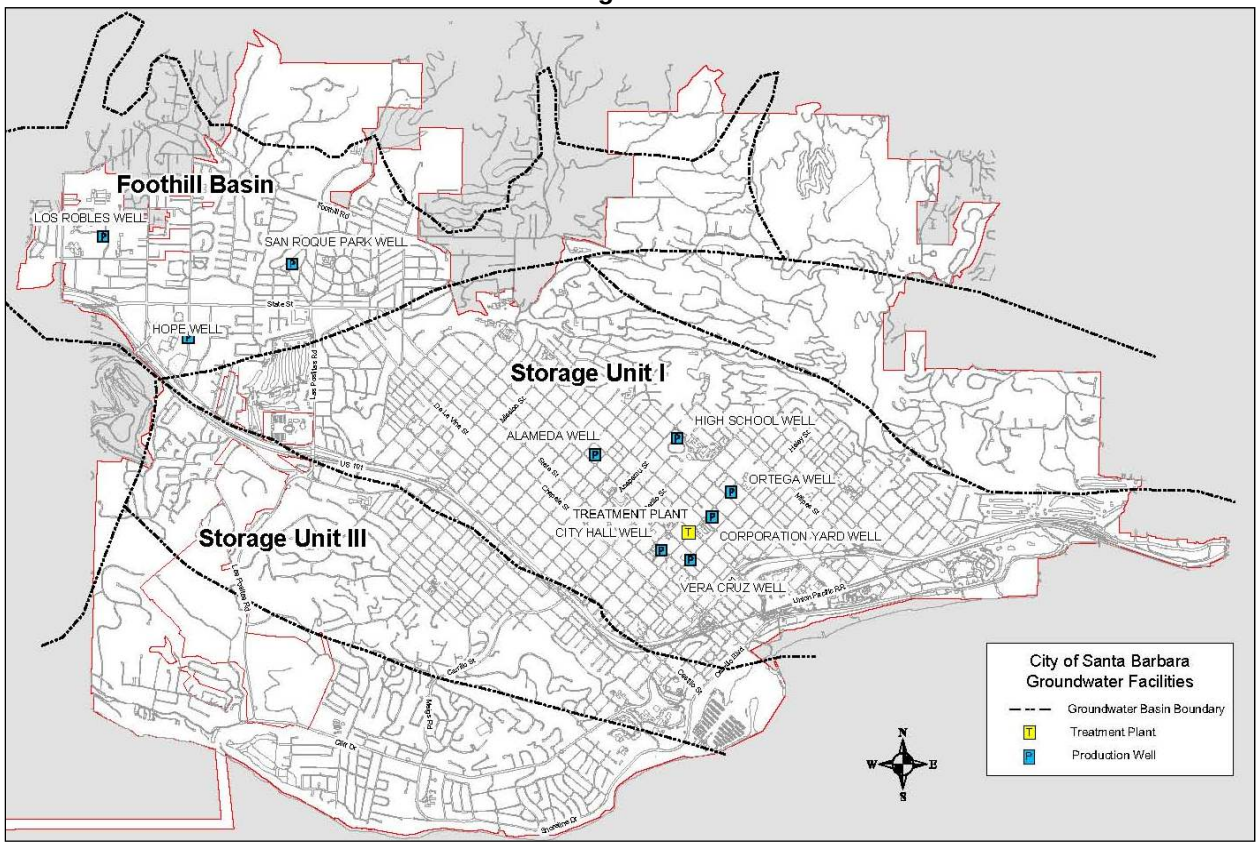
Figure 3

An additional important consideration is the ability of the SWP pipeline to convey non-project water to augment drought year supplies. These potential supplemental water supplies include the State's Dry Weather Water Purchase Program, purchase of unused Table A water available through San Luis Obispo County, or other open market water purchases, such as purchase of agricultural water.

Groundwater

City groundwater supplies are produced from two basins: Storage Unit No. 1 (downtown area) and the Foothill Basin (outer State Street area) as shown in Figure 4. The City conjunctively manages groundwater supplies, withdrawing water when needed and allowing recharge to occur following drought periods. A primary goal of this program is to attempt to utilize the perennial yield of the groundwater basins, while also managing the basins to maximize available storage to act as a back-up supply during drought periods.

Figure 4



The estimated long-term safe yield of these two basins is approximately 1,800 AFY. Extraction by private pumpers is estimated at 500 AFY. The City has six production wells in Storage Unit No. 1 and three in the Foothill Basin, though the wells are in need of varying degrees of maintenance or replacement. While the estimated total pumping capacity is approximately 4,500 AFY, a capacity of 4,150 AFY is assumed for planning

purposes. The total usable storage capacity of these two basins is estimated at 16,000 AF of City pumping. A third basin (Storage Unit No. 3 in the Las Positas Valley area) provides additional safe yield of approximately 100 AFY, but water quality is inferior and is not planned for use.

Seawater intrusion into Storage Unit No. 1 is a key issue because the groundwater basin is in contact with seawater that can flow into the basin during periods of heavy pumping. Under normal periods of little or no pumping, the groundwater flow is toward the ocean, which stops intrusion and pushes the seawater interface seaward. The City's Multiple Objective Optimization Model (developed by USGS) was used to estimate pumping levels that represent a compromise between maximizing production and minimizing seawater intrusion. The model results in total pumping of up to about 17,800 AF during the drought period, allowing some intrusion for the last portion of the drought. It should be noted that this modeling was based on one additional well in each basin, which may have implications for future capital program needs. In Storage Unit No. 1, the assumption was that new wells would be placed further inland to minimize intrusion.

Recycled Water

Recycled water is used in the City to irrigate over 400 acres of landscaped areas (including schools, parks, the zoo, and golf courses) and for toilet flushing in some public restrooms. The City system as currently configured has the capacity to treat and deliver approximately 1,400 acre-feet per year (AFY) of recycled water. Current connected recycled water demand is approximately 800 AFY, plus approximately 300 AFY process water used at the wastewater treatment plant, leaving about 300 AFY of additional capacity.

To meet a City goal of no more than 300 mg/L of chloride during irrigation season, approximately 300 AFY of potable water has historically been blended into the recycled water. This is because blending is the least costly solution and potable water is currently available for this use. A ten-year history of blend amounts is shown in Figure 5.

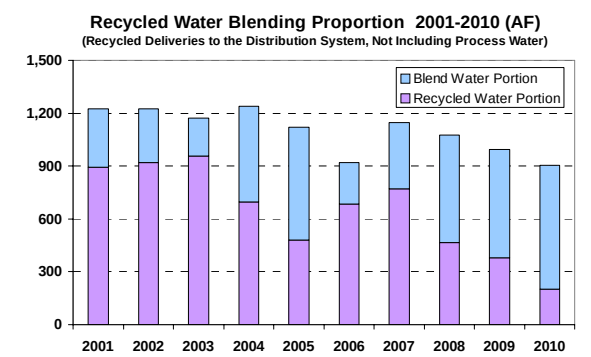


Figure 5

Secondary Process Issues: Beginning in 2004, due to challenges with the secondary treatment process, blending has increased recently to approximately 700 AFY to meet regulatory requirements. Improvements to the secondary process are being evaluated to address this recent increased use of potable water for blending. Once the secondary process is resolved, it is expected that the blend water component can be reduced.

Further Mineral Reduction: Mineral content suitable for irrigation purposes is an important part of fully utilizing the City's recycled water capacity and a standard other than the 300 mg/L chloride limit has been considered. Carollo Engineers identified an Environmental Protection Agency guideline of 1,000 mg/L of total dissolved solids (TDS) as a possible updated standard. A Carollo Engineers study on the recycled water filter rehabilitation project identified a conceptual project to meet this target without the need for blending. For a production rate of 1,910 AFY, the demineralization component was estimated to have a capital cost of $4.6 million. Annualized costs were estimated at approximately $652,000 (including the capital component) resulting in added unit cost of $341/AF of produced recycled distribution water. A blending alternative to meet the same standard is estimated to resulting in added unit cost of about $180/AF of produced water, assuming a cost of $600/AF for potable blend water. A modified blending alternative could involve blending only during the primary irrigation season, as is currently conducted to meet the chloride standard.

The recycled water system provides an important component of the City water supply, even with a partial potable water component for blending. In addition, the fact that users are signed up and connected to the separate recycled water system provides increased flexibility in how the City balances the economic and water supply aspects of this source of water.

Desalination

The Charles Meyer Desalination Facility was built in 1991 at an original capacity of 7,500 AFY and has a maximum hydraulic capacity of 10,000 AFY. Sale of a portion of this facility reduced current production capacity to a maximum of 3,125 AFY, which is also the capacity identified in the environmental analysis and permitting to convert the facility to permanent status in 1996. Due to reduced demand and relatively wet weather since 1992, the facility has been kept in long-term storage mode. However, the facility is permitted as a permanent part of the City water supply under a Coastal Development Permit approved by the City and the Coastal Commission. The City's current Regional Water Quality Control Board National Pollutant Discharge Elimination System (NPDES) permit for discharge from the City's wastewater treatment plant includes provisions for discharge of brine when the desalination facility is in operation.

The construction and operation of the Desalination Facility was approved by City voters in an advisory election held in 1991. No major technical barriers have been identified that would prevent reactivation of this facility to produce 3,125 AFY if needed. Although permit requirements would be subject to review by various regulatory agencies, the City has approval of all major permits required to operate this facility.

Reactivation of the facility at a capacity of 3,125 AFY was estimated by Carollo Engineers to cost $17.7 million. (An additional $2.5 million in distribution system improvements that would be required to operate the facility are already planned for construction due to their value in improving overall distribution of water throughout the

system). Operating costs are estimated to be $1,470 per AF, compared to variable costs of about $100 to $700 for other City water supplies. It should be noted that desalinated water includes a substantial energy component, estimated at 4,615 kilowatt-hours (kWh) per AF of produced water. This is lower than the original facility's energy use of 6,600 kWh per AF, but still well in excess of the energy requirements for other City water supplies. Should the need arise, reactivation is estimated to require about 16 months from the time of approval of any required permits.

Demand Management

Demand management (i.e., water conservation), provides a viable alternative to the high marginal costs of procuring new water supplies or increased deliveries from the more expensive existing supplies. Projected water demand is a key input assumption of the water supply planning process. Balancing the assumptions of projected water demand with the projected water conservation savings is necessary to develop an accurate water demand forecast. This section reviews the history of the City's water demand, summarizes current water conservation efforts, and discusses recent analysis and regulations that are relevant to the anticipated level of demand during the planning period.

Current Status

The total water system production is used to track the demand for water, since water is produced and put into the distribution system to match customer demand. The history of water demand from 1986 to present is shown in Figure 6 as a moving 12-month average.

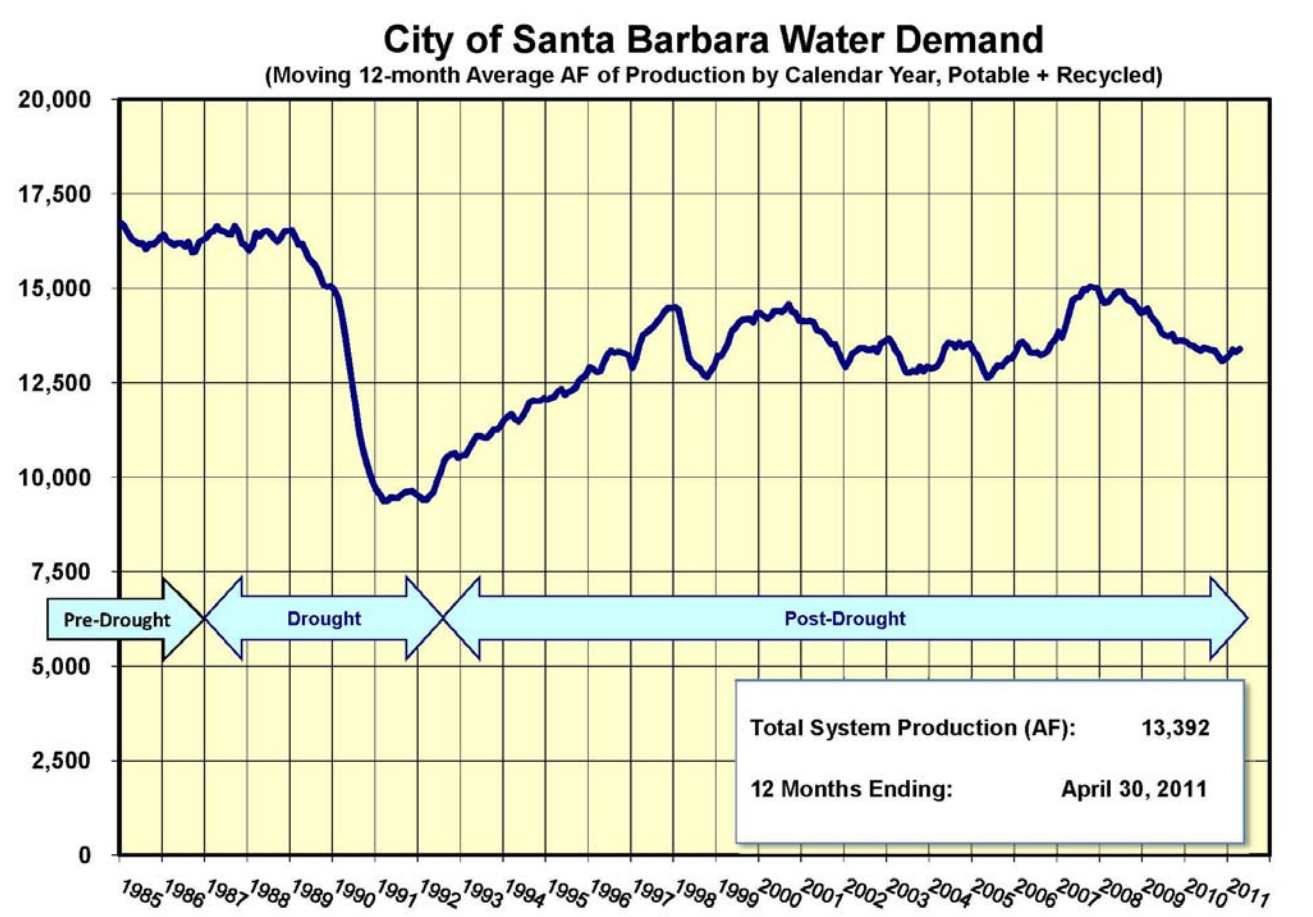


Figure 6

Moderate cutbacks in response to a Stage 1 Drought are evident during 1989 and response to the Drought Emergency is reflected in significant reductions during 1990. From 1992 to 1998, a steady post-drought recovery occurred, followed by a period of generally flat demand, but with significant fluctuations from year to year. To analyze this period of fluctuations, staff began tracking demand in relation to rainfall and evapotranspiration (ETo) data, as shown in Figure 7.

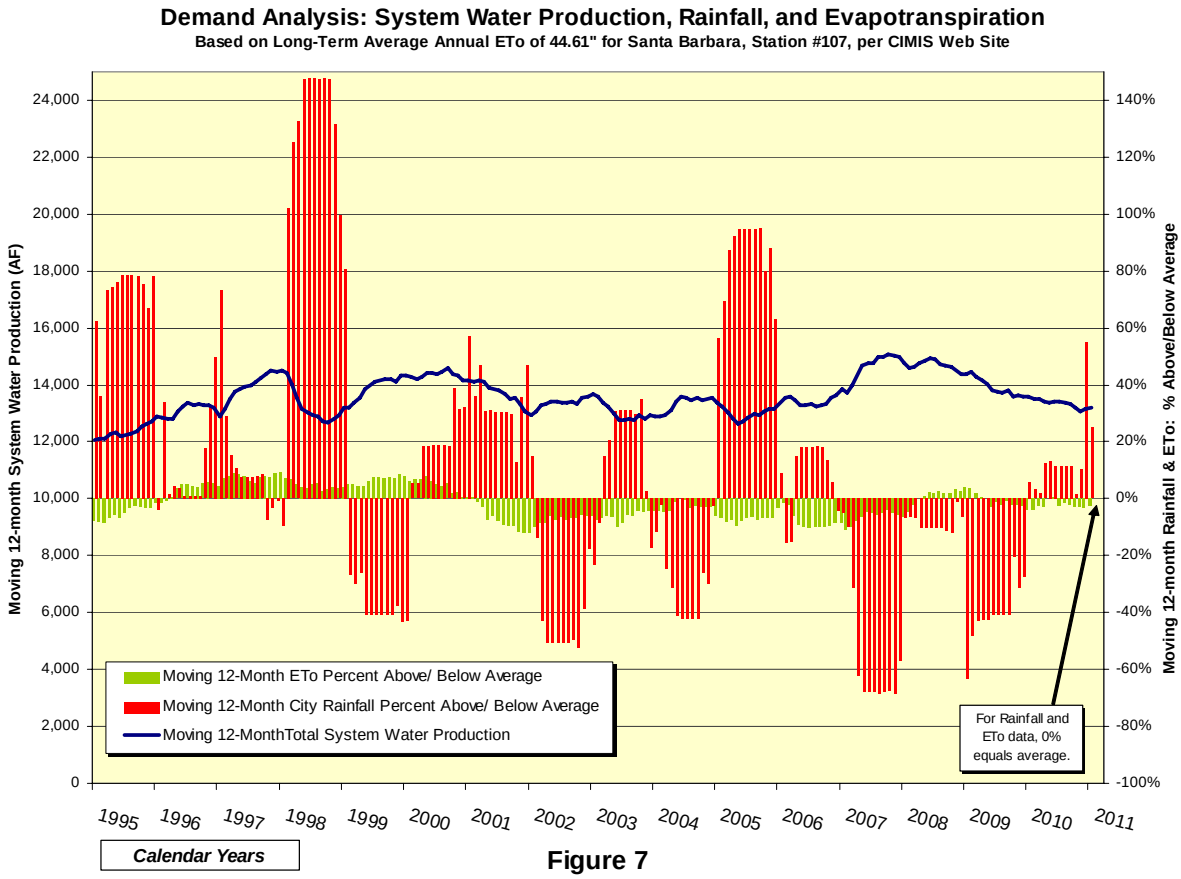


Figure 7

This information suggests that weather based fluctuations are the predominant effect on water demand. It is used to help estimate the "normal year" demand (i.e., approximately average rainfall), as the basis for planning water supply and estimating revenues.

Under the 1994 LTWSP, the City's water supply was planned to meet a total water system demand of 18,200 AFY. This number was derived as 17,900 AFY of demand projected during the 1989 update of the City's General Plan, plus a 10% safety margin, for a total of 19,700 AFY, minus an assumed "supply" of 1,500 AFY from new water conservation (some rounding included). Demand without safety margin for the end of the period was projected to be 16,400 AFY, including the assumed effects of water conservation. As the 1994 LTWSP planning period comes to an end, the normal year

demand is approximately 14,000 AFY, about 2,400 AFY less than projected. Demand for the 2010 water year, with rainfall about 12% above average, was 13,347 AFY.

The significant reduction in current demand compared to pre-drought levels can be attributed to a number of factors:

- An aggressive water conservation program;
- Less actual development than was projected;
- The cumulative effects of stricter plumbing codes and appliance standards on both new and existing development, and
- The relatively high cost of water, accentuated by the block rate pricing structure that charges a higher unit rate for higher levels of water usage.

The City's Water Conservation Program has developed into a comprehensive demand management effort. An important focus of the water conservation program has been to comply with, and to help shape, the Best Management Practices for Urban Water Conservation (BMPs) administered by the California Urban Water Conservation Council (CUWCC). These BMPs constitute the officially recognized standard for urban water conservation. Implementing the BMPs satisfies contractual requirements associated with the Cachuma Project. The BMPs have become a requirement for water utilities to remain eligible for state and federal loans and grants and Urban Water Management Plan acceptance. The City has been a signatory to the CUWCC Memorandum of Understanding Regarding Urban Water Conservation since 1992 and has worked with CUWCC to insure that the BMPs are practical and effective in achieving cost effective conservation savings.

Highlights of the water conservation program include:

- A broad selection of up-to-date print and on-line information on indoor and outdoor water conservation for both homes and businesses, including water wise plant selection, on-line irrigation scheduling tools, sustainable landscaping, high efficiency appliances, and water use awareness;

- Rebates for installation of water wise plants, smart irrigation controllers, and efficient irrigation systems, as well as high efficiency toilets, urinals, and clothes washers;

- A youth education program for elementary and secondary students, including classroom presentations, curriculum, treatment plant tours, and assemblies;

- The Green Gardener program, which trains landscape maintenance professionals in resource efficient and pollution prevention landscape maintenance practices;

- Practical guidelines and ordinances that reflect current technology for water conservation, including the City's Landscape Design Standards for Water Conservation;

- Targeted billing system analysis to reach customers with particularly high water usage, with an emphasis on providing site-specific landscape water budgets and real-time irrigation demand information; and

- A residential and commercial customer assistance program, providing free water check-ups to evaluate all water uses on the property and make recommendations for improved indoor efficiency, water wise plant selections, and irrigation system upgrades.

The current program is outlined in more detail in Appendix A (Water Conservation Program Summary).

City General Plan Growth Policies

Growth policies and projections analyzed for the City's General Plan update process (*Plan Santa Barbara*) were used as the basis for projecting water demand through the end of the planning period. Under proposed General Plan policies, development of up to 2,795 new dwelling units (DU) and 2.0 million square feet of new non-residential development are projected to occur within the City limits by the year 2030. Water demand for these projections is estimated as follows, based on recently updated aggregate demand factors for applicable customer classes:

Single Family Residential:	13% of 2,795 DU = 363 DU X .40 AFY/DU =	145 AFY
Multi-Family Residential:	87% of 2,795 DU = 2,432 DU X .16 AFY/DU =	389 AFY
Non-Residential:	2,000,000 ft^2 X .13 AFY per 1,000 ft^2 =	260 AFY

When 100 AFY of demand from projected added demand outside the current City limits is included (e.g. for annexations to the City), the result is a projected new demand of about 895 AFY. It is important to note that using current aggregate demand factors to project future demand can be expected to overestimate demand for new development. This is because new development will be subject to new codes and standards, while aggregate demand includes a significant portion of the building stock constructed under older standards.

State and Federal Requirements

A number of factors at the State and Federal levels will affect water demand in the future:

CUWCC BMP's: As noted above, the City's ongoing implementation of the BMP's can be expected to continue to exert a downward pressure on water use.

State & Federal Plumbing Codes: Currently, Federal plumbing and appliance efficiency standards require 1.6 gpf toilets, 1.0 gpf urinals, and 2.5 gpm showerheads. Effective 2014, all toilets and urinals sold in California will need to meet the new standards of 1.28 gallons per flush for toilets and 0.5 gallons per flush for urinals. This change will affect demand from new development, as well as demand from existing development as older fixtures are gradually replaced with models meeting the new standards. As required by the legislation, compliant models are already on sale in California at major retail and wholesale outlets. In addition, the California Green Building Standards have recently become effective and now essentially mandate the above standards for new construction. Additionally, after July 1, 2011, the 2010 California Plumbing code will require installations of 1.28 gpf toilets and .5 gpf urinals for all residential occupancy remodels. These include single family residential, dorms, hotels, apartments and basically any structure where overnight sleeping takes place.

S.B. 407 Fixture Replacement: Recent State legislation requires that new building owners be notified if the property does not have high efficiency fixtures. Implementation requirements are still unclear, but this can be expected to further the pace of conversion to high efficiency plumbing fixtures.

California's 20 X 2020 Requirement: In 2008, the Governor initiated a goal of 20% reduction in per capita urban water use by 2020. In 2009, the legislature adopted this goal into law by passing the Water Conservation Act of 2009 (SBx7-7). The penalty for non-compliance is ineligibility for State grants and loans. The focus is on public potable water distribution systems only. As such, the use of recycled water helps toward meeting the requirement. Targets were established by hydrologic regions, with several options for defining the baseline and the eventual 2020 target of per capita water use. The most suitable option for the City is "Method #3" in the legislation. This results in a baseline of 154 gallons per capita per day (GPCD) and a 2020 target of 117 GPCD. The 2009 potable per capita demand for the City was 130 GPCD, as calculated in compliance with the legislation.

Water Conservation Technical Evaluation

In preparing this plan, it was important to evaluate all of the above factors and determine to what extent additional water conservation could be relied upon during the planning period. This is in the context of meeting the State requirements of 20 X 2020

for per capita water use, meeting the CUWCC BMP requirements, and for properly identifying a cost effective role for water conservation in avoiding water supply costs.

Maddaus Water Management (MWM) is an engineering firm that is widely recognized as expert in estimating the costs and benefits of water conservation measures. MWM was hired to analyze the City's existing conservation program and use its proprietary Demand Management Decision Support System (DSS) to model current and potential conservation measures. The DSS also quantified the demand reduction effects of these measures along with the effects of plumbing codes and appliance standards. The process evaluated 92 potential measures which were screened for several factors to identify 23 that are most appropriate for Santa Barbara water customers. These 23 measures were inserted into the model, along with detailed information about the City's customer base and demand history. The project is described in more detail in the Executive Summary of the project report included as Appendix B (Water Conservation Technical Evaluation – Executive Summary). Key findings, including the effect of assumed development consistent with the Plan Santa Barbara process, are as follow:

- The 2030 demand would be expected to increase by 1,202 AFY (compared to the 2006 model reference point of 13,623 AFY) to 14,825 AFY, if the effects of already adopted plumbing codes and appliance standards were <u>not</u> considered. (It should be noted that this is not a projection that will actually occur, but it is a useful reference point to illustrate the ongoing effect of stricter codes and standards on both new and existing development.)

- The effects of the plumbing code and appliance standards are estimated to reduce 2030 demand by 919 AFY, to 13,906 AFY, not including the effects of conservation program activities and measures.

- Conservation Program B, which includes current conservation program measures along with those that together meet a utility benefit-cost ratio of 1.0, is estimated to reduce demand by an additional 498 AFY, to 13,408 AFY.

The benefit-cost ratio was calculated on the basis of an avoided cost of $600 per AF, which is an average of the variable costs associated with State Water Project Table A deliveries, groundwater produced from the Ortega Groundwater Treatment Plant, and deliveries of purchased water through the State Water Project during non-critical drought periods.

Figure 8

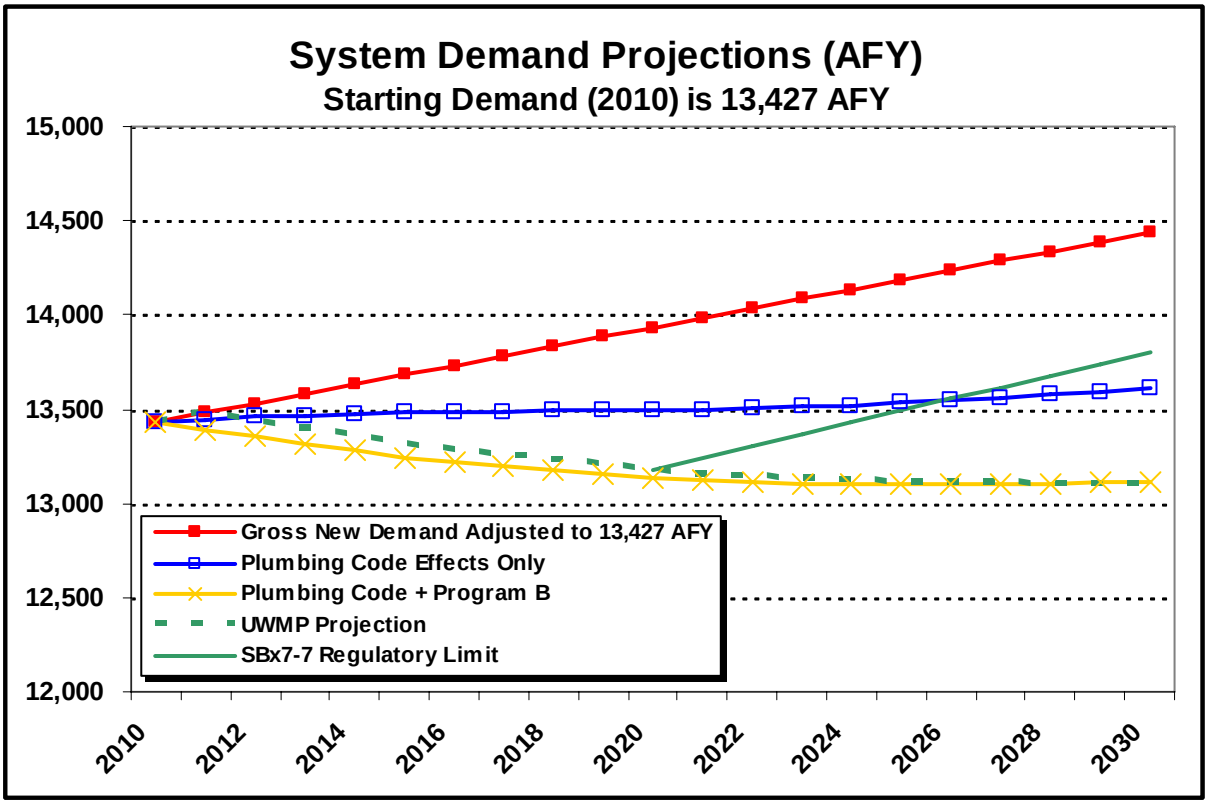


Figure 8 shows demand projections reflecting the various factors that will influence the City's actual water demand over the course of the planning period. These are based on the modeling results from the Maddaus report, adjusted to a reference point equal to the Fiscal Year 2010 total system demand of 13,427 AFY.

Primary Planning Issues

Given the water supply as described above, there are several key issues that shaped the water supply policies contained in this plan, as discussed below.

Planned Duration of Critical Drought Period

The critical drought period for the City's water supply occurs when there are multiple consecutive years of below average rainfall. This is due to the particular hydrology of the Santa Ynez River, where little or no inflow to Lake Cachuma typically occurs until at least average rainfall has occurred. When this condition of average or less rainfall continues for multiple years in succession, the storage level of Lake Cachuma drops and shortages in deliveries occur. Based on historical data, the critical drought period has had a duration of five years.

Climate change has the potential to impact the water supply, though it is still unclear whether this will have a significant effect during the planning period. To the extent information is available for the local area, overall rainfall amounts would be expected to be similar to recent history, but an increasing frequency of extreme rainfall events can be expected. This has the potential to result in an extended irrigation season with some associated increase in demand. From a water supply perspective, more concentrated rainfall events may have the benefit of increased inflow to Lake Cachuma. Guidance from the State planning agencies is that California can expect a 20% increase in both the frequency and the duration of dry periods. For the City's water supply this would suggest a critical drought period frequency of perhaps once every 30 years, instead of 40 years, and a duration of 6 years, instead of 5 years. Even though climate change impact information is incomplete and still undergoing critical review, the six-year drought period is a reasonable test and staff has used it for critical drought period analysis of the water supply.

Role of Desalination

The City's desalination facility is a vital resource as a back-up for potential prolonged drought and unforeseen interruptions of the water supply and would help mitigate the economic impact of such situations. It is also a reliable source of water, once in operation. However, as noted above, reactivation of the facility will result in significant costs, if only for the planning and design work that would be needed to start the process. In recent years, a dry period of only three years has been enough to trigger the start of planning to reactivate the facility in case of continuing dry weather. In 2004, after three years of drought, the storage level at Lake Cachuma had been reduced to about 70,000 AF out of 190,000 AF (37% of capacity) and the City was beginning this process of planning for reactivation.

As a result of discussion of this issue between staff and the Water Commission, the water supply has been modeled to stretch available Cachuma supplies over a potential 6-year drought period, with the goal of deferring the reactivation process, i.e. to plan for operation in the sixth year of a critical drought period instead of the fifth year. This would reduce the frequency of the planning and design effort, as well as reducing the likelihood that the substantial expense of actually reactivating the facility would be needed. This is another basis for the six-year critical drought period used in performance modeling.

Sedimentation Management at Reservoirs

Reservoirs on the Santa Ynez River are vulnerable to loss of storage capacity due to siltation, as are reservoirs throughout the west. Reduced storage capacity reduces the yield of a reservoir. At Gibraltar Reservoir, efforts to maintain storage capacity by dredging have had marginal impact and high cost. There has been some interest on the part of federal agencies to cooperate in vegetation management using controlled burns, but budget issues have made this unlikely to occur. Implementation of the Pass

Through provisions of the Upper Santa Ynez River Operations Agreement will essentially stabilize Gibraltar deliveries at a level close to historical amounts, despite continuing sedimentation. Still, an updated analysis of potential alternatives for managing sediment will be useful.

Efforts to control sedimentation at Lake Cachuma will require a joint effort among the Cachuma Project members, the downstream water users, and the various state and federal agencies that would have responsibility for permitting and/or implementing measures to address siltation. Issues related to such efforts are likely to be shared with numerous other reservoirs throughout the state, meaning that a coordinated statewide effort may be appropriate.

Groundwater Management

The City has initiated a three-year USGS study to update the groundwater flow and water quality models to allow more accurate management of groundwater. Better indicators of basin fullness are expected to be developed. More importantly, the modeling of seawater intrusion effects in Storage Unit No. 1 is expected to be made more accurate. This will guide placement of new wells in the basin, assist with scheduling well operation to minimize intrusion, and provide the ability to estimate the benefits of groundwater recharge for basin replenishment and creating barriers to seawater intrusion. In addition, the City should formalize its groundwater management role by developing a Groundwater Management Plan in accordance with State regulations.

Recycled Water Expansion

Recycled water is a relatively expensive source of water, but it is a reliable way to extend potable water supplies, thereby deferring the expense of procuring additional potable supplies. Additionally, increased recycled water connections will allow flexibility in meeting regulatory demand management requirements, such as the statewide requirement to reduce gross daily per capita water consumption. Current recycled water system capacity is 1,400 AFY, and current demand includes 800 AFY of retail demand and about 300 AFY of process water at EEWTP, for a total of 1,100 AFY. Carollo Engineers identified about 300 AFY of potential new users of recycled water, some adjacent to the existing system and some that could be served with extensions of the distribution system. These opportunities are being evaluated for their potential to cost effectively improve the reliability of the City's water supply and aid in meeting the state mandate on per capita water use. A caveat is that such expanded use will be more difficult to achieve if the mineral content is not reduced below that of the raw wastewater that feeds the recycled water system.

Water Supply Performance

The charts included as Appendix C are based on a worksheet developed by staff to simulate the City's water supply using the long-term model results from the Santa Ynez River Hydrology Model and other delivery assumptions as described above. An additional hypothetical year was added at the end of the 1947-1951 drought to simulate the 6-year critical drought period. For this sixth year, deliveries from Gibraltar, Mission Tunnel, and SWP are assumed to be the average of the preceding five years of drought. Cachuma is assumed to have negligible inflow during year six and the 5-year modeled yield is stretched out over the 6-year period. The charts illustrate how the City's water supplies would be used in the most cost effective manner to meet the projected demand during varying water supply conditions, ranging from very wet to very dry. The worksheet was used to explore the potential to defer the use of desalination at least until the sixth year of a drought. Three conditions are represented:

- The first represents "Current Conditions", with Cachuma entitlement of 8,277 AFY and no use of the safety margin.
- The second represents the near-term condition with Cachuma entitlement also at 8,277, but with a 10% safety margin included.
- The third represents 2030 conditions, with projected future Cachuma entitlement at 7,863 AFY and 10% safety margin included.

Planned demand reductions during the critical drought period are set at 10% in year 4, 15% in year 5, and 15% in year 6.

The worksheet uses a projected system demand of 14,000 AFY (plus safety margin as specified above), based on the combined effects of new development during the planning period, reductions in water use due to updated plumbing codes and appliance standards, the effects of the City's water conservation program, and the statutory requirement to meet a reduction in per capita daily water use by 2020.

A category called "Drought Supplies" is used to indicate water that would be used defer the use of desalination, either from unused State Water that is banked for use during dry periods or from the purchase of water during the critical drought period. The worksheet estimates that approximately 4,400 AF of unused State Water would be available for banking if contractual arrangements could be made to store the water for future use. Assuming a 50% deduction for the service of banking the water, about 2,200 AF of water would be available to meet the need for drought supplies. Water purchases would be pursued if additional water were needed. The desalination facility is proposed to remain a part of the City's water supply and would be used, if needed, to address shortages remaining after the use of banked water and purchased water.

The worksheet uses supplies as needed to meet the target demand according to the following sequence of priorities:

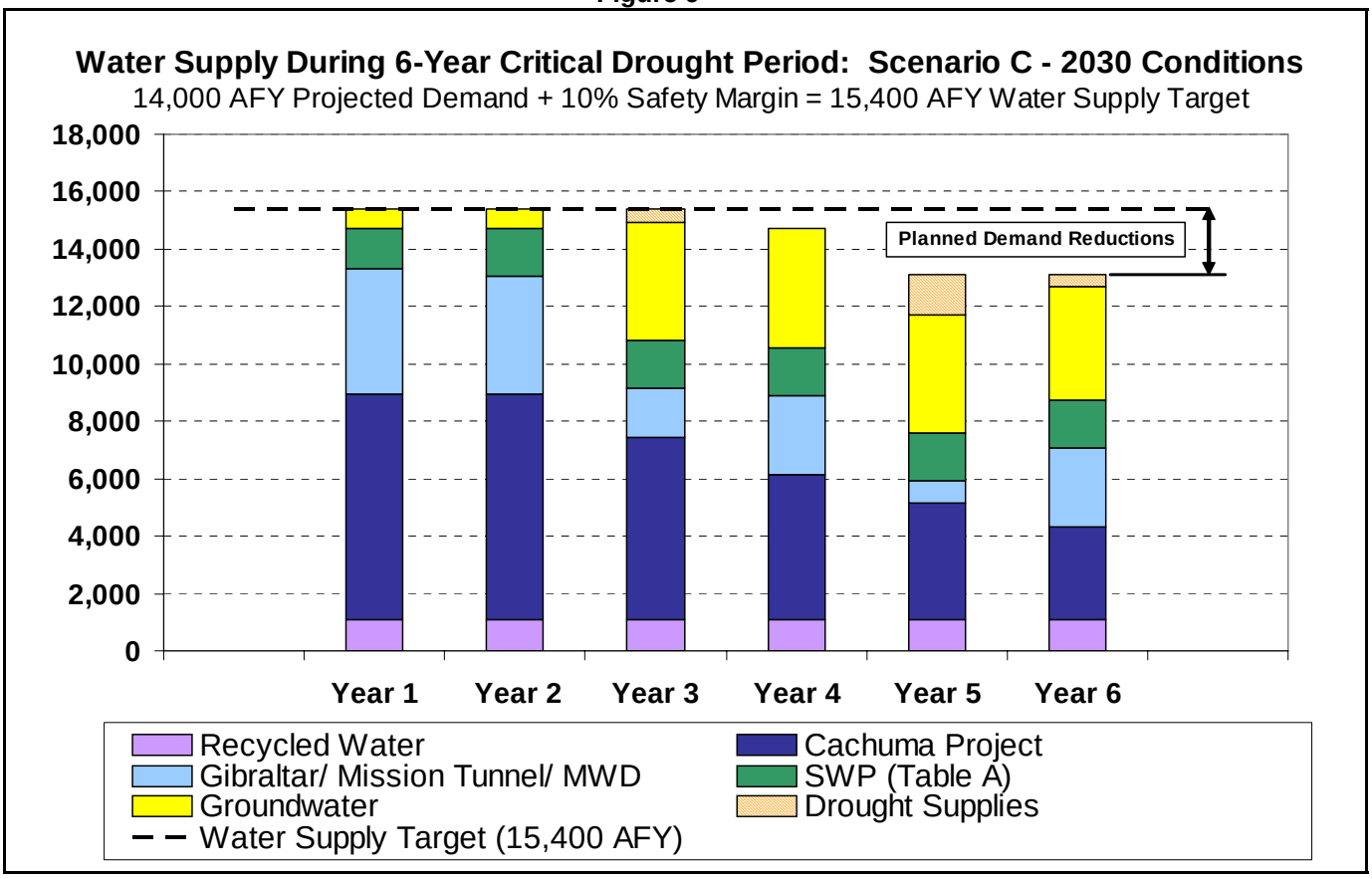
1. All available water from Gibraltar, Mission Tunnel and the Montecito Water District transfer, plus the 1,100 AFY of recycled water;
2. Minimum groundwater usage of 700 AFY;
3. The City's "exchange water" obligation of SWP Table A water (600 AFY);
4. Available Cachuma entitlement (except that remaining SWP Table A water is taken in year 2 and later to preserve available Cachuma water);
5. Remaining available SWP Table A water;
6. Added groundwater pumping up to the maximum amount of 4,150 AFY, subject to a cumulative pumping limit to minimize seawater intrusion;
7. Deliveries of "Drought Supplies" (banked water or purchased water to the extent available) through SWP facilities; and
8. Desalination (if necessary).

The worksheet is set up to take Planned Demand Reductions in years 4, 5, and 6 prior to taking delivery of Drought Supplies. The cumulative drawdown of available groundwater is tracked.

The water supply charts illustrate that the City's water supply can be met in most years with limited groundwater pumping, an average of only about 75% of available State Water, no drought supplies (banked water, purchased water, or desalination), and no need for extraordinary demand reductions. The real test of the water supply is the six-year critical drought period, beginning with model year 1947. Note that the sixth year is a hypothetical year that extends the historical 5-year drought to a 6-year drought. The 6-year critical drought period for 2030 Conditions (Scenario C) is highlighted in Figure 9. Key points illustrated include:

- Years 1 & 2: much like any non-drought year (mostly surface water, plus limited groundwater pumping);
- Year 3: Cachuma deliveries reduced to stretch remaining supplies; maximum groundwater pumping begins; small amount of Drought Supplies required;
- Year 4: First year of Planned Demand Reductions (4% of allowed 10%); further reduction at Cachuma is offset by some increased inflow at Gibraltar; no Drought Supplies required;
- Year 5: 15% Planned Demand Reductions; 1,364 AF of Drought Supplies taken; zero water delivered from Gibraltar; and
- Year 6: 15% Planned Demand Reductions; maximum pumping constrained slightly by the cumulative limit; some Drought Supplies required as a result; rainfall provides water from Gibraltar, but not enough to increase Cachuma deliveries.

Figure 9


Water Supply During 6-Year Critical Drought Period: Scenario C - 2030 Conditions
14,000 AFY Projected Demand + 10% Safety Margin = 15,400 AFY Water Supply Target
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Planned Demand Reductions
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Recycled Water
Gibraltar/ Mission Tunnel/ MWD
Groundwater
Water Supply Target (15,400 AFY)
Cachuma Project
SWP (Table A)
Drought Supplies

Water Supply Policies

This plan has been developed to evaluate the adequacy and reliability of the City's water supply and provide a long-term view of how the City's water supplies will be managed. It is based on the best currently available projections and assumptions, and is to be considered a plan, not a prescription. New information or conditions may necessitate adjustments or new policy direction. Based on the information contained and referenced herein, the City's water supply management program will be guided by the following policies:

1. Safety Margin: A safety margin of 10% above projected demand will be used for planning purposes to accommodate unplanned increases in demand or decreases in available supply.

2. Demand Reductions During Drought: Planned short-term reductions of up to 15% in customer demand will be a part of the City's response during a critical drought period. Such reductions will be in addition to the ongoing promotion of long-term water use efficiency and will be achieved by measures such as restrictions on landscape irrigation and other water uses, a modified water rate structure, and intensive public information efforts to promote the community goal of reduced water use. This policy of planned cutbacks is established in recognition of short-term elasticity in customer demand that can be tapped during rare emergency conditions to avoid the cost of 100% reliability of the water supply.

3. Recycled Water: State and City regulations requiring use of recycled water where available will be implemented. Capacity in the City's recycled water system will be utilized to continue to serve existing connected demand plus an additional 300 AFY of expanded use, for a total of approximately 1,100 AFY, in addition to recycled water used for process water. The use of potable water for blending will be tracked and reported annually. A contingency plan for eliminating the need for blending will be developed for implementation based on economic, regulatory or water supply requirements. The City's goal is to be able to deliver recycled water to its customers, without blending, by the end of the planning period. Status of this goal will be reported at five-year intervals as a part of the City's Urban Water Management Plan updates.

4. Water Conservation: The City will operate a water conservation program aimed at minimizing the use of potable water supplies, meeting the requirements of the California Urban Water Conservation Council Best Management Practices, and achieving compliance with 20 X 2020 per capita water use limitations. Conservation measures will be evaluated for cost effectiveness based on avoided cost of additional water supplies.

5. Groundwater Management: Groundwater production capacity of at least 4,125 AFY will be maintained in Storage Unit No. 1 and the Foothill Basin to augment

depleted surface water supplies during a severe drought. Ongoing modeling will assess strategies for groundwater management, including optimal use of available recharge, injection of potable water for artificial recharge, and injection of recycled water as a barrier to sea water intrusion. Sites for new or replacement production wells will be evaluated with the goal of minimizing sea water intrusion. The City will develop a Groundwater Management Plan, consistent with state law, to provide for the orderly and responsible use of the City's groundwater resources.

6. Gibraltar Pass Through Operations: Pass Through operations will be implemented for storage of Gibraltar water in Lake Cachuma, pursuant to the 1989 Upper Santa Ynez Rive Operations Agreement. An updated analysis of sedimentation management will be conducted to assess whether efforts to arrest or reverse the sedimentation process at Gibraltar Reservoir are feasible.

7. Sedimentation Management at Lake Cachuma: To address ongoing reduction in capacity at Lake Cachuma due to sedimentation, the City will promote development of a long-term strategy to minimize sedimentation in conjunction with Cachuma Project Member Units and other appropriate parties and agencies, including state and federal agencies.

8. Water Banking: The City will investigate opportunities to bank unused State Water, with the goal of using this water to reduce the amount of drought water purchases that may be needed during a critical drought period, and deferring the potential need for production from the desalination facility at least until the sixth year of a critical drought period.

9. Desalination Facility: The City's desalination facility is an important component of the City's water supply, despite the significant cost of activating and operating the plant. The desalination facility will be retained as an official part of the City's water supply for use as may be needed during extended drought.

10. Water Supply Reliability: The City will adequately fund the maintenance, rehabilitation, and replacement of the water conveyance and distribution infrastructure to provide reliable delivery of the City's water supplies and prevent increased costs from deferred maintenance. In addition to planning for periodic droughts, the City will develop an emergency water supply plan to address catastrophic interruption of water supplies due to earthquake, South Coast Conduit failure, or other disaster that could interrupt the City's ability to convey water from the Santa Ynez River for a substantial period of time. The groundwater production capacity identified for drought response will also be maintained for response on short notice to such catastrophic interruptions.

11. Management of Water Fund Assets: Land and equipment assets purchased with Water Fund resources will be managed for the purpose of optimizing the economic and sustainable operation of the water system.

12. Monitoring and Reporting: Ongoing monitoring and reporting of the City's water supply status will be conducted, including annual reports to City Council on the near-term drought outlook, preparation of 5-year updates of the City's Urban Water Management Plan, and an update of this plan in approximately 2030, or sooner as may be appropriate.

Finding

Based on implementation of the above policies, the City's water supply is determined to be adequate to serve anticipated demand for the duration of the planning period.

FINAL

Prepared by:

CDM Smith
523 West Sixth Street, Suite 400
Los Angeles, CA 90014

El Estero Wastewater Treatment Plant
Tertiary Filtration Facility
Engineering Assessment and
Preliminary Design Services

Tertiary Filtration Facility

Preliminary Design Report

Prepared for:

City of Santa Barbara
735 Anacapa Street
Santa Barbara, CA 93102-1990

Agreement No. 29,977
CDM Smith Project No. 120499-90670

February 19, 2013

Prepared by:

CDM Smith
523 West Sixth Street, Suite 400
Los Angeles, CA 90014

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Version:	FINAL
Prepared For:	Rebecca Bjork, City of Santa Barbara Christopher J. Toth, P.E., City of Santa Barbara
Prepared by:	Don Cutler, P.E., CDM Smith – Project Manager Marie Burbano, P.E., CDM Smith – Filtration Design Lead Greg Wetterau, P.E., CDM Smith – Demineralization Design Lead Evelyn You, P.E., CDM Smith – Project Engineer Jason Yoshimura, P.E., CDM Smith – Project Engineer Mike Lin, P.E., CDM Smith – Civil Design Jeff Woon, P.E., CDM Smith – Geotechnical Alan Hahn, CDM Smith – Structural Brian Young, P.E., CDM Smith – Electrical Misty Walpole, CDM Smith – Instrumentation and Control Kirk Johnson, CDM Smith – Cost Estimating Margie Nellor, Nellor Environmental Associates – Permitting Jamie Harlan, MNS – Recycled Water System Study Leroy Cadena, P.E., MNS – Recycled Water System Hydraulic Analysis
Reviewed by:	R. Bruce Chalmers, P.E., CDM Smith – Technical Review Bill O'Neil, P.E., CDM Smith – Technical Review
Contributors:	Amanda Flesse, City of Santa Barbara Todd Heldoorn, City of Santa Barbara Cathy Taylor, City of Santa Barbara Thomas Welche, City of Santa Barbara David Lewis, City of Santa Barbara Vincent Pimentel, City of Santa Barbara
Date:	February 19, 2013

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Section 1

Filtration TM No.1 – Final Summary Assessment Report on Tertiary Filtration

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Memorandum

To: *Rebecca Bjork, City of Santa Barbara*

From: *Don Cutler, CDM Smith*
Marie Burbano, CDM Smith
Greg Wetterau, CDM Smith

Date: *November 21, 2012*

Subject: *Tertiary Filtration Preliminary Design Technical Memorandum (TM) No.1 – Final Summary Assessment Report on Tertiary Filtration*

1.1 Introduction

The City of Santa Barbara (City) has been providing, protecting, and preserving groundwater, drinking water and recycled water for its community for over 150 years. The City has been a leader in water system planning and use of recycled water. Committed to protecting the environment and public health and safety, the City now seeks to sustainably and reliably improve treatment at their El Estero Wastewater Treatment Plant (EEWWTP).

EEWWTP is an 11 mgd wastewater treatment plant that was initially constructed in 1951; the plant has primary sedimentation, secondary processing, tertiary filtration, and disinfection. At EEWWTP, the City produces Title 22 recycled water for 60 to 80 users, according to the 2009 Recycled Water Expansion Assessment. The City is committed to providing recycled water to system users who depend on the reliability of the recycled water system.

In the recent years, the tertiary filter effluent has not been able to reliably meet the required turbidity limit of <2 NTU (nephelometric turbidity units). The influent wastewater is also relatively high in total dissolved solids (TDS), which results in high TDS in the tertiary filter effluent. As a result, the City currently blends tertiary filter effluent with potable water to decrease turbidity and TDS in the recycled water.

In 2012, the City embarked on this project to provide assessment and preliminary design services related to upgrading the existing tertiary filtration system. This project is divided into three tasks.

- **Task I – Assessment** includes the assessment activities and memoranda to determine the path forward for preliminary design.
- **Task II – Filtration Preliminary Design** provides technical memoranda (Filtration TMs) and a preliminary design report (Filtration PDR) for the selected filtration alternative.

- **Task III – Demineralization Preliminary Design** provides technical memoranda (Demineralization TMs) and a preliminary design report (Demineralization PDR) for the selected demineralization alternative.

This TM (Filtration TM No.1) summarizes the six assessment memoranda (AMs) completed as part of Task I – Assessment and is part of Task II – Filtration Preliminary Design. This memorandum also outlines the additional Filtration TMs that will be completed as part of Task II – Filtration Preliminary Design.

Note that there is another TM (Demineralization TM No.1) that will summarize the same details related to Task III – Demineralization Preliminary Design. The purpose of duplicate TMs is to provide independent, stand-alone Preliminary Design reports for filtration and demineralization.

1.2 Summary of Assessment Memoranda

The following is a list of the assessment memoranda (AMs) completed as part of Task I - Assessment.

- AM No.1. Introduction & Project Background
- AM No.2. Recycled Water System Study
- AM No.3. Filtration Alternatives
- AM No.4. Demineralization Alternatives
- AM No.5. Investigation of TDS Sources
- AM No.6. Recycled Water System Hydraulic Analysis

The AMs for Task I addressed both filtration and demineralization, with specific focus on filtration or demineralization as appropriate.

The following sections provide a summary of the evaluations and recommendations provided in the previously completed AMs.

1.2.1 AM No.1 Summary: Introduction and Project Background

AM No.1 provides of list of the AMs associated with the assessment phase of the project and the references and as-built drawings that provide the basis for the AMs, and subsequent technical memoranda and preliminary design report.

1.2.2 AM No.2 Summary: Recycled Water System Study

AM No.2 provides an overview of the existing recycled water system and evaluates future recycled water demands, potential system improvements, and current and future water quality goals.

Currently, recycled water produced by the EEWWTP serves over 400 acres of landscaped areas. These areas include golf courses, parks, schools, and the zoo. Recycled water demand occurs primarily at night with the distribution time occurring between the hours of 9pm and 6am. Though this is an ideal time for irrigation due to the lessened direct human contact, it may also present some issues due to the low influent flow to the treatment plant during the early morning hours.

According to the 2011 Recycled Water Use data, the EEWWTP usage for process water was approximately 258 Acre Feet per Year (AFY). In the City of Santa Barbara Long Term Water Supply Plan, the EEWWTP process water is approximated at 300 AFY. The metered sales to customers was approximately 478 AFY compared with the 800 AFY cited in the City of Santa Barbara Long Term Water Supply Plan. One possible reason for this discrepancy is the particularly high rainfall for the previous water year. The 2010-2011 water year saw 28.49 inches of rain.

The recycled water system, as it is currently, has the capacity to treat and deliver 1,400 AFY (Long Term Water Supply Plan) of recycled water. If the El Estero process water usage totals approximately 300 AFY and the demand from sales to customers is about 800 AFY that would leave approximately 300 AFY of additional capacity.

It is the City of Santa Barbara's policy to require recycled water for irrigation purposes for properties situated along the main recycled water lines. It is also the City's policy to encourage users who are not required to utilize recycled water to do so. Nine potential new recycled water users were identified. The potential users are situated adjacent to the system and would be easy to connect to the system.

In addition to nine identified new users, there is the potential to increase quantities of water used by current customers. These customers would need to be identified by the City from any requests or wishes for additional supply.

Another area for possible expansion is the industrial sector. Currently, the City's recycled water is distributed primarily for irrigation purposes. However, there is a potential for growth in use for businesses such as car washes and laundries in the area.

Lastly, if there is enough capacity for additional customers on the system, there is always the possibility of system expansion. Sixteen potential new users were identified in areas for expansion in Phase I and Phase II. This table also shows possible customers situated near the proposed expansion pipelines. These areas include parks, schools, office complexes, and housing.

1.2.3 AM No.3 Summary: Filtration Alternatives

AM No.3 presents several filtration treatment process alternatives and provides a preliminary analysis to recommend a treatment process to accomplish the desired water quality of the recycled water produced at the EEWWTP.

Recycled water quality criteria and usage are specified in Title 22, Division 4 of the California Code of Regulations (CCR). The EEWWTP produces recycled water that meets the Title 22 criteria for disinfected tertiary recycled water. Depending on the groundwater basin and recycled water usage location, the Regional Water Quality Control Board (RWQCB) can include additional requirements to Title 22. At the EEWWTP, the Central Coast Region of the RWQCB lists the current recycled water requirements in the Waste Discharge Requirements and Master Reclamation Permit Order No. 97-44. Note that Title 22 was written after Order No. 97-44. However, the requirements in Order No. 97-44 are more stringent than Title 22 and, therefore, apply to the EEWWTP. Table 1-1 summarizes the primary water quality requirements for disinfected tertiary recycled water.

Table 1-1: EEWWTP Recycled Water Permit Requirements per Order No. 97-44

Parameter	Requirements
Turbidity [1]	2 NTU (Mean) 5 NTU (Maximum)
Total Non-filterable Residue (Suspended solids)	10 mg/L (Mean) [2] 25 mg/L (Maximum)
Settleable solids	0.1 mL/L (Maximum)
Total dissolved solids	1,500 mg/L (Maximum)
Cadmium	0.01 mg/L (Maximum)
Lead	5.0 mg/L (Maximum)
Total Coliform Most Probable Number (MPN) [3]	2.2 per 100 mL (Average) 23 per 100 mL (Maximum)

Notes:

1. Maximum limit shall not be exceeded more than five percent of the time during any 24-hour period.
2. Compliance shall be determined from the results of the five most recent samples.
3. No sample shall exceed an MPN of 240 total coliform bacteria per 100 mL.

Title 22 provides requirements for both filtered wastewater and disinfected tertiary recycled water. For the purposes of this analysis, the filtered wastewater standards must be met using the filtration alternative selected. Disinfection occurs at El Estero in the chlorine contact basin and onsite storage reservoir. All of the technologies evaluated in AM No.3 meet the Title 22 requirements for filtered wastewater.

The existing filter complex was constructed in 1988 as part of the City's Water Reclamation Project at El Estero. The existing chlorine contact basin and recycled water reservoir were constructed at the same time. The filters are single-media gravity filter type filters with an air/water backwash system.

Existing filter limitations include difficulty to meet effluent turbidity requirements, continuous operational challenges, and operations and maintenance safety concerns. Structural and corrosion problems with the existing filter complex are well documented in the Corrosion Engineering Evaluation Report completed by HAE Engineers in January 2012. These structural and corrosion problems cause operational safety concerns for plant staff. Additionally, one of the greatest challenges to operations is the instrumentation and controls with the existing filter complex. In recent years, the online instrumentation and automated backwashing has not been effective. Access to control instrumentation such as level sensors is limited as well.

Filtration technologies evaluated were as follows.

- Gravity deep bed filters (upgrade existing)
- Upflow continuous backwash media filters
- Cloth or disk filters
- Microfiltration/Ultrafiltration (MF/UF).

Filtration will be prior to any proposed demineralization. For the purposes of the filtration analysis, it is assumed that reverse osmosis (RO) is the preferred alternative for demineralization. For any flow

going through the RO, MF pretreatment is highly preferred. For the first four technologies listed (gravity deep bed filters, upflow continuous backwash media filters, cloth or disk filters), a sidestream of MF will be required prior to the RO. For the full MF alternative, no additional sidestream RO pretreatment is required.

In order to evaluate filtration alternatives, criteria were developed and scored during an April 9, 2012 workshop with City staff. The purpose of this workshop was to develop criteria to compare filtration alternatives. The process started with brainstorm to identify list of criteria. The list was narrowed down to the 6 most important criteria. Each meeting attendee then prioritize this list with weights, where 1 = low priority, and 5 = high priority. The weights were averaged and discussed to develop the final criteria and weights, provided in Table 1-2.

Table 1-2: Evaluation Criteria

Criteria	Weight
Increase ease of O&M and safety for plant staff	5
Optimize site layout	3
Minimize recycled water system shutdowns	4
Improved water quality: reduce turbidity & TDS	5
Minimize blending	4
Life-cycle cost	4

Note: 1 = low priority, 5 = high priority

In addition to this evaluation criteria and assessment, capital, operations and maintenance (O&M), and life-cycle cost evaluations were completed to determine the life-cycle cost scores. Table 1-3 summarizes the cost evaluation of the various alternatives.

Table 1-3: Lifecycle Cost Evaluation Summary

	Rehab Existing Filters/ Sidestream MF	Upflow in Existing / Sidestream MF	New Upflow/ Sidestream MF	Disk Filters in Existing/ Sidestream MF	Full MF
Capital Cost	$4.9M	$4.8M	$6.6M	$4.6M	$6.5M
Yearly O&M Cost	$0.08M	$0.08M	$0.08M	$0.08M	$0.1M
20-Year Life-cycle cost	$6.1M	$6M	$7.8M	$5.8M	$7.9M
Life-cycle cost score	4	4	3	4	3

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Table 1-4 provides the complete filtration assessment scores for each alternative.

Table 1-4: Evaluation Summary

Criteria	Weight	Rehab Existing Filters/ Sidestream MF	Upflow in Existing / Sidestream MF	New Upflow/ Sidestream MF	Disk Filters in Existing/ Sidestream MF	Full MF
O&M and safety	5	3	3	4	4	4
Optimize site layout	3	2	2	3	4	4
Minimize shutdowns	4	3	4	4	3	5
Reduce turbidity & TDS	5	3	4	4	3	5
Minimize blending	4	5	5	5	5	5
Life-cycle cost	4	4	4	3	4	3
Total Weighted Score		84	93	97	95	109

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Based on the evaluation criteria and filter scores, the full MF alternative is the recommended technology to provide tertiary filtration at the EEWWTP to produce Title 22 recycled water. MF will provide excellent water quality for recycled water users and is a sufficient pretreatment for sidestream RO.

1.2.4 AM No.4 Summary: Demineralization Alternatives

Demineralization is not required to produce Title 22 recycled water at the EEWWTP, but may be provided in the future to further improve the recycled water quality for irrigation users. The following provides a brief summary of the scope of AM No.4. A more detailed summary of AM No.4 is provided in the Demineralization Preliminary Design TM No.1.

AM No.4 identifies and describes four demineralization treatment alternatives:

- Reverse Osmosis (RO)
- Nanofiltration (NF)
- Electrodialysis Reversal (EDR)
- Blending with potable water

AM No.4 evaluates the four demineralization treatment alternatives based on the same evaluation criteria developed for the filtration alternatives. AM No.4 recommends RO as the demineralization treatment alternative for use at the EEWWTP.

1.2.5 AM No.5 Summary: Investigation of TDS Sources

Investigation of TDS sources in the influent to the EEWWTP is part of the Demineralization task. The following provides a brief summary of the scope of AM No.5. A more detailed summary of AM No.5 is provided in the Demineralization Preliminary Design TM No.1.

1.2.6 AM No.6 Summary: Recycled Water System Hydraulic Analysis

AM No.6 provides an evaluation of the existing recycled water distribution system, including the on-site reservoir and transfer pump station at the EEWWTP site and the existing storage reservoirs. An assessment of the existing system is performed to evaluate how to better control recycled water distribution to reliably achieve CT times and to provide better control of the distribution system.

In summary, the El Estero Recycled Water system is currently operating in a batch mode, which produces inconsistent levels of turbidity and which leads to blending the effluent with potable water which leads to inconsistent chlorine residuals and CT Values. Upgrading the recycled water plant with membrane treatment will provide more consistent effluent and give the plant the opportunity to produce continuous and more consistent quality recycled water. The continuous process system will also make it easier to size additional storage tanks to meet future demands.

1.3 Filtration Preliminary Design

The following summarizes the scope of the technical memoranda (TMs) that will provide the basis of the preliminary design.

1.3.1 Filtration Preliminary Design

The following is a list of the filtration TMs to be provided as part of the filtration preliminary design task (Task II).

- Filtration TM No.1 – Final Summary Assessment Report on Tertiary Filtration
  - Summarizes the evaluations and recommendations provided in the Task I AMs
- Filtration TM No.2 – Permitting Requirements and Considerations for Membrane Filtration for Recycled Water
  - Summarizes permitting requirements for the tertiary filtration system
- Filtration TM No.3 – Structural and Geotechnical Design Criteria
  - Summarizes preliminary geotechnical and structural design criteria for the tertiary filtration system
- Filtration TM No.4 – Process Mechanical Design Criteria
  - Summarizes preliminary process mechanical design criteria for the tertiary filtration system
- Filtration TM No.5 – Electrical and Instrumentation and Control Design Criteria
  - Summarizes preliminary electrical and control systems design criteria for the tertiary filtration system
- Filtration TM No.6 – Civil Design Criteria and Demolition and Constructability Considerations
  - Summarizes demolition requirements and evaluates the constructability of the tertiary filtration system
- Filtration TM No.7 – Opinion of Probable Cost of Construction and Implementation Schedule
  - Summarizes opinion of probable cost of construction and implementation schedule for the tertiary filtration system

1.3.2 Demineralization Preliminary Design

Preliminary design of the demineralization system is included under Task III. The following is a list of the demineralization TMs to be provided under Task III.

- Demineralization TM No.1 – Final Summary Assessment Report on Demineralization
- Demineralization TM No.2 – Permitting Requirements and Considerations for Demineralization for Recycled Water
- Demineralization TM No.3 – Structural and Geotechnical Design Criteria
- Demineralization TM No.4 – Process Mechanical Design Criteria
- Demineralization TM No.5 – Electrical and Instrumentation and Control Design Criteria
- Demineralization TM No.6 – Civil Design Criteria and Demolition and Constructability Considerations
- Demineralization TM No.7 – Opinion of Probable Cost of Construction and Implementation Schedule

Section 4

Filtration TM No.4 – Process Mechanical Design Criteria

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Memorandum

To: *Rebecca Bjork, City of Santa Barbara*

From: *Don Cutler, CDM Smith*
Marie Burbano, CDM Smith
Evelyn You, CDM Smith
Jason Yoshimura, CDM Smith

Date: *November 21, 2012*

Subject: *Tertiary Filtration Preliminary Design Technical Memorandum (TM) No.4 –Process Mechanical Design Criteria*

4.1 Introduction

This Technical Memorandum No.4 (Filtration TM No.4) provides the preliminary design for tertiary filtration treatment using membrane filtration for recycled water produced at El Estero Wastewater Treatment Plant (EEWWTP) in City of Santa Barbara (City).

4.2. Design Criteria

This section summarizes the overall design requirements for the filtration system. As discussed in Assessment Memorandum No.3 (CDM Smith. June 2012), the selected treatment process to provide filtration of the recycled water at the EEWWTP is microfiltration (MF) or ultrafiltration (UF) membrane filtration. The MF and UF membranes provide a physical barrier, resulting in more complete rejection of particles greater than a specified size (on the order of 0.1 µm for MF and on the order of 0.01 µm for UF. Membranes of this kind remove particles down to such small sizes that they both remove pathogens and also particles that adversely affect the aesthetic appearance of the water. Membrane filtration has been successfully employed in the treatment of secondary effluent to make it suitable for reverse osmosis (RO), which is the selected recycled water demineralization process as discussed in Assessment Memorandum No.4 (CDM Smith, June 2012). It also meets Title 22 filtered wastewater requirements without the use of RO. For the purposes of this memorandum, membrane filtration and MF/UF will be used interchangeably.

4.2.1 Water Quality Goals

Recycled water quality criteria and usage are specified in Title 22, Division 4 of the California Code of Regulations (CCR). EEWWTP produces recycled water that meets the Title 22 criteria for disinfected tertiary recycled water. Depending on the groundwater basin and recycled water usage location, the Regional Water Quality Control Board (RWQCB) can include additional requirements to Title 22. At EEWWTP, the Central Coast Region of the RWQCB lists the current recycled water requirements in the Waste Discharge Requirements and Master Reclamation Permit Order No. 97-44.

Table 4-1 summarizes the primary water quality requirements for disinfected tertiary recycled water.

Table 4-1: EEWWTP Recycled Water Permit Requirements per Order NO. 97-44

Parameter	Requirements
Turbidity[1]	2 NTU (Mean) 5 NTU (Maximum)
Total Non-filterable Residue (Suspended solids)	10 mg/L (Mean) [2] 25 mg/L (Maximum)
Settleable solids	0.1 mL/L (Maximum)
Total dissolved solids	1,500 mg/L (Maximum)
Cadmium	0.01 mg/L (Maximum)
Lead	5.0 mg/L (Maximum)
Total Coliform Most Probable Number (MPN)[3]	2.2 per 100 mL (7-day Median) 23 per 100 mL (Maximum)

Notes:

1. Maximum limit shall not be exceeded more than five percent of the time during any 24-hour period.
2. Compliance shall be determined from the results of the five most recent samples.
3. No sample shall exceed an MPN of 240 total coliform bacteria per 100 mL.

Title 22 provides requirements for both filtered wastewater and disinfected tertiary recycled water. The filtered wastewater standards have specific requirements for an MF/UF System. Disinfection for recycled water occurs at EEWWTP in the recycled water chlorine contact basin (CCB) and onsite storage reservoir.

Title 22 requirements for filtered wastewater using MF/UF are as follows.

"Filtered wastewater" means an oxidized wastewater that meets the criteria …

(b) Has been passed through a microfiltration, ultrafiltration, nanofiltration, or reverse osmosis membrane so that the turbidity of the filtered wastewater does not exceed any of the following:

(1) 0.2 NTU more than 5 percent of the time within a 24-hour period; and

(2) 0.5 NTU at any time."

In addition, the MF/UF System provides pretreatment for RO System to reduce the particulate and biological fouling of the RO membranes. The MF/UF System will effectively remove inert particulates, organic particulates, colloidal particulates, pathogenic organisms, bacteria and other particles by the size-exclusion sieve action of the membranes.

Table 4-2 presents the MF/UF filtrate water quality design criteria for the MF/UF System. Note that this table also provides the following source of the requirement for the MF/UF System.

Table 4-2: MF/UF Filtrate Water Quality Design Criteria

Constituent	Design Criteria	Requirement Basis
Turbidity	<0.2 NTU (95% of the time) <0.5 NTU (at any time)	Title 22 requirement for filtered wastewater using MF
Total Non-filterable Residue (Suspended solids)	10 mg/L (Mean) [1] 25 mg/L (Maximum)	Master Reclamation Permit Order No. 97-44
Settleable solids	0.1 mL/L (Maximum)	Master Reclamation Permit Order No. 97-44
Total dissolved solids	1,500 mg/L (Maximum) [2]	Master Reclamation Permit Order No. 97-44
Cadmium	0.01 mg/L (Maximum) [2]	Master Reclamation Permit Order No. 97-44
Lead	5.0 mg/L (Maximum) [2]	Master Reclamation Permit Order No. 97-44

Note:
Compliance shall be determined from the results of the five most recent samples.

MF/UF is not designed to remove TDS, cadmium, or lead. TDS is assumed to be less than 1,500 mg/L, cadmium is assumed to be less than 0.01 mg/L, and lead is expected to be less than 5.0 mg/L in the secondary effluent feeding the MF/UF system.

Although the permit requirements allow up to 25 mg/L of suspended solids, the MF/UF filtrate is not expected to contain any measureable concentration of suspended solids.

The existing disinfection system at the EEWWTP utilizes sodium hypochlorite and existing ammonia in the secondary effluent to generate chloramines. A chlorine contact basin is used to achieve a minimum concentration times time (CT) value of 450 milligram minutes per liter (mg·min/L) per the requirements of Title 22.

As part of the secondary process upgrades currently under design, the disinfection system will continue to use chloramines. The secondary process upgrades will include the addition of an ammonia feed since secondary improvements will result in full nitrification (i.e. removal of the ammonia from the secondary effluent). The planned feed point for the ammonia to the secondary effluent is in the secondary effluent channel, upstream of the split to the MF/UF system. This ammonia feed system is part of the secondary process upgrades and will not be part of the tertiary filtration project scope. If the secondary improvements project is not complete prior to the tertiary filtration project, the plant will continue to have residual ammonia in the secondary effluent. Therefore, a separate ammonia feed system is not needed as part of the tertiary filtration project.

For the condition after the secondary improvements are completed, there will continue to be the ability to dose sodium hypochlorite to the CCBs and reclaimed reservoir. This would be a backup process in case the residual drops too low through the MF/UF System. In that case, it will be important to dose sufficient ammonia at the secondary effluent to generate chloramines.

4.2.2 MF/UF Feed Water Quality

For the MF/UF System design, the feed water quality is based on the quality of the EEWWTP secondary effluent. Currently, the City intends to make improvements to the secondary system from the current non-nitrifying process to a process with full nitrification and partial denitrification. The intent of the secondary improvements is to achieve an improved water quality that will be better for

the filtration system. At this time, it is unclear on if the secondary improvements will be completed before or after the construction of the MF/UF System.

For the purposes of this PDR, the MF/UF System design is based on an assumed water quality after the secondary improvements are completed. Table 4-3 provides the assumed secondary effluent quality following secondary improvements that will be used as the design influent to the MF/UF System.

Table 4-3: Assumed Secondary Effluent Quality After Secondary Improvements at EEWWTP

Parameter	Level
Biochemical Oxygen Demand (BOD)	10 mg/L
Total Suspended Solids (TSS)	10 mg/L
Turbidity	<10 NTU
Ammonia	>5 mg/L as N (using ammonia addition to secondary effluent line)

In the event that secondary improvements are not completed prior to the construction of the MF/UF System, the MF/UF System will still be able to operate using the current secondary effluent as a source. Using the current secondary effluent may result in a slightly decreased output of the MF/UF System for the time until the secondary improvements are completed due to a decreased flux rate with a higher influent solids loading. The extent of the decrease in output will depend on the quality of the secondary effluent and the actual flux rate that the MF/UF System is able to achieve. This is expected to be for a short duration (i.e. a few years), and therefore the City decided not to increase the size of the MF/UF System to accommodate this short period of operation.

4.2.3 Facility Sizing

The recycled water demand for the EEWWTP is 1,400 acre-feet per year (AFY) based on discussions with the City as well as the 2011 Long Term Water Supply Plan (City of Santa Barbara, June 2011) and the Urban Water Management Plan (City of Santa Barbara, June 2011). On an average basis, 1,400 AFY results in an annual average daily demand of 1.25 mgd. However, the recycled water demand is not constant throughout the year, with typically higher flows required during the summer peak irrigation season. The 2009 Recycled Water Expansion Assessment (Carollo, August 2009), indicates a maximum monthly demand peaking factor of 2, resulting in a maximum month demand of 2.5 mgd. Assessment Memorandum No.2 provides a detailed analysis of 2011 recycled water demands, including the scale-up to the long-term goal of 1,400 AFY. The results of Assessment Memorandum No.2 projected that the projected recycled water demand in year 2030 will be 2.09 mgd for the daily demand in the peak month, 2.28 mgd for the projected maximum 7-day rolling average, and 3.14 mgd for the daily demand in the peak day, and 2.56 mgd for the projected 99th percentile daily demand. To avoid oversizing the tertiary filtration system, the overall recycled water system is designed to produce 2.5 mgd of recycled water on an average daily basis to meet projected 98th percentile daily recycled water demand for year 2030.

The operations for minimum daily flows through the MF/UF System can be as low as 0.5 mgd or less. To appropriately size an MF/UF System, the full range of minimum to maximum flow may not be feasible because an extensive number of units will be required to provide turndown. For the purpose of this design, the minimum recycled water flow is assumed to be 1 mgd on a daily basis. If the demand is less than 1 mgd, the recycled water system storage can be utilized and the MF/UF System can be shut down for a period of time.

To meet the recycled water demands, it is important to appropriately size the MF/UF System based on the available quantity of secondary effluent. The primary concern for available water for the recycled water system is the ability to meet recycled water demands at night when the influent flows to the EEWWTP are low. Effluent flow data from the EEWWTP for April-May 2011 and July- August 2012 were used to determine the amount of flow available for the recycled water system during these low flow conditions. These months were used since they are typically the higher demand months, instead of the winter months when demand was lower.

The City provided data for the entirety of these two-month durations in 15-minute time intervals. Each interval contained four separate flow measurements, all in million gallons per day: Actual, Average, Minimum, and Maximum. These individual measurements were combined to provide a comprehensive data set for analysis.

The minimum daily flows during April and May 2011 were constant at close to 3.0 mgd. The minimum daily flows for July and August 2012, however, showed a wider variation. Although a consistent trend shows minimum daily flows of approximately 2.5 mgd for the majority of this duration, many days in the first half of July show much lower minimum daily flows. Many of these days had minimum flows of less than 2.1 mgd. On July 7, the flow decreased to below 1.5 mgd, but only for 30 minutes. Because this was only one day and for a short time, this period was considered an outlier and not used as a design condition.

To appropriately size the treatment facilities for these varied flows, it is necessary to estimate an expected minimum flow rate for each hour of the day. Based on the July data on the most extreme days, the design flow condition will include absolute minimum flow rates from 3am until 7:30am and more typical flow rates from 7:30am until 3am the next day.

Design flow conditions were selected to average a total daily recycled water flowrate of 2.5 mgd. First, it was determined that the minimum flow from 3am to 7:30am was 1.5 mgd, as indicated in the graph. Using that as the main constraint, the flow for the remainder of the day (7am to 3am) was increased until a product water of 2.5 mgd on an average basis was achievable. It was important to account for flows that were required from secondary effluent but did not product recycled water, for example MF backwash and RO brine, when determining the secondary effluent flow to the system.

Figure 4-1 shows the measured secondary effluent flow rates for every day in July and August 2012 as well as the design flow conditions. This shows that the design secondary effluent flow will be available on a daily basis for the plant. This also shows that, during the low-flow periods, all of the secondary effluent flow will be used for the recycled water system to meet the 2.5 mgd daily demand. The design secondary effluent flow for normal periods is 3.2 mgd, and low periods is 1.5 mgd, as indicated by the red line in the figure.

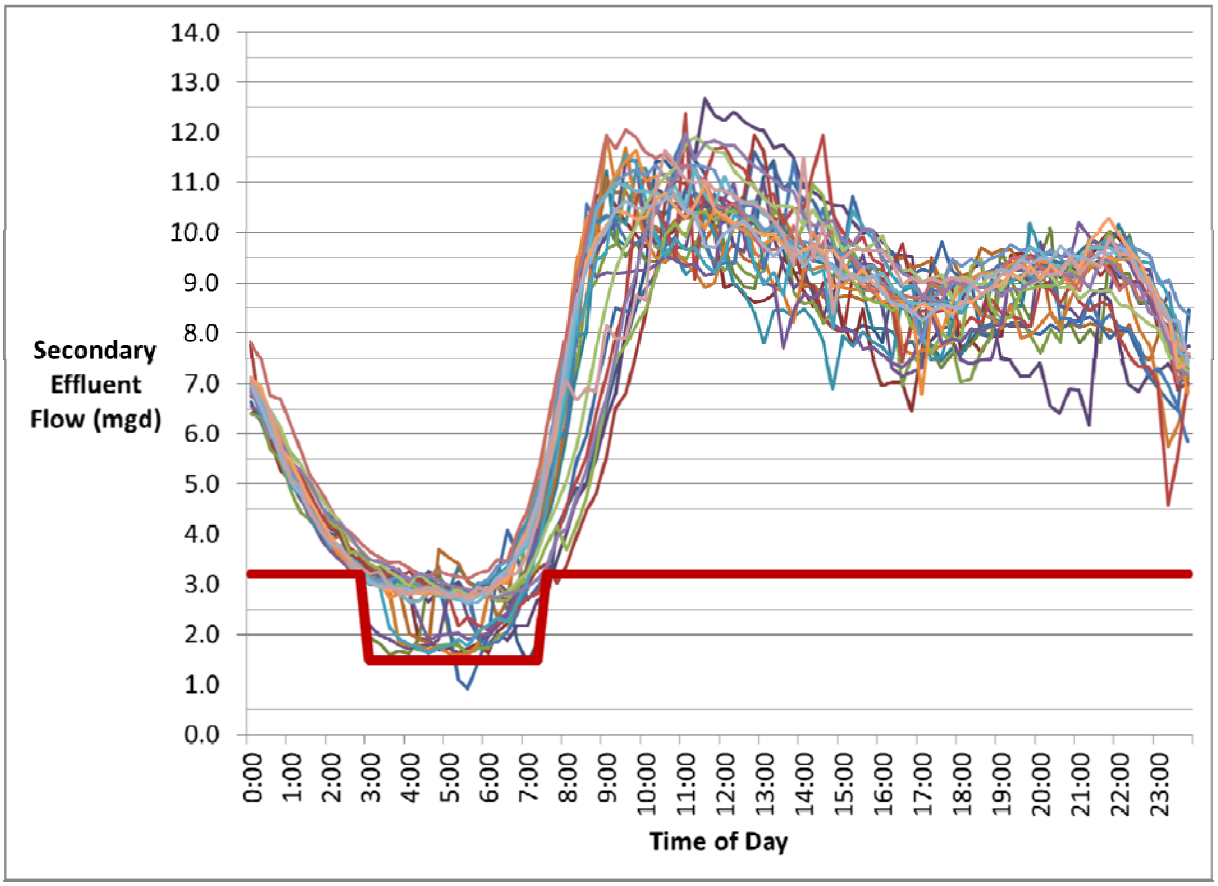

Figure 4-1: July and August Daily Secondary Effluent Flow with Design Flow Conditions in Red

As previously stated, it is important to account for the MF/UF filtrate flow and RO brine flow when sizing the system. Table 4-4 and Figure 4-2 show the design flow conditions through all portions of treatment at the different flow conditions. Using these flows, the combined CCB feed provides 2.5 mgd of recycled water for the system on a daily basis.

Table 4-4: Tertiary System Design Flowrates

	Design Flowrates (mgd)						
Time of Day	Secondary Effluent to MF	Strainer Effluent	Total MF Filtrate	RO Feed Pump Suction	RO Permeate	RO Brine	Combined CCB Feed
3:00 am to 7:30am	1.5	1.5	1.4	1.2	1.0	0.2	1.2
7:30am to 3:00 am	3.2	3.1	3.0	1.2	1.0	0.2	2.8

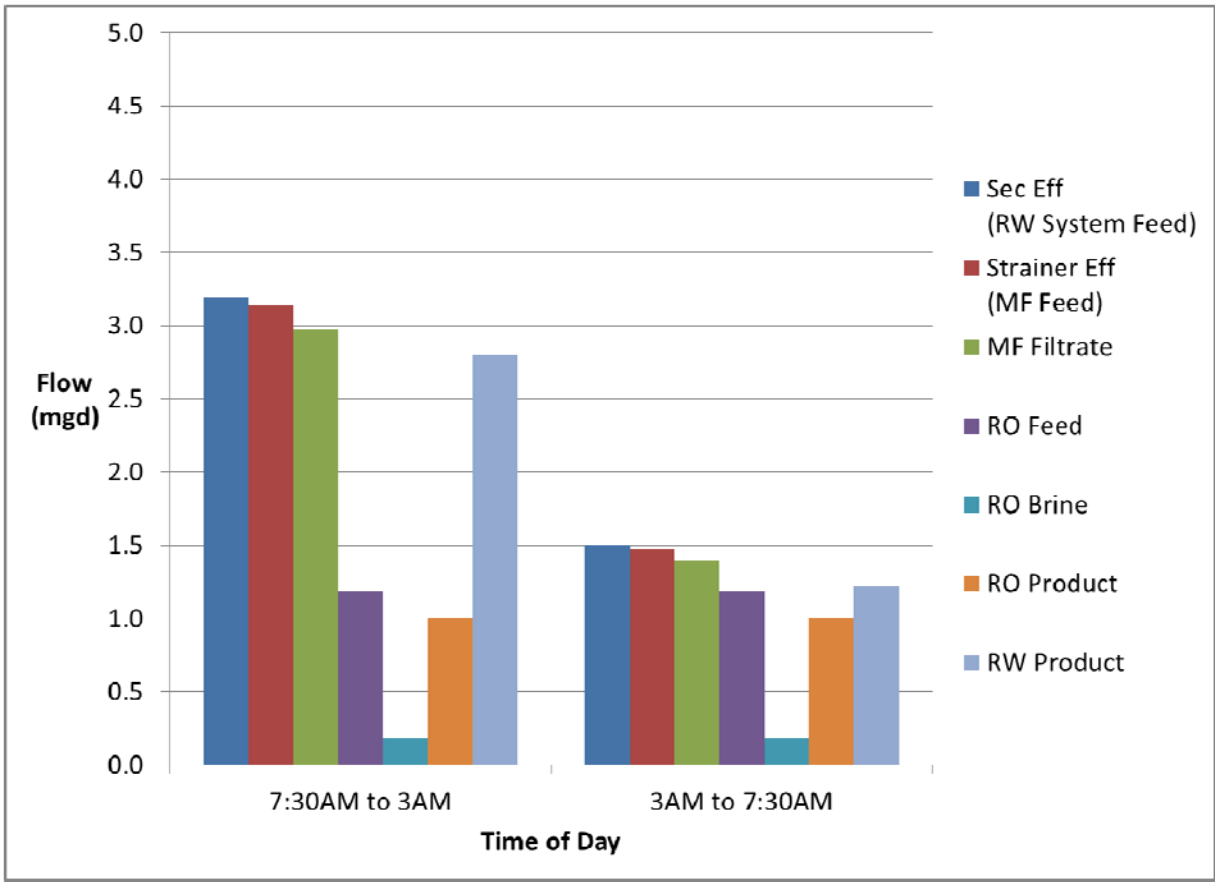

Figure 4-2: Design Flows through the Tertiary System

The MF/UF System is designed to provide an ultimate MF/UF filtrate flow of 3.0 mgd, assuming an overall minimum MF/UF system recovery of 93 percent (95 percent recovery for the MF/UF system and 98 percent recovery for the automatic strainers). This flow will be enough to allow for a RO System to treat a sidestream of the MF/UF filtrate flow to produce 1.0 mgd of RO permeate (1.2 mgd of filtrate is required, based on an RO System recovery of 85 percent). The blended MF/UF filtrate and RO permeate will provide a total recycled water treatment capacity of 2.8 mgd during high flow conditions, and 1.2 mgd during low flow conditions.

The RO System is not required to meet regulatory requirements, so the City may elect to construct only the MF/UF System and construct the RO System in the future. If the RO System is not installed at the same time as the MF/UF System, the MF/UF System may produce less filtrate because the RO brine will not be used.

The control of the MF/UF System to accommodate these flows is provided in Section 4.3.4.3. The existing recycled water storage capacity, and additional storage required to equalize the recycled water flows on-site (e.g., store recycled water produced during the day to be used at night for reuse) is discussed in Assessment Memorandum No.6.

4.3. Treatment Process Description

The AWPF consists of the following treatment components, as shown in Figure G-03B:

- MF/UF Feed Pumps
- Pre-treatment Chemical Addition (chloramination for biofouling control)
- Automatic Strainers
- MF/UF Membranes
- MF/UF Filtrate Tank
- MF/UF System Ancillary Equipment
- MF/UF Backwash System
- MF/UF CIP System
- MF/UF Compressed Air System
- Chemical Facilities

Figure G-03A shows a process flow diagram of the MF/UF system operating without a future RO system. Figure G-03B shows a process flow diagram of the MF/UF system and modified flows when the future RO System will be installed to treat a sidestream of the MF/UF filtrate.

4.3.1 MF/UF Feed Pumps

Feed water for the MF/UF System will be pumped from the secondary effluent line through the MF/UF membranes by the MF/UF feed pumps. Table 4-5 summarizes the design criteria for the MF/UF feed pump.

Table 4-5: MF/UF Feed Pump Design Criteria

Parameter	Criteria
MF/UF Feed Flow	Min = 1.6 mgd Avg = 2.9 mgd Max = 3.1 mgd
Pump Type	Horizontal end suction centrifugal
No. of Pumps	3 (2 duty, 1 standby)
Capacity per Pump	1,074 gpm
TDH	50 psi
Motor Size	50 hp
Drive	VFD

4.3.2 Pre-treatment Chemical Addition

Sodium hypochlorite will be added downstream of the MF/UF feed pumps and upstream of the automatic strainers for chloramination to control the biological fouling of the MF/UF membranes and the future RO membranes. The target combined chlorine concentration (chloramines) is 3 to 5 mg/L.

The chemicals will be flow paced based on the MF/UF feed flow rate and trimmed based on combined chlorine concentration.

Ammonium hydroxide addition is also needed for the formation of chloramines, and included as part of the secondary process improvements, as discussed in Section 4.2.1. If the secondary improvements are not complete prior to the tertiary filtration project, then the secondary treatment plant will not nitrify and the expected secondary effluent ammonia is greater than 4.5 mg/L, sufficient for the formation of chloramines. Table 4-6 summarizes the chemical dose requirements for ammonium hydroxide and sodium hypochlorite.

The design criteria for these chemical systems are described in detail in Section 4.3.6.

Table 4-6: Aqueous Ammonia and Sodium Hypochlorite Doses

Parameter	Criteria
Aqueous Ammonia Doses	
Minimum	2.5 mg/L
Average	3.0 mg/L
Maximum	4.5 mg/L
Sodium Hypochlorite Doses	
Minimum	10.0 mg/L
Average	12.0 mg/L
Maximum	18.0 mg/L

4.3.3 Automatic Strainers

The automatic strainers will be provided immediately upstream of the MF/UF membranes to protect the MF/UF membranes from damage and/or fouling due to larger particles. Automatic strainers are required to meet MF/UF membrane warranty requirements, and thus are typically provided by the membrane manufacturers as part of a complete MF/UF System package. Table 4-7 presents the design criteria for the automatic strainers.

Table 4-7: MF/UF Automatic Strainer Design Criteria

Parameter	Criteria
Type	Auto-Backwash Strainer
No. of Units	2 Duty
Capacity per Unit	1,074 gpm
Screen Pore Size, Minimum	300 microns
Strainer Recovery, Minimum	98%

4.3.4 Microfiltration/Ultrafiltration (MF/UF) System

The MF/UF System is the core process of the filtration system and will be comprised of three MF/UF trains connected in parallel to produce a high quality filtered product, or MF/UF filtrate. The secondary effluent will be chemically conditioned using chloramination and the resultant MF/UF feedwater will be pumped to the MF/UF System for removal of suspended solids. The MF/UF filtrate will then be sent to the MF/UF Filtrate Tank, from which it will overflow to the recycled water chlorine contact basin (CCB) for disinfection and distribution to recycled water users. A portion of the

MF/UF filtrate may pass through RO membranes prior to disinfection for further treatment to remove dissolved constituents for a higher recycled water quality.

This section describes the selection and sizing of the membrane system and components. Critical in this discussion are the determination of feedwater quality and the establishment of treatment goals. These parameters have been defined in Section 4.2. Once these parameters are defined, the basic building blocks of the process, the membrane elements, can be selected and the physical and operational requirements of the specific membrane installation can be determined. These requirements include: MF/UF recovery, number of trains and number membrane modules per train.

It is assumed that future expansion of the Membrane Filtration Facility will not be required. This facility is designed for the projected maximum daily recycled water demand of year 2030.

4.3.4.1 Standardized MF/UF Skid Design versus Preselection

The majority of MF and UF plants today employ proprietary systems with non-uniform element sizing, unique backwashing approaches, and irregular skid configurations, requiring that the membrane system supplier be identified and selected at the beginning of the facility design. This requirement can extend the design process and reduce competitive bidding both during the initial design and in future expansions or plant upgrades. However, the competitive bidding for this type of system can be conducted early in the design process to provide competition.

For this PDR, the proposed MF/UF System utilizes a standardized skid design, which will accommodate membranes by multiple candidate MF/UF membrane manufacturers, to promote competition when selecting the MF/UF System. By employing the standardized skid approach with MF/UF elements that are generally compatible, the elements can be replaced in the future with alternative membranes, allowing for continued competition after the initial facility is constructed. Note that the proposed system does not include all MF/UF manufacturers. Additional details on candidate MF/UF membrane manufacturers that could be considered for utilizing standardized skid design are provided in Section 4.3.4.2.

Two construction schedules are provided in Section 7. One is for the standardized MF/UF skid design and the other is using pre-selection of the MF/UF Manufacturer. The decision on how to proceed should be made based on schedule requirements.

4.3.4.2 Candidate MF/UF System Manufacturers

MF/UF vendors must provide equipment that meets the following minimum qualifications to be considered for use at the EEWWTP:

- Technology and equipment shall have been used for reuse applications in the United States at recycled water treatment facilities of 5.0 mgd capacity or greater
- Technology shall be approved by CDPH for production of tertiary filtered recycled water in accordance with the requirements of Title 22

There are several MF/UF vendors who meet these requirements. Hydranautics offers an MF membrane that provides a higher surface area than other systems; however, the membrane is relatively new and does not yet have a track record. The vendors are summarized in Table 4-8.

Table 4-8: Pressure MF/UF System Candidate Vendors

Parameter	Criteria			
Vendor	Toray	GE	Dow	Pall/Asahi [1]
Membrane Model	HFS-2020	ZeeWeed 1500	SFP-2860	Microza UNA-620A
Membrane Classification	UF	UF	UF	MF
Nominal Pore Size	0.02 µm	0.02 µm	0.03 µm	0.1 µm
Material	Polyvinylidene difluoride (PVDF)	PVDF	PVDF	PVDF
Membrane Area per Module	775 ft^2/module (72 m^2/module)	550 ft^2/module (51 m^2/module)	549 ft^2/module (51 m^2/module)	538 ft^2/module (50 m^2/module)
Flow Direction	Outside-In	Outside-In	Outside-In	Outside-In
Module Dimension – Diameter	8.5 inch	7.0 inch	8.9 inch	6.5 inch
Module Dimension – Length	85.0 inch	75 inch	73.2 inch	85.0 inch

Note:

1. While all Pall MF systems designed/installed in the US utilize Pall's proprietary skid design, Asahi Microza membranes can be utilized in standardized skid configurations.

4.3.4.3 MF/UF System Design Criteria

As stated in Section 4.2.3, the MF/UF System is designed to meet an MF/UF filtrate flow of 3 mgd during high flow periods and 1.4 mgd during low flow periods. This is to meet the daily average flow requirement of 2.5 mgd for the overall recycled water system.

Three skids will be provided for the MF/UF System, with 2 duty skids and 1 redundant skid. Table 4-9 outlines the flows to the MF/UF skids and the RO trains in the different recycled water demands. The MF/UF skids must be operating with at least two units to allow for continuous flow from the system during backwashing. If the minimum flow is less than 1 mgd, system shutdowns will occur.

Table 4-9: MF/UF System and RO System Operation at Different Recycled Water Demand Conditions

Recycled Water Demand	Flow Condition	Skid Operation
Maximum RW demand (Summer Months) – 1.64 mgd (based on Year 2011 RW demand data) to 2.44 mgd (based on Year 2030 projected RW demand data)	Early morning low secondary effluent flow conditions (secondary effluent = 1.5 mgd)	• Operate 2 MF/UF skids at ~ 1.8 mgd total • Operate 1 RO train at 0.5 mgd total • Blend ratio (MF/UF filtrate to RO permeate) is 2:1
	Mid-day max secondary effluent flow conditions (MF feed flow = 3.2 mgd)	• Operate 3 MF/UF skids at ~ 2.98 mgd total • Operate 2 RO trains at 1.0 mgd total • Blend ratio (MF/UF filtrate to RO permeate) is 1.5:1
Minimum RW Demand (Winter Months) – 0.29 mgd (based on Year 2011 RW demand data) to 0.43 mgd (based on Year 2030 projected RW demand data)	All day operating condition (RW demand and production set-point controls are tied) (secondary effluent = 1.26 mgd)	• Operate 2 MF/UF skids at ~ 1.2 mgd • Operate 1 RO train at 0.5 mgd • Blend ratio (MF/UF filtrate to RO permeate) is 1:1

The MF/UF System is configured with a pressurized outside-in configuration. The MF/UF System design criteria utilizing standardized skid design is summarized in Table 4-10.

Table 4-10: MF/UF System Design Criteria

Parameter	Criteria
MF/UF Membranes	
MF/UF Recovery, Minimum	95%
Nominal Pore Size	0.10 µm (MF); 0.02 to 0.08 µm (UF)
Material	PVDF
Type/Fiber Flow Path	Pressurized/Outside-In
Membrane Area Per Module	500 to 840 ft^2 depending on manufacturer (see Table 4-8)
MF/UF System Configuration	
No. of Duty Skids	2
No. of Redundant Skids	1
MF/UF Trains	
Production Capacity per Skid	1 mgd (667 gpm)
Average Design Flux	20 gfd (overall average)
Maximum Design Flux	25 gfd (to account for backwashing)
Maximum Instantaneous Flux with One Skid Offline for Maintenance or Recovery Cleaning	35 gfd
Required Membrane Area per Skid	48,000 sf
Required No. of Membrane Elements per Skid	62 to 96 depending on membrane area per module (see Table 4-8)
Spare Space	15%
Total No. of Membrane Space per Skid [1]	71 to 110 depending on membrane area per module (see Table 4-8)
Operating Flux	
Online factor	88%
Average Flux	20 gfd
Maximum Instantaneous Flux	23±1 gfd
Maximum Instantaneous Flux with One Train Offline	35±1 gfd
Filtration Duration	25 to 30 minutes

4.3.4.4 MF/UF System Design Flux

Since the design of secondary treatment improvements is currently underway, the secondary effluent water representative of future MF/UF feed water quality is currently not available for pilot testing. The assumptions for MF/UF feed water quality are provided in Section 4.2.2. The following conservative design flux rates were used as the basis of design:

- average flux rate of 20 gfd – flux rate based on average daily production
- maximum instantaneous flux of 25 gfd with all skids operational – higher production during normal operation to accommodate filtrate lost during backwashing
- maximum instantaneous flux of 35 gfd with one skid offline for maintenance or recovery cleaning – full design flow will be treated by two trains

These flux rates are conservative when compared to average design flux rates of 26 gfd used at the Water Replenishment District of Southern California's Leo Vander Lans Water Treatment Facility and 30 gfd used at the City of San Diego's Indirect Potable Reuse Demonstration Project Advanced Water Purification Facility.

4.3.5 MF/UF System Ancillary Equipment

The following sections describe the various ancillary systems associated with the MF/UF System.

4.3.5.1 MF/UF Backwash System

The MF/UF filtrate tank is designed to provide backwash water supply to the MF/UF system. The MF/UF filtrate flow will always be more than the RO feed flow, so equalization volume beyond the minimum storage volume required for the RO feed pump is not needed between MF and RO.

Typically, an MF/UF system that is running at a sustainable flux rate can operate with backwash and cleaning intervals that provide a target overall system recovery of greater than 95 percent (i.e., 5 percent of the total flow is used for backwash and cleanings) at a reasonable rate of transmembrane pressure (TMP) increase. Each MF/UF train is expected to backwash approximately every 20 to 30 minutes with no overlap in backwash sequences between trains. Each backwash sequence will last approximately 3.6 minutes. The MF/UF backwash system consists of the following:

- MF/UF filtrate tank to supply MF/UF backwash water
- MF/UF backwash pumps
- Compressed air system to provide process air for air scour (See Section 4.3.5.3)
- Backwash waste line to plant sewer

The MF/UF filtrate tank will provide MF/UF backwash water needed for routine MF/UF System backwash cycles. The tank will also provide the feed water for the RO feed pumps. The MF/UF filtrate tank influent and effluent configuration will differ when operating without the RO system and with the RO system as follows:

- Operating without the RO system:
  - The MF/UF filtrate will be conveyed to the MF/UF filtrate tank with residual pressure from the MF/UF system. The MF/UF filtrate tank fill line (filtrate line from MF/UF skids) will be located at the top of the tank.
  - The tank effluent line leading to the MF/UF backwash pumps will be located at the side bottom side of the tank to provide flooded suction even when the tank is not a full level (during MF backwash).
  - The MF/UF filtrate will overflow out of the tank and flow by gravity to the chlorine contact basin. With this configuration, providing MF/UF filtrate to the MF/UF backwash pumps will have higher priority than sending the water to the chlorine contact basin. Also, by overflowing out of the MF/UF filtrate tank, the line going to the recycled water CCB will have a relatively constant head.
- Operating with the RO system:

- The MF/UF filtrate will be conveyed to the MF/UF filtrate tank with residual pressure from the MF/UF system. The MF/UF filtrate tank fill line (filtrate line from MF/UF skids) will be located at the side bottom of the tank. Another tank fill line will be located at the top of the tank, and RO permeate will overflow out of the RO Flush Tank into the Mf/UF filtrate tank from the top of the tank.

- The RO feed pump suction line will be teed off of the MF/UF filtrate tank fill line. When the MF/UF skids are in filtration mode, the MF/UF filtrate will feed RO feed pump suction and remaining flow will fill the filtrate tank. When MF/UF filtrate flow is less than the RO feed flow (e.g., when only one MF/UF skid is in operation and it goes into backwash) MF/UF filtrate tank will provide feed water to the RO feed pump suction.

- The blend of MF/UF filtrate and RO permeate water will overflow out of the tank and flow by gravity to the chlorine contact basin. With this configuration, providing flow to the RO feed pumps and MF/UF backwash pumps will have higher priority than sending the water to the chlorine contact basin. Also, by overflowing out of the MF/UF filtrate tank, the line going to the recycled water CCB will have a relatively constant head.

Table 4-11 presents the MF/UF filtrate tank design criteria.

Table 4-11: MF/UF Filtrate Tank Design Criteria

Parameter	Criteria
No. of Tanks	1
Nominal Tank Volume	12,000 gal
Diameter	12 ft
Straight Sideshell Height	16.5 ft
Residence Time at Design Flow	5.8 minutes
Type of Tank	HDPE
Tank Color	Black

The MF/UF backwash pumps will be horizontal end suction or vertical in-line centrifugal pumps. Table 4-12 presents the MF/UF backwash pump design criteria.

Table 4-12: MF/UF Backwash Pump Design Criteria

Parameter	Criteria
Pump Type	Horizontal end suction or vertical in-line centrifugal
No. of Pumps	2 (1 duty, 1 standby)
Required Capacity per Pump	1,600 gpm (MF); 1,000 gpm (UF)
TDH	50 psi
Motor Size	50 hp
Drive	Variable speed

Backwash waste from the MF/UF system will be sent to the nearby 42-inch interceptor, and routed to the EEWWTP headworks.

The backwash waste from the MF/UF system cannot be sent direct to the outfall because it would likely violate the NPDES permit limits, especially during low flow periods. The MF/UF system is

designed for an overall recovery of 95% recovery. It is assumed that the secondary effluent will have a maximum of 10 mg/L TSS after the improvements. It is also assumed that all the TSS is removed by the MF/UF system, and therefore will be in the backwash waste. Assuming 10 mg/L TSS in the secondary effluent, the backwash waste from the MF/UF system will have 200 mg/L. During low flow periods, nearly all of the secondary effluent will be used for the recycled water system. Therefore, the backwash waste cannot be sent directly to the outfall since it would violate the outfall permit.

The MF/UF backwash flow rate is metered on the backwash supply side. Sample taps could be provided on above grade MF/UF backwash waste pipe. However, the grab samples of MF/UF backwash waste may not be representative of the total composite flow.

4.3.5.2 MF/UF CIP System

Membrane fouling, the accumulation of contaminates on the surface of the membrane material, can significantly impact the operation of a membrane process. When a membrane becomes fouled, operation is compromised due to decreased membrane porosity, decreased hydraulic diameter, and increased effective thickness. In order to prevent fouling, two types of chemical cleaning regimens are typically performed for MF/UF Systems: (1) chemically enhanced backwashes (CEBs) to maintain the day by day membrane permeability, and (2) chemical clean-in-place (CIP) to restore the membrane permeability between phases or when the TMP reaches the terminal value (approximately 35 psi).

CEBs are preventive cleans performed in place at specified regular intervals to maintain the permeability of the membrane at an acceptable level. Typically, CEBs occur once every 1 to 7 days. During these types of cleanings, the membranes will be exposed to chemicals such as sodium hypochlorite, citric acid, and sodium hydroxide for a short period of time (<15 minutes). Other chemicals, including strong acids, may be used depending on the supplier's membrane chemical compatibility and foulants of concern. Chemical concentrations will depend on the severity of the organic or inorganic membrane fouling. Before resuming production, chemical residuals must be flushed out from the membrane modules. Typically, the equipment supplier is responsible for providing input for the optimization of the CEB cleaning regimen. CEBs are automated and can be operator initiated or on a time schedule without operator supervision. Projected staffing requirements are provided in Section 4.6.

CIP cleans are an intensive chemical cleaning used to restore the membrane permeability to pre-fouled conditions. This intensive cleaning are typically performed roughly once every 30 days (40 days maximum) as needed, although longer cleaning intervals may be used if reliable operation is maintained. The chemicals used for recovery cleanings will depend on the severity of the organic or inorganic membrane fouling, and can include sodium hypochlorite, sodium hydroxide, and citric acid or other comparable acids. This cleaning is performed in place, requires a significant soaking or recirculation time (>4 hours), and typically uses higher chemical concentrations than CEBs. CIPs are operator initiated and require operator supervision. Projected staffing requirements are provided in Section 4.6.

The CIP system consists of the following components:

- CEB tank
- CIP tank (to be shared with future RO system)
- CEB/CIP pumps

- Sodium hypochlorite storage and feed system
- Citric acid storage and feed system
- Sodium hydroxide storage and feed system

The CEB and CIP tanks are sized for the MF/UF System is based on an assumption of three volumes required to clean a skid, one volume for the batch chemical solution and two volumes for rinse cycles. The CIP tank is also sized for RO CIP. Table 4-13 presents the CEB and CIP tanks design criteria.

Table 4-13: CEB and CIP Tank Design Criteria

Parameter	Criteria
No. of Tanks	2 (2 duty, 0 standby)
Tank Sizing Requirements	
Required Capacity for MF/UF CIP	1,700 gal (MF); 3,200 gal (UF)
Tank Sizing Calculations	
Required CIP Tank Usable Volume	3,200 gal
Diameter	7 ft
Required Sideshell height	12.5 ft
Required Nominal Tank Volume	3,500 gal
Type of Tank	FRP

The MF/UF CEB/CIP pumps will be horizontal end suction or vertical in-line centrifugal pumps. These common pumps will be shared for both the CEBs and CIPs. Table 4-14 presents the MF/UF CEB/CIP pump design criteria.

Table 4-14: MF/UF CEB/CIP Pump Design Criteria

Parameter	Criteria
Pump Type	Horizontal end suction or vertical in-line centrifugal
No. of Pumps	2 (1 duty, 1 standby)
Required Capacity per Pump	720 gpm (MF); 1,000 gpm (UF)
TDH	50 psi
Motor Size	25 hp (MF); 40 hp (UF)
Drive	Constant speed

CEB and CIP waste from the MF/UF system will be neutralized in the corresponding tanks and then sent to the nearby 42-inch interceptor, and routed to the EEWWTP headworks.

4.3.5.3 MF/UF Compressed Air System

The MF/UF System requires process low pressure air for air scour during membrane backwash, low pressure air for membrane integrity testing, and high pressure control air for the control of automatic control valves that utilize pneumatic actuators. The compressed air system for the MF/UF System will be sized with extra capacity to provide control air for automatic control valves for the future RO System. Table 4-15 presents the compressed air system design criteria.

Table 4-15: Compressed Air System Design Criteria

Parameter	Criteria
No. of Air Compressors	2 (1 duty, 1 standby)
Required Capacity per Air Compressor	TBD
Motor Size	25 hp
No. of Air Receiver Tanks	1 (1 duty, 0 standby)
Required Capacity per Tank	TBD

4.3.6 Chemical Facilities

The chemical systems consist of the following:

- Sodium hypochlorite for chloramination and CIP
- Citric acid for CIP
- Sodium hydroxide for CIP

The primary purpose of chloramination is to prevent biological fouling of the membranes, both to the MF/UF and RO Systems. Chloramines are a disinfectant that will achieve this goal. Free chlorine could also prevent biological fouling, but the RO membrane material cannot tolerate free chlorine, so free chlorine cannot be used. Therefore, chloramination, which is a combination of ammonia and chlorine, will be used for disinfection. These chemical systems are described in detail below.

The recovery clean of the MF/UF membranes is achieved with the following cleans:

- Sodium Hypochlorite, or Sodium Hypochlorite plus Caustic Soda Clean
- Citric Acid Clean

Citric Acid and Sodium Hypochlorite system will be used for RO CIP as well.

4.3.6.1 Aqueous Ammonia

As stated in Section 4.2.1, aqueous ammonia will be added to the secondary effluent line upstream of the MF/UF feed pumps as part of the secondary improvements project. If the secondary improvements project is not complete prior to the tertiary filtration project, the plant will continue to have residual ammonia in the secondary effluent that will be used for chloramine formation.

4.3.6.2 Sodium Hypochlorite

Sodium hypochlorite will be added upstream of the MF/UF feed pumps for chloramination to control the biological fouling of the MF/UF membranes. The chemical will be flow paced based on the MF/UF feed flow rate, and combined chlorine residual or ORP will be monitored to alarm when the measured levels are outside of acceptable range. In addition, sodium hypochlorite will also be used for CIP on an as-needed basis.

Table 4-16 presents the design criteria for the sodium hypochlorite storage and feed system. There are three existing sodium hypochlorite storage tanks in the bulk chemical storage area. Two of three tanks are currently in use. The third tank, which is currently not connected to the system, will be connected as part of this project, and the three tanks will be used in conjunction to provide storage

sodium hypochlorite use for effluent disinfection, recycled water disinfection, MF/UF feed chloramination and MF/UF membranes cleaning.

Furthermore, as discussed in Section 4.3.8 below, programming changes will be considered to automate the sodium hypochlorite addition for chlorination and sodium bisulfite addition for dechlorination of the plant effluent to ocean outfall.

Table 4-16: Sodium Hypochlorite Storage and Feed System Design Criteria

Parameter	Criteria
Demand (MF/UF Feed)	
Dose, Minimum	10 mg/L
Dose, Average	12 mg/L
Dose, Maximum	18 mg/L
Storage	
No. of Tanks	3 (existing)
Volume, Each	7,500 gal
Type of Tank	HDPE
Days of Storage, Average Dose	30
Pumps	
No. of Pumps	2 (1 duty, 1 standby)
Pump Type	Diaphragm metering
Flow Range	2.9 to 15.9 gph
Pump Capacity	16.9 gph

4.3.6.3 Citric Acid

Citric acid will be used for the cleaning of the MF/UF membranes. The cleaning requirements are specific to each membrane system vendor. The design of the citric acid system will include either storage drums or totes with a diaphragm metering pump. Although citric acid can be supplied as a dry chemical or as a 20 to 50 percent solution, the MF/UF system is designed around a liquid system for ease of operation. If dry chemical is preferred, the MF/UF filtrate or RO permeate can be used for batching of the citric acid onsite.

4.3.6.4 Sodium Hydroxide

Sodium hydroxide will be used for the cleaning of the MF/UF membranes and neutralization of CIP waste. The cleaning requirements are specific to each membrane system vendor. The design of the sodium hydroxide system will include either storage drums or totes with a diaphragm metering pump. Sodium hydroxide is typically supplied as a 25 to 50 percent solution. A 50 percent sodium hydroxide solution has a relatively high freezing point and must be stored and utilized at temperatures above approximately 55 degrees Fahrenheit, or the storage and handling equipment must be insulated and heat traced. To avoid the need for insulation and heat tracing, use of a 25 percent solution is recommended. The freezing point of the 25 percent solution is -13.9 degrees Fahrenheit.

4.3.7 Process Piping and Valves

The process piping and valves for the MF/UF system will be as shown in Table 4-17:

Table 4-17: Piping and Valves Design Criteria

Parameter	Material	Pressure Rating
Process Piping Upstream of Automatic Strainers	Cement Mortar Lined Ductile Iron or Epoxy Lined Carbon Steel	150 psi
Process Piping Downstream of Automatic Strainers	PVC	150 psi
Process Piping for MF/UF Filtrate	PVC	150 psi
CIP Piping	PVC	150 psi
Sodium Hypochlorite	PVC Schedule 80	150 psi
Citric Acid	PVC Schedule 80	150 psi
Sodium Hydroxide	PVC Schedule 80	150 psi

Process valves will have cast iron bodies, rated for 150 psi. Valves for chemical systems will have PVC bodies, rated for 150 psi.

4.3.8 Miscellaneous Improvements

When the MF/UF system is operated to maximize the recycle water production for reuse, as described in Section 4.3.4.3, there may be times in the early morning hours when all secondary effluent flows will be treated by the MF/UF system, and the secondary effluent flows to Chlorine Contact Tank (CCT) for ocean outfall discharge will be temporarily stopped. To mitigate impacts to the plant effluent chlorination and dechlorination chemical feed systems under these low flow conditions, addition of flow meters on the 48-inch secondary effluent pipe and the 48-inch ocean outfall pipe will be considered during the final design. The CCT influent flow signal will be used for flow pacing the sodium hypochlorite addition for chlorination, and the CCT effluent flow signal will be used for flow pacing the sodium bisulfite addition for dechlorination.

4.4 Membrane Filtration Facility Layout Considerations

The majority of the equipment associated with the MF/UF System, including the MF/UF skids, will be located in the footprint of the existing tertiary filters. It will be necessary to demolish the existing filters in order to install the new MF/UF System. Therefore, during construction of the MF/UF System, the recycled water supply will be from potable water.

4.4.1 Process Connections

The various process headers on the MF/UF skid connect to risers that terminate at the top of the skid. The piping required to convey flows to and from the MF/UF skid connect to these risers.

4.4.2 Preliminary Layout

The MF/UF feed pumps, automatic strainers, MF/UF skids, MF/UF filtrate tank and backwash pumps, CEB and CIP tanks and CEB/CIP pumps, and chemical storage facilities will be located outside in the footprint of the existing tertiary filters. Figure M-01A shows a preliminary layout of the MF System.

The MF/UF system layout shows standardized MF skids with 100-modules, which accommodates Toray, GE, Dow, and Pall/Asahi systems.

4.5 System Reliability and Redundancy

The MF/UF System includes a redundant feed pump, a redundant automatic strainer, and a redundant membrane skid to allow equipment and components to be taken out of service for maintenance or

cleaning while still maintaining the ability to produce recycled water at full design capacity. Instrumentation will be provided to protect equipment from damage by shutting down the system when certain conditions, such as high pump discharge pressure, or high transmembrane pressure, occur.

Unlike the main treatment plant processes, the tertiary filtration system is not required to remain online during a power outage as loss of recycled water service does not constitute a public health risk. In addition, recycled water customers can be served with potable water if necessary. Therefore, it is not necessary to connect the MF/UF System to the plant backup power supply.

If the MF/UF System went without power for an extended period of time, the following should be provided.

If the shutdown is shorter than two weeks, the MF/UF membranes should be flushed to sit idle.

If the shutdown is longer than two weeks, the MF/UF membranes should be pickled.

A discussion on temporary power for the MF/UF System is provided in Section 5.

The pipes and equipment are generally designed for a 20-year life. However, the MF/UF membranes typically last five to seven years before requiring replacement. Generally, replacement is required when the production capacities are reduced or membrane recovery cleanings are required more frequently than planned.

4.6 Impacts to Operations and Maintenance Staff Requirements of Proposed Membrane Filtration Facility

In general, the operator time required for daily operation of the MF/UF system will be less than that for the existing filters since the MF/UF system is a more automated and robust treatment system that could handle a wider range of feed water quality than the existing filter system, while reliably producing the desired filtrate water quality. The MF/UF system does not rely on chemical pretreatment to enhance filtration, which will reduce the time and attention required by operators to react to changes in secondary effluent quality. The system will also be programmed to respond automatically to variations in feed flows. Therefore, it will be much less likely that the operators would need to respond to short-term variations in feed flows or feed water quality when operating the MF/UF system, although they would need to be trained to monitor and evaluate the long-term trending of the membrane permeability and other operating parameters to schedule chemical cleanings and plan for membrane replacements.

The staff requirement for equipment maintenance of the MF/UF system will be more than for the existing filters, mainly due to a higher number of pneumatic valves in the MF/UF system and a higher reliance on automation. The individual membrane filters, each containing thousands of membrane fibers, are also more complex than the existing media filters, requiring time and attention to pin broken fibers, replace faulty seal, and investigate integrity failures. Additional training time will be required, as the MF/UF system is a new treatment process for the existing staff and may require a higher degree of training for reliable maintenance.

The impacts to O&M staff requirements for the proposed Membrane Filtration Facility are summarized in Table 4-18.

Table 4-18: Operations and Maintenance Staff Requirements for Membrane Filtration Facility

Activities	Existing Filter System	MF/UF System
Daily Operations		
Normal Operation	Operator needs to respond quickly to variations in feed flows and feed water quality, upsets in coagulant feed, and upsets in filtrate water quality.	Operation is fully automated. Operator response to short-term variations in feed flows and feed water quality is minimal. Operator needs to monitor long-term trending of membrane permeability to plan for membrane cleaning and long-term replacement.
Chemical Cleanings	Not applicable.	Daily CEBs are fully automated, can be initiated on a timer, and do not require operator presence. Monthly CIPs are fully automated as well. However, CIPs are operator initiated and operator presence is highly recommended.
Membrane Fiber Breakage/Pinning	Not applicable.	Operator will be required to pin broken membrane fibers in the event that integrity failures occur. Frequency of membrane fiber breakage varies for all membrane plants (zero to 10 fibers per week is typical).
Filter Media or Membrane Replacement	Filter media replacement as needed.	Membrane replacement typically required once every 5 to 10 years.
Equipment Maintenance	Feed pumps, backwash air blowers, air compressors, coagulant feed system, and valves require routine maintenance.	Feed pumps, automatic strainers, backwash pumps, CIP pumps, CIP tanks and heaters, air compressors, chemical feed systems, and valves require routine maintenance. MF/UF system includes many pneumatic valves on the MF/UF skids that require maintenance.
Training	Periodic training recommended, particularly for new employees.	MF/UF system requires additional operator training. Training is important to familiarize the operators with understanding MF/UF system performance parameters, such as membrane permeability, that would help determine longevity of the membranes and efficiency of operation. Training is also important as proper operation of the MF/UF system will impact performance of the downstream RO system (future).
Summary	--	**Operator time for daily operation of MF/UF system will be less than that for the existing filters.** **Staff requirement for equipment maintenance will be more than that for the existing filters mainly due to higher number of pneumatic valves, instruments, and filter elements in the MF/UF system.** **Training time will be required as MF/UF system is a new treatment process for the existing staff.**

Appendix B-2: AM No.2 Recycled Water System Study

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In association with

Memorandum

To: *Rebecca Bjork, City of Santa Barbara*

From: *Jamie Harlan, MNS Engineers*
Don Cutler, CDM Smith
Evelyn You, CDM Smith

Date: *February 19, 2013*

Subject: *Assessment Memorandum (AM) No. 2 – Recycled Water System Study*

Purpose and Background

The purpose of this assessment memorandum (AM) is to evaluate key existing and future recycled water system characteristics at the City of Santa Barbara's El Estero Wastewater Treatment Plant (EEWWTP) and to develop a design basis for process flow rates and treatment requirements to be considered in the development of improvements to the recycled water system. The information presented herein includes an evaluation of the existing and future recycled water demands, recycled water production capacities, and existing recycled water quality goals.

Recycled Water System Overview

Construction of EEWWTP, located at 520 East Yanonali Street, Santa Barbara, CA 93103, was completed in 1979, including secondary treatment processes. EEWWTP was upgraded with the addition of a tertiary treatment processes and water reclamation facility in 1991. The Santa Barbara Water Recycled Water System was developed in two phases. Phase I construction, completed in July of 1989, included the recycled water treatment facilities, plant storage, plant pumping facilities, and approximately 5.2 miles of pipeline. Phase II construction, completed in May 1991, included the remainder of the pipeline, a large storage tank under the municipal golf course, a booster pump station, and a pump station at the storage tank.

Recycled water is produced by taking effluent that has already undergone primary and secondary treatment and directing it through tertiary filters. After tertiary filtration and disinfection, the recycled water can be used for many reuse purposes. Appropriate uses for the City's recycled water include irrigation, supply for impoundment (lakes/ponds), supply for cooling or air conditioning, and other uses. Some examples of other uses include, but are not limited to, toilet flushing, industrial process water, mixing concrete, and dust control on roads. By using recycled water for these tasks, potable water supplies may be maximized.

Facilities

The recycled water production and distribution system facilities are described in AM6 – Recycled Water System Hydraulic Analysis.

Recycled Water Regulations

The City of Santa Barbara adheres to the California Code of Regulations' Recycled Water guidelines (Titles 17 and 22) for its Recycled Water Program. The City's recycled water system is also operated and managed according to the Regional Water Quality Control Board Order No. 97-44, Master Reclamation Permit for the City of Santa Barbara, Producer/User and Primary Producer/User of Recycled Water. The NPDES Permit for El Estero Wastewater Treatment Plant Waste Discharge Requirements for the City of Santa Barbara El Estero Wastewater Treatment Facility was adopted by the Regional Water Quality Control Board and became effective on May 13, 2010.

Table 1 summarizes the recycled water regulations that currently influence and control the operations of EEWWTP.

Table 1 Recycled Water Regulations Applicable to EEWWTP

Entity	Regulations	
California Department of Public Health	Title 17 Division 1	State Department of Health Services, Chapter 5. Sanitation (Environmental)
	Title 22 Division 4	Environmental Health
	Health and Safety Code Division 6	Sanitary Districts
	Water Code Division 6	Conservation, Development, and Utilization of State Water Resources
	Water Code Division 7	Water Quality
Regional Water Quality Control Board	Order No. 97-44	General Permit Master Reclamation Permit for the City of Santa Barbara
	Order No. R3-2010-0011 NPDES No. CA0048143	NPDES Permit for El Estero Wastewater Treatment Plant Waste Discharge Requirements for the City of Santa Barbara El Estero Wastewater Treatment Facility
California Recycled Water Policy	Resolution No. 2009-0011	Adoption of a Policy for Water Quality Control for Recycled Water
State Water Resources Control Board	Order No. 2009-0006-DWQ	General Waste Discharge Requirements for Landscape Irrigation Uses of Municipal Recycled Water
City of Santa Barbara	Recycled Water Program and Policies	See Policy Statement

The City of Santa Barbara Recycled Water Program and Policies are as follows:

"California Water Law (Title 22) regulates recycled water use. The law states that the following uses are approved for tertiary treated recycled water (City's recycled water):

Irrigation of: food crops, orchards, all landscaping (residential, commercial and public), and pasture for animals.

Supply for impoundment (lakes/ponds): nonrestricted recreational impoundments (swimming allowed), fish hatcheries, and landscape impoundments.

Supply for cooling or air conditioning: industrial or commercial cooling or air conditioning with cooling tower, evaporative condenser, or spraying that creates a mist

Other uses: flushing toilets and urinals, priming drain traps, industrial process water that may contact workers, structural and nonstructural fire fighting, decorative fountains, commercial laundries, consolidation of backfill material around potable water pipelines, artificial snow making, industrial boiler feed, soil compaction, mixing concrete, dust control on roads and streets, flushing sanitary sewers, and cleaning roads, sidewalks and outdoor work areas.

The City's policy (and State law) is to require recycled water for irrigation for: multiple family developments, developments with common area irrigated lots, and commercial developments that are adjacent to the recycled water main line. (City Municipal Code 14.23.010-14.23.030.) The City's policy is to encourage but not require all other uses. Single family residential parcels adjacent to the recycled water main line are not required but are encouraged to use recycled water on their sites.

There are plan specifications that must be followed for recycled water, a user agreement that must be recorded and other review requirements that all sites must go through before the recycled water meter is issued."

California's Recycled Water Policy may have an effect on EEWWTP and its future operations. Table 2 summarizes the various elements of the State Recycled Water Policy.

Table 2 State Recycled Water Policy Requirements Applicable to EEWWTP

Entity	Regulations	Requirements
State Recycled Water Policy	Mandate for the Use of Recycled Water	The State Water Board has mandated that the state will have an increase the use of recycled water in California by 200,000 AFY by the year 2020 and by an additional 300,000 AFY by 2030.
	Salt/Nutrient Management Plans	It is the state's goal to have a salt/nutrient management plan for all groundwater basin/sub-basin in the state.
	Landscape Irrigation Projects	The goals of this section are to control incidental runoff and to streamline the permitting process for recycled water projects. This streamlining process will be accomplished by creating consistent criteria.
	Recycled Water Groundwater Recharge Projects	This is a potential use for recycled water that would be examined on a site specific basis and would vary project to project.
	Anti-degradation	The goal of this section is to ensure that the state waterways are regulated to obtain optimum water quality.
	Emerging Constituents/Chemicals of Emerging Concern	This policy results in the research and examination of CECs. The state hopes to research and develop analytical methods to determine potential environmental and public health impacts of CECs.
	Incentives for the Use of Recycled Water	Funding – The State Water Board has a goal of providing funding for the salt/nutrient management plans, recycled water projects, and stormwater recharge projects. Stormwater – The Board strongly encourages water purveyors to provide financial incentives for water recycling and stormwater recharge and reuse projects as well as encouraging the Regional Water Boards to require less stringent monitoring and regulatory requirements for stormwater treatment and use projects than for projects involving untreated stormwater discharges. TMDLs – The Regional Water Boards will assign waste load allocations in such a way that gives an incentive for more water recycling.

Existing and Future Recycled Water Demands

According to the City's 2011 Long Term Water Supply Plan, the City's recycled water system has the capacity to treat and deliver 1,400 AFY of recycled water. The EEWWTP process water usage is approximately 300 AFY, and the current connected recycled demand from sales to customers is approximately 800 AFY, which leaves approximately 300 AFY of capacity for new recycled water customers.

The historical recycled water demand data is presented in Table 3.

Table 3 Historical Recycled Water Demand

Average Annual Demand	2003	2004	2005	2006	2007	2011	Average Peaking Factor
Total Annual Demands (AFY)	702	824	710	656	846	942	
Average Day Demand (mgd)	0.63	0.74	0.63	0.59	0.76	0.84	
Month with Minimum Demand	Jan	Mar	Mar	Apr	Jan	Feb	
Minimum Month (acre-feet)	8.9	17.2	5.9	7.6	25.7	35.8	
Minimum Month (mgd)	0.10	0.19	0.06	0.08	0.28	0.42	
Minimum Month Peaking Factor	0.1	0.2	0.1	0.1	0.3	0.5	0.25
Month with Maximum Demand	Sept	Aug	Jul	Jul	Aug	May	
Maximum Month (acre-feet)	131	123	117	117	127	131	
Maximum Month (mgd)	1.43	1.33	1.27	1.27	1.38	1.38	
Maximum Month Peaking Factor	2.2	1.8	2.0	2.1	1.8	1.6	1.95

According to the 2011 Recycled Water Use data, EEWWTP usage of total recycled water (reclaimed water plus potable water blend) was approximately 942 Acre Feet per Year (AFY) for the 2011 calendar year. The monthly distribution of the recycled water demand for year 2011 is shown in Figure 1. The monthly recycled water demand peaking factors, based on year 2011 data, are shown in Figure 2.

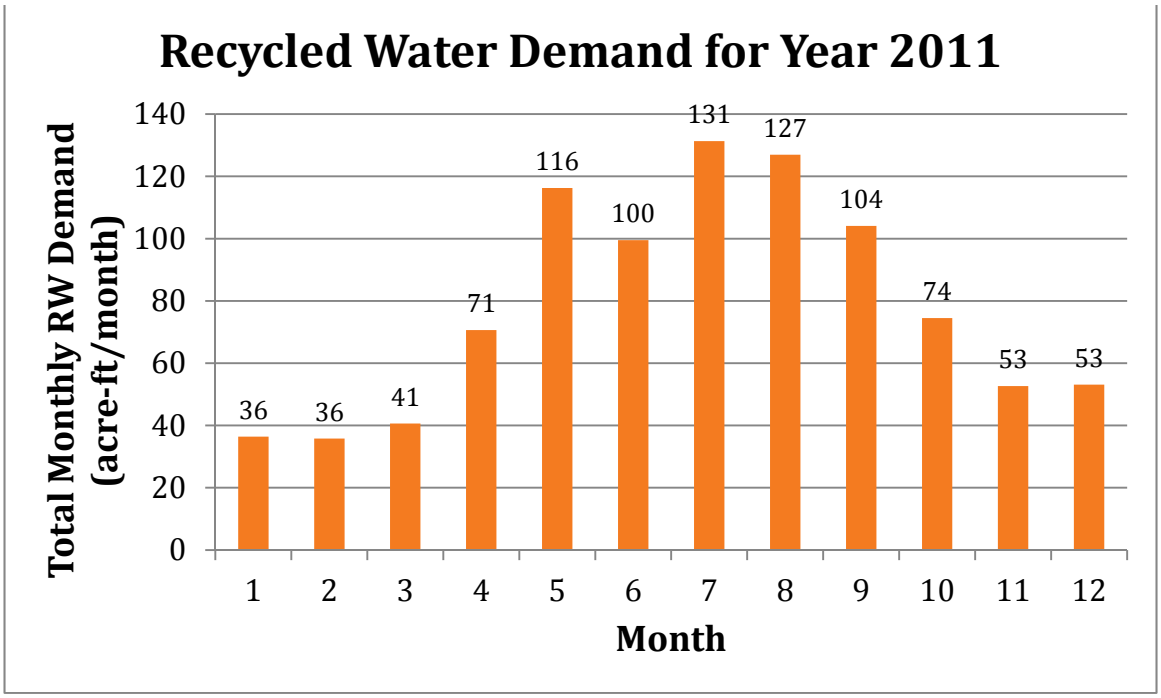

Figure 1
Monthly Recycled Water Demand for Year 2011

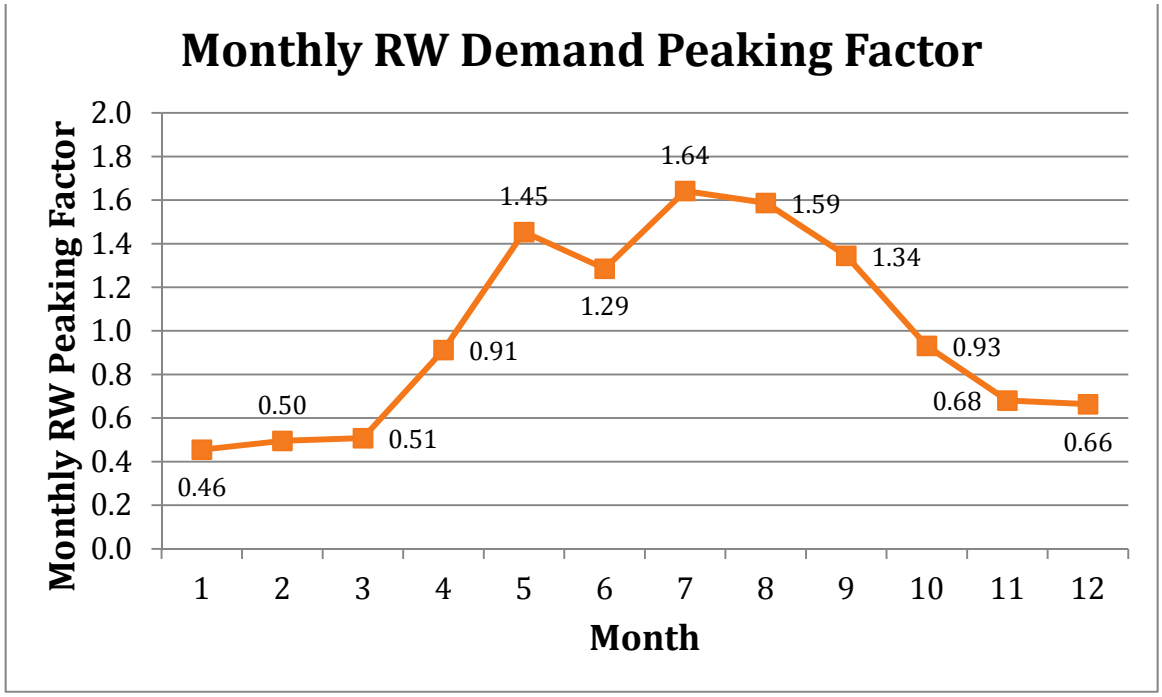

Figure 2
Monthly Recycled Water Demand Peaking Factor Based on 2011 Data

Table 3 shows the actual and projected recycled water sales.

Table 3 Actual and Projected Recycled Water Demand

Average Annual Demand	Actual 2005	Actual 2010	Actual 2011	Projected 2015	Projected 2020	Projected 2025	Projected 2030
EEWWTP Usage for Process Water (AFY) [1]	300	300	300	300	300	300	300
Connected Recycled Water Customers							
# of Accounts	76	84	N/A	99	114	129	144
Usage (AFY)	718	697	642	875	950	1,025	1,100
Total Recycled Water Demand (AFY)	1,020	997	942	1,180	1,250	1,330	1,400

Notes:

1. Estimated Value

Existing Recycled Water Users

Currently recycled water produced by EEWWTP serves over 400 acres of landscaped areas. These areas include golf courses, parks, schools, and the zoo. The list of the current metered recycled water users can be found in Attachment A.

Potential New Recycled Water Users

It is the City's policy to require recycled water for irrigation purposes for properties situated along the main recycled water lines. These properties include multiple family developments, developments with common area irrigated lots, and commercial developments (City Municipal Code 14.23.010-14.23.030.) It is also the City's policy to encourage users who are not required to utilize recycled water to do so.

The potential new recycled water users located adjacent to existing recycled water distribution pipelines are summarized in Table 4. The City has recently reached out to the Santa Barbara Cemetery and the 23-acre Clark Estate, both situated along East Cabrillo Boulevard.

Table 4 Potential New Users – Pipeline Adjacent

Potential User	Address
City of Santa Barbara Cemetery	901 Channel Drive
Clark Estate	Situated Adjacent to the Above
Harbor View Inn	22 W. Cabrillo Blvd.
The Armory	700 E Canon Perdido
Mission Terrace Convalescent	623 Junipero St.
Santa Barbara Community College	Restroom Facilities
West Beach Inn	306 West Cabrillo Boulevard
Best Western Beachside Inn	336 West Cabrillo Boulevard
Santa Barbara Convalescent Hospital	2225 De La Vina Street

In addition to adding new recycled water users, there is also the potential to increase quantities of recycled water used by current customers. The City would need to identify these customers based on any requests or wishes for additional supply from the recycled water customers.

Another area for possible recycled water expansion is industrial use. Currently, the City's recycled water is distributed primarily for irrigation purposes. However, there is a potential for growth in use for businesses such as car washes and laundries in the area.

Lastly, if there is enough capacity, there is always the possibility for expansion of the recycled water distribution system. Table 5 shows potential areas for expansion in Phase I and Phase II, and possible customers situated near the proposed expansion pipelines. These areas include parks, schools, office complexes, and housing. Any system expansion would need further analysis including a system model.

Table 5 Potential Areas for Recycled Water Expansion

Area	Proposed Expansion Pipeline	Potential New Customers
Phase I	State Street or Santa Barbara Street	Plaza De Vera Cruz
		Anacapa School
		Sunken Gardens
		City and County Offices
		Alameda Park
		Alice Keck Park Gardens
		Santa Barbara Public Library
		Santa Barbara Assisted Living
Phase II	Meigs Road / Carillo St.	Arroyo Hondo Park
		Hilda McIntyre Ray Park
	San Roque Road	San Roque Park
		Stevens Park
	State Street	Rocky Nook Park
		Santa Barbara Museum of Natural History
		San Roque High School
		Several Hotels Along Upper State Street

Required Recycled Water Production Capacity

According to the City's 2011 Long Term Water Supply Plan, the recycled water system as it is currently configured has the capacity to treat and deliver approximately 1,400 acre feet per year (AFY) of recycled water. Current demand is 800 AFY plus 300 AFY of onsite process water used at EEWWTP, which leaves 300 AFY additional capacity for addition of future recycled water customers. To achieve the goals set forth in the City's 2011 Long Term Water Supply Plan and the Urban Water Management Plan, use of 1,400 AFY is the goal in this study.

Applying the peaking factors shown in Figure 2, the projected monthly recycled water demand for years 2015, 2020, 2025 and 2030 are summarized in Table 6. Also applying the minimum month peaking factor of 0.25 and maximum month peaking factor of 1.95, based on the historical recycled water demand data (See Table 3), the minimum and maximum month recycled demands are also projected. As shown in Table 6, the minimum month recycled water demand could be as low as 0.26 mgd (Year 2015) and the maximum month demand could be as high as 2.44 mgd (Year 2030). Based on this information, and considering the City's goal of minimizing potable water blending, the recycled water treatment system at EEWWTP will be sized for 2.5 mgd capacity.

Table 6 Historical Recycled Water Demand

Recycled Water Demand	Monthly Peaking Factor	2011	2015	2020	2025	2030
Average Annual Demand (AFY)		942	1180	1250	1330	1400
Average Annual Demand (mgd)		0.84	1.05	1.12	1.19	1.25
January	0.46	0.39	0.48	0.51	0.55	0.57
February	0.5	0.42	0.53	0.56	0.59	0.62
March	0.51	0.43	0.54	0.57	0.61	0.64
April	0.91	0.76	0.96	1.01	1.08	1.14
May	1.45	1.22	1.53	1.62	1.72	1.81
June	1.29	1.08	1.36	1.44	1.53	1.61
July	1.64	1.38	1.73	1.83	1.95	2.05
August	1.59	1.34	1.67	1.77	1.89	1.99
September	1.34	1.13	1.41	1.49	1.59	1.67
October	0.93	0.78	0.98	1.04	1.10	1.16
November	0.68	0.57	0.72	0.76	0.81	0.85
December	0.66	0.55	0.69	0.74	0.78	0.82
Minimum Month Demand	0.25	0.21	0.26	0.28	0.30	0.31
Maximum Month Demand	1.95	1.64	2.05	2.17	2.31	2.44

To meet the recycled water demands, it is important to appropriately size the recycled water treatment system based on the available quantity of secondary effluent. The primary concern for available water for the recycled water system is the ability to meet recycled water demands at night when the influent flows to the EEWWTP are low. Effluent flow data from the EEWWTP for April-May 2011 and July- August 2012 were used to determine the amount of flow available for the recycled water system during these low flow conditions. These months were used since they are typically the higher demand months, instead of the winter months when demand was lower.

The City provided data for the entirety of these two-month durations in 15-minute time intervals. Each interval contained four separate flow measurements, all in million gallons per day: Actual, Average, Minimum, and Maximum. These individual measurements were combined to provide a comprehensive data set for analysis.

The minimum daily flows during April and May 2011 were constant at close to 3.0 mgd. The minimum daily flows for July and August 2012, however, showed a wider variation. Although a consistent trend shows minimum daily flows of approximately 2.5 mgd for the majority of this duration, many days in the first half of July show much lower minimum daily flows. Many of these days had minimum flows of less than 2.1 mgd. On July 7, the flow decreased to below 1.5 mgd, but only for 30 minutes. Because this was only one day and for a short time, this period was considered an outlier and not used as a design condition.

To appropriately size the treatment facilities for these varied flows, it is necessary to estimate an expected minimum flow rate for each hour of the day. Based on the July data on the most extreme

days, the design flow condition will include absolute minimum flow rates from 3am until 7:30am and more typical flow rates from 7:30am until 3am the next day.

Design flow conditions were selected to average a total daily recycled water flowrate of 2.5 mgd. First, it was determined that the minimum flow from 3am to 7:30am was 1.5 mgd, as indicated in the graph. Using that as the main constraint, the flow for the remainder of the day (7am to 3am) was increased until a product water of 2.5 mgd on an average basis was achievable. It was important to account for flows that were required from secondary effluent but did not produce recycled water, for example microfiltration/ultrafiltration (MF/UF) backwash and reverse osmosis (RO) brine, when determining the secondary effluent flow to the system.

Figure 3 shows the measured second effluent flow rates for every day in July and August 2012 as well as the design flow conditions. This shows that the design secondary effluent flow will be available on a daily basis for the plant. This also shows that, during the low-flow periods, all of the secondary effluent flow will be used for the recycled water system to meet the 2.5 mgd daily demand. The design secondary effluent flow for normal periods is 3.2 mgd, and low periods is 1.5 mgd, as indicated by the red line in the figure.

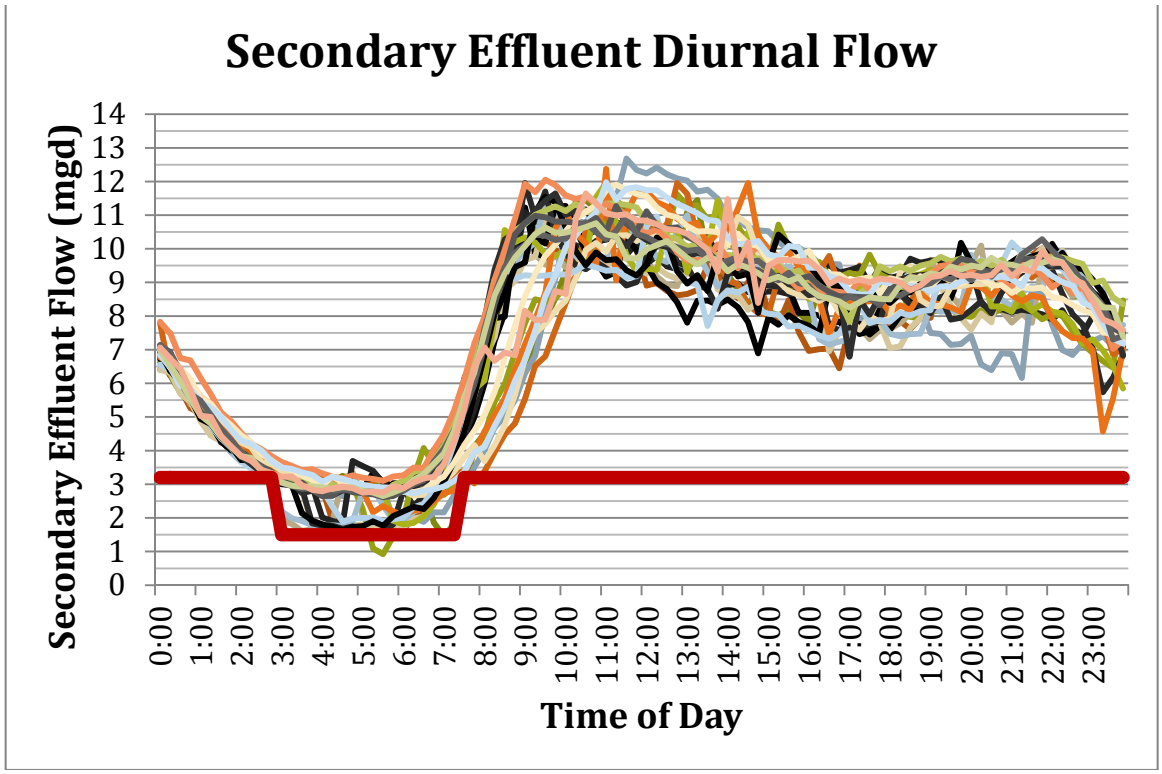

Figure 2
July and August 2011 Daily Secondary Effluent Flow with Design Flow Conditions in Red

Existing Facility Produced Water Quality and Future Water Quality Goals

Current Water Quality

California Code of Regulations' Recycled Water guidelines (Titles 17 and 22) are followed by the City of Santa Barbara's Recycled Water Program. The City's recycled water system is also operated and managed according to the Regional Water Quality Control Board Order No. 97-44, Master Reclamation Permit for the City of Santa Barbara, Producer/User and Primary Producer/User of Recycled Water. The NPDES Permit for EEWWTP Waste Discharge Requirements was adopted by the Regional Water Quality Control Board and became effective on May 13, 2010.

The City of Santa Barbara follows Monitoring and Reporting Program No. 97-44 as set forth in their Master Reclamation Permit.

Table 7 Reclaimed Water Monitoring Requirements

Constituent	Units	Type of Sample	Minimum Sampling and Analyzing Frequency
Daily Flow Volume[1]	gpd[2]	Metered	Daily
Maximum Daily Flow[1]	gpd[2]	Metered	Monthly
Mean Daily Flow[1]	gpd[2]	Calculated	Monthly
Turbidity[3]	NTU	Metered	Continuous
Chlorine Residual[4,3]	mg/L	Metered	Continuous
Total Coliform Organisms	MPN/100mL	Grab	Daily
Settleable Solids	mL/L	Grab	Daily
pH	pH Units	Grab	Daily
Total Non-Filterable Residue (Suspended Solids)	mg/L	24-hr Composite	Five days per week
Total Dissolved Solids	mg/L	Grab	Quarterly (Jan, Apr, Jul, Oct)
Cadmium	mg/L	24-hr Composite	Semi-annually (Apr, Oct)
Lead	mg/L	24-hr Composite	Semi-annually (Apr, Oct)

1. Flow shall be metered at the distribution system pump station to provide a record of the quantity of reclaimed water used each day (per normal irrigation period).
2. Report daily maximum and daily mean valued. In reporting turbidity, the amount of time that NTU limitation was exceeded each day shall be reported. Turbidity samples may be obtained anywhere in the treatment process following filtration.
3. Report daily maximum and daily minimum values before discharge and at the end of the chlorine contact chamber. Compliance shall be determined by daily minimum values measured within the chlorine contact zone at the end of the chlorine contact chamber.
4. Monitor at the distribution system pump station.

Permit Reclamation Specifications

Daily flow (per normal irrigation period) averaged over each month shall not exceed 4.3 million gallons.

Recycled Water shall not contain constituents in excess of the following:

Table 8 Reclaimed Water Quality Requirements

Constituent	Unit of Measurement	Mean	Maximum
Turbidity	NTU	2	5
Total Non-Filterable Residue (Suspended solids)	mg/L	10	25
Settleable Solids	mL/L		0.1
Total Dissolved Solids	mg/L		1500
Cadmium	mg/L		0.01
Lead	mg/L		5

The Median concentration of total coliform bacteria in the disinfected effluent shall not exceed a Most Probable Number (MPN) of 2.2 per 100 milliliters, utilizing the bacteriological results of the last seven days for which analyses have been completed, and the MPN shall not exceed 23 per 100 mL in more than one sample in any 30-day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 mL.

The filtered wastewater must be disinfected by a chlorine disinfection process that provides a CT (chlorine concentration times modal contact time) value of not less than 450 milligram-minutes per liter at all times with a modal contact time of at least 90 minutes, based on a peak dry weather flow. Contact time shall be determined using the volume of the chlorine contact chamber and the 600,000 gallon storage tank at the EEWWTP.

Reclamation Quarterly Reports

Quarterly reclamation reports are produced as required by the California Regional Water Quality Control Board.

It was reported to the California Regional Water Quality Board that in Quarter 3 of 2011 (July, August and September) there was a violation at the plant. Contact Time and Total Coliform Bacteria were the offending parameters. Reclamation Quarterly Report: Quarter 3 – CY 2011 states that these parameters were violated on two occasions each. The explanation given for the cause of the violations is as follows:

> "The CT value <450 mg-min/L violations occurred when the filter was not producing recycle water at desired levels and potable water was used to fill the reservoir. Potable water has low chlorine residual which results in low CT values. The violation of the 23 MPN100ml daily maximum was caused by the utilization of potable water with low chlorine residual in conjunction with a low volume filter production."

The corrective action taken by EEWWTP and the City of Santa Barbara was to issue a request for proposal to study the tertiary treatment facilities. This request for proposal resulted in this current study being performed by CDM Smith.

Current water quality tables and graphs may be found in Attachment B. Graphs display the minimum, average, and maximum values of each constituent for the years 2006 to 2011.

Future Water Quality Goals

The two main parameters that prompted this particular study are the chlorine contact time and the total coliform bacteria. It is a goal to meet the requirements as set forth in the Master Reclamation Permit.

In the Long Term Water Supply Plan mineral reduction is addressed. The City desires to achieve a mineral content that is suitable for irrigation purposes. It has been a goal of the City to not allow more than 300 mg/L of chloride during the irrigation season. The maximum Total Dissolved Solids (TDS) as required by the general permit is 1,500 mg/L. Though 1,500mg/L is the upper limit of TDS, the city averaged 951.7 mg/L from 2006 to 2011. In 2011 the TDS averaged 692 mg/L.

One goal of the City is to reduce potable water mixing. In order to achieve its turbidity and mineral requirements, potable water is often blended with the recycled water. In recent years the blend water proportion has been increasing. Figure 4 shows the ten-year history of blend proportions. According to the Long Term Water Supply, issues with the Secondary Process began in 2004 in conjunction with the Secondary Process issues.

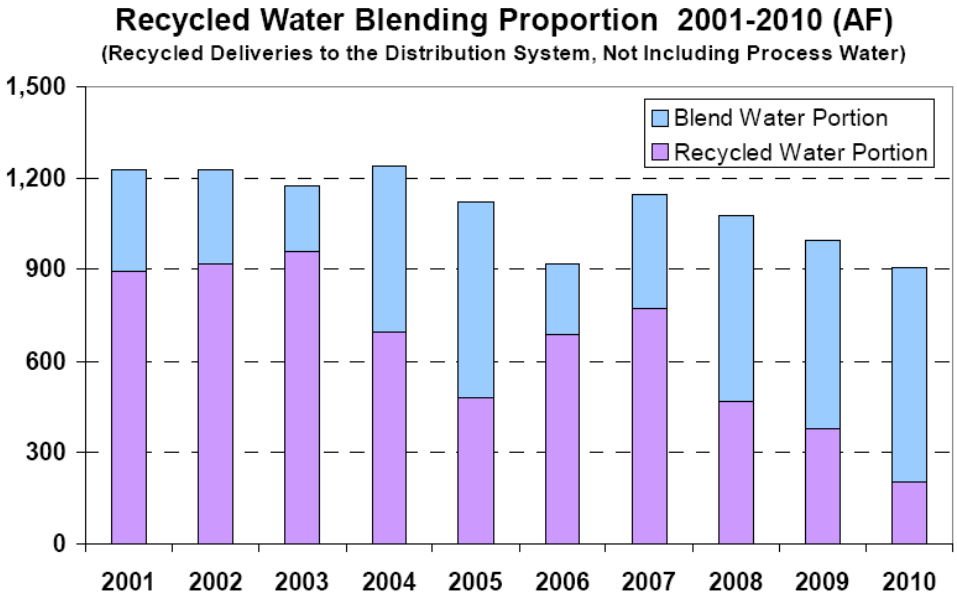

Figure 4
Recycled Water Blending Proportion 2001-2010 (AF)

The water produced by the tertiary filters has not been consistent in meeting the turbidity requirements of less than 2 NTU. If the City wishes to reach its turbidity requirement of less than 2 NTU without blending, other treatment options must be examined.

Utilizing potable water in this heightened capacity can be very expensive. Also, by eliminating potable water from this process, the City will be even closer to achieving the 20 by 2020 mandate.

Other draft legislation includes the creation of Salt/Nutrient Management Plans and examination of Constituents of Emerging Concern (CEC) as mentioned in the discussion of the State Recycled Water Policy.

Appendix B-3: AM No.3 Filtration Alternatives

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Memorandum

To: *Rebecca Bjork, City of Santa Barbara*

From: *Don Cutler, CDM Smith*
Marie Burbano, CDM Smith

Date: *June 4, 2012*

Subject: *Assessment Memorandum (AM) No. 3 – Filtration Alternatives*

Purpose and Background

This technical memorandum (TM) evaluates treatment process alternatives for the filtration of recycled water produced at the City of Santa Barbara's El Estero Wastewater Treatment Plant (El Estero).

The purpose of this memorandum is to present several filtration treatment process alternatives and provide a preliminary analysis to recommend a treatment process to accomplish the desired water quality of the recycled water produced at El Estero. The treatment processes that are considered in this evaluation are gravity deep bed filters, upflow continuous backwash media filters, cloth or disk filters, and microfiltration (MF). The recommended treatment process will be further developed during the preliminary design phase.

For all capital cost estimates, the following allowances have been included.

- 15% for engineering design and services during construction
- 5% for permitting, administration, and legal

For the life-cycle cost estimates, the following has been included.

- 20 year life cycle
- Unit power cost of $0.085/kWh. This is based on an evaluation of El Estero summer and winter 2011 electricity bills. The summer was approximately $0.11/kWh, while winter was $0.07/kWh. Additional information from Chris Toth (City of Santa Barbara) on April 26, 2012 showed that the expected power purchased from the new Cogen facilities would be $0.085/kWh, which was selected for the purposes of this study.
- 3.5% interest rate

This TM is organized into the following sections.

- Filtration requirements
- Existing filter complex
- Filtration alternatives
- Filtration alternatives evaluation
- Recommendations

Filtration Requirements

Recycled water quality criteria and usage are specified in Title 22, Division 4 of the California Code of Regulations (CCR). El Estero produces recycled water that meets the Title 22 criteria for disinfected tertiary recycled water. Depending on the groundwater basin and recycled water usage location, the Regional Water Quality Control Board (RWQCB) can include additional requirements to Title 22. At El Estero, the Central Coast Region of the RWQCB lists the current recycled water requirements in the Waste Discharge Requirements and Master Reclamation Permit Order No. 97-44. Note that Title 22 was written after Order No. 97-44. However, the requirements in Order No. 97-44 are more stringent than Title 22 and, therefore, apply to El Estero.

Table 1 summarizes the primary water quality requirements for disinfected tertiary recycled water.

Table 1 El Estero Recycled Water Permit Requirements per Order NO. 97-44

Parameter	Requirements
Turbidity[1]	2 NTU (Mean) 5 NTU (Maximum)
Total Non-filterable Residue (Suspended solids)	10 mg/L (Mean)[2] 25 mg/L (Maximum)
Settleable solids	0.1 mL/L (Maximum)
Total dissolved solids	1,500 mg/L (Maximum)
Cadmium	0.01 mg/L (Maximum)
Lead	5.0 mg/L (Maximum)
Total Coliform Most Probable Number (MPN)[3]	2.2 per 100 mL (Average) 23 per 100 mL (Maximum)

[1]Maximum limit shall not be exceeded more than five percent of the time during any 24-hour period.

[2]Compliance shall be determined from the results of the five most recent samples.

[3]No sample shall exceed an MPN of 240 total coliform bacteria per 100 mL.

Title 22 provides requirements for both filtered wastewater and disinfected tertiary recycled water. For the purposes of this analysis, the filtered wastewater standards must be met using the filtration alternative selected. Disinfection occurs at El Estero in the chlorine contact basin and onsite storage reservoir.

Title 22 requirements for filtered wastewater are as follows.

"Filtered wastewater" means an oxidized wastewater that meets the criteria in subsection (a) or (b):

- *(a) Has been coagulated and passed through natural undisturbed soils or a bed of filter media pursuant to the following:*
  - *(1) At a rate that does not exceed 5 gallons per minute per square foot of surface area in mono, dual or mixed media gravity, upflow or pressure filtration systems, or does not exceed 2 gallons per minute per square foot of surface area in traveling bridge automatic backwash filters; and*
  - *(2) So that the turbidity of the filtered wastewater does not exceed any of the following:*
    - *(A) An average of 2 NTU within a 24-hour period;*
    - *(B) 5 NTU more than 5 percent of the time within a 24-hour period; and*
    - *(C) 10 NTU at any time.*
- *(b) Has been passed through a microfiltration, ultrafiltration, nanofiltration, or reverse osmosis membrane so that the turbidity of the filtered wastewater does not exceed any of the following:*
  - *(1) 0.2 NTU more than 5 percent of the time within a 24-hour period; and*
  - *(2) 0.5 NTU at any time."*

All of the technologies evaluated in this TM meet the Title 22 requirements for filtered wastewater.

Existing Filter Complex

The existing filter complex was constructed in 1988 as part of the City's Water Reclamation Project at El Estero. The existing chlorine contact basin and recycled water reservoir were constructed at the same time.

The filters are single-media gravity filter type filters with an air/water backwash system. The original manufacturer was General Filter Co., but this technology has since been purchased by Siemens and is currently marketed as CenTROL® LP Conventional Gravity Filters. The filters consist of four cells, each 14 ft x 14 ft and 20 ft deep with 4 ft of media depth. The design filter loading rate is 750 gpm/cell (3.83 gpm/sq ft). At this nominal loading rate, the influent filter loading capacity is 4.32 mgd, not accounting for backwash waste and time for backwashing of the filters. Table 2 provides original design details for the existing filters.

Table 2 Existing Filter Design

Description	Details
Type	Single-media gravity filter with air/water backwash
Manufacturer	General Filter Co. (now owned by Siemens)
Flocculation chamber HRT	7 minutes at 3,000 gpm
Size	4 cells, 14 ft x 14 ft each
Media depth	4 ft
Filter rate	750 gpm/cell (3.83 gpm/sq ft) (results in 4.32 mgd)

The filters receive secondary effluent that is pumped through two filter supply pumps, one duty and one standby. The filter supply pumps are supplied by a 48" secondary effluent pipe. Filter supply pumps feed flow to the flocculation chamber. At the design flowrate of 3000 gpm, the filter influent is in the flocculation chamber for approximately 7 minutes. Influent then flows into an influent flume to a center distribution box. The distribution box consists of internal stilling baffles and weirs, which are adjustable to divide flow to each of the filter cells. The design elevation of the filter influent weirs is set at 32.00 ft. Figure 1 shows the hydraulic profile of the original plant design for the filters. The full hydraulic profile, including the chlorine contact basin and reclaimed water storage reservoir, can be found in the Water Reclamation Project Treatment Systems 1988 Record Drawings, Dwg No. G-11.

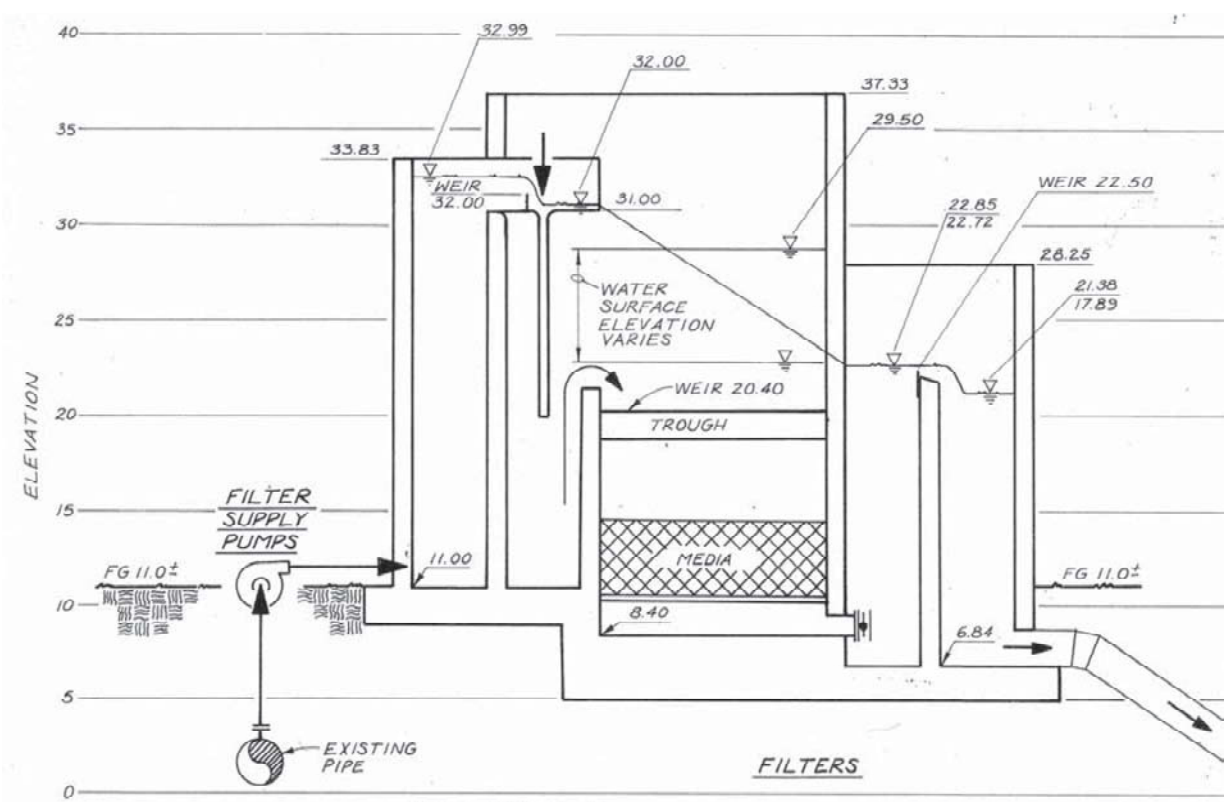


Figure 1
Filter Hydraulic Profile

A pneumatically operated valve is provided at the bottom of the distribution box for each cell, which is open during normal operation and closed during a backwash cycle. Filter influent flows through 4 ft of media, which was originally finely ground anthracite coal filter media ranging in size from 1.4 mm to 1.6 mm. The filter media has not been recently replaced, although additional media has been added on an as-needed basis. Figure 2 shows the general layout of the main features in the current filters.

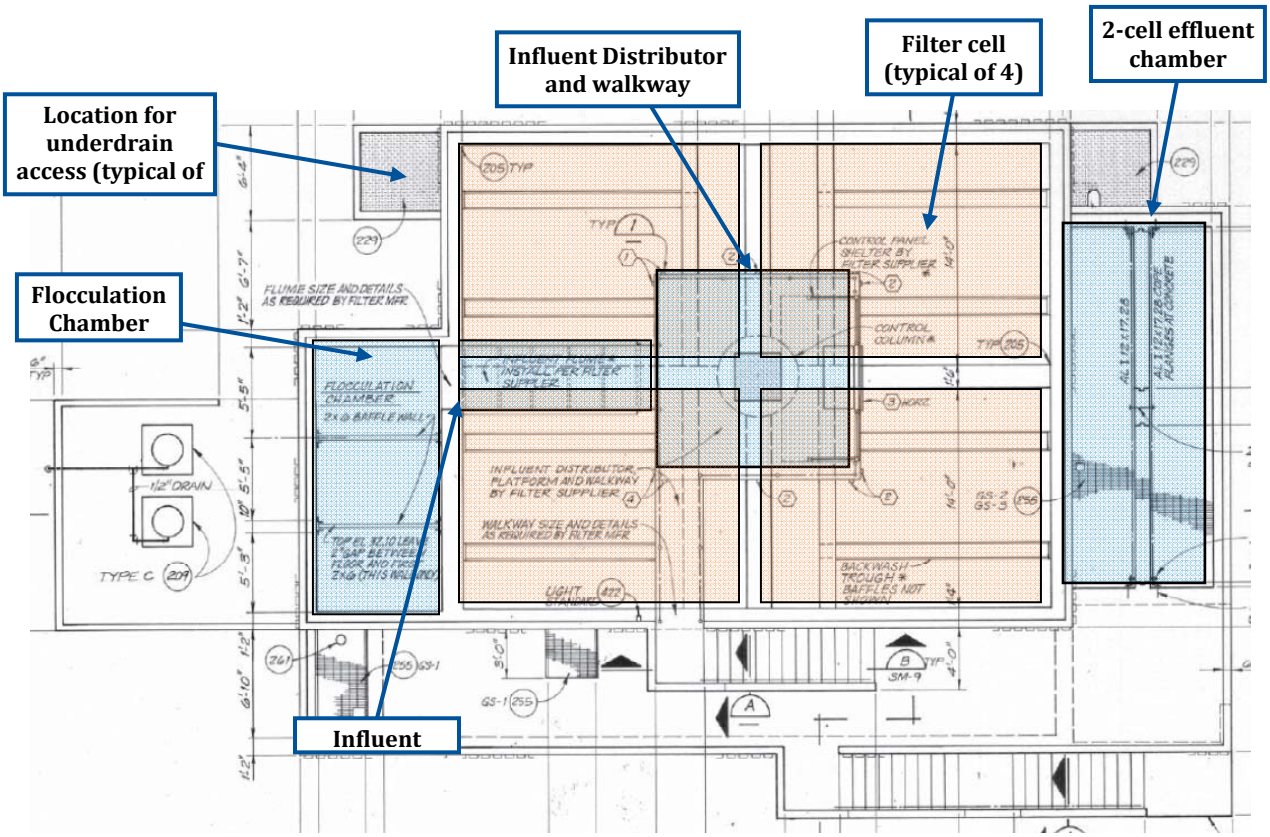


Figure 2
Existing Filter Layout

Following filtration, filtered effluent flows to 16” effluent collection pipes located under the underdrain. The effluent collection pipes have holes to provide distributed collection system for each filter. Effluent collection pipes convey the water to a two-cell effluent chamber. An effluent weir is set at 22.50 ft, resulting in maximum of 9.5 ft of headloss through the existing filters. Filter effluent flows by gravity to the chlorine contact basin.

Polymer and alum feed systems are provided for the filter complex, as well as the ability to add chlorine as needed. Anionic and cationic polymer are supplied prior to a static mixer in the filter influent line before the flocculation chambers. Alum and chlorine are added after the static mixer.

Repairs in a 2005 retrofit included the following: coating surfaces, replacing conduit, and replacing valve operators.

Existing Backwash System

Online instrumentation is provided to monitor the water level in each cell. When the water level in a cell has risen to approximately 8.5 ft above the filter media, a backwash cycle is designed to automatically start for that cell. In addition, turbidimeters are provided to monitor the filter effluent of each filter cell. The backwash system is designed to be controlled by an automatic backwash controller.

During backwash, the influent to the filter cell is closed and water is designed to be allowed to filter through until it reaches 1 ft above the effluent weir. At this point, the backwash waste valve for that cell in the center column is opened and water drains into the backwash equalization basin. When the water level reaches approximately the top of the backwash trough, the backwash air blower starts which forces air through the filter media. Filter effluent will also flow up through the media because the water level in the cell is less than the filter effluent chamber, forcing the water to back up in the effluent plenum. Following a backwash, the filters are operated as filter-to-waste to mitigate the potential of increased turbidity of the first flush.

Backwash water is collected in backwash troughs in the center column and sent in an 18" pipe to the backwash equalization tank and then to the plant influent sewer. Filter-to-waste is also sent to the backwash equalization tank.

Backwash air supply is provided by a low pressure air supply distribution header as part of the backwash system. Two backwash blowers feed the low pressure air supply for backwash. An air compressor pack, and an air dryer are utilized to operate filter function valves. Table 3 provides the existing backwash system design details.

Table 3 Existing Backwash System Design

Description	Details
Backwash rate	12 gpm/sq ft (2,400 gpm)
Backwash air rate	4 cfm/sq ft (780 cfm)
Backwash blowers	1 duty, 1 standby Positive displacement, capacity 780 cfm

Existing Filtration Complex Limitations

Existing filter limitations include difficulty to meet effluent turbidity requirements, continuous operational challenges, and operations and maintenance safety concerns. It is important to assess

these limitations in order to evaluate what improvements to the existing system are needed and if a new process would be beneficial over improving the existing system.

The existing filter complex is a compact process which eliminates the need for a filter gallery and utilizes the effluent from other filters to backwash without the need for pumping. The process also does not require complex filter effluent rate of flow controls and relies simply on hydraulics with influent flow splitting and variable level filtration. The variable level is in response to increased headloss in the media during a filter run. This also provides the operator with a clear visualization of filter headloss without instrumentation. The overall headloss through this system can also be less than other granular media filtration systems. Although there are many positive features with this type of system, the current filter complex has clearly reached its useful life. In addition, the focus on compact design has also contributed to some difficulties associated with access. The materials of construction were also not optimized for a corrosive environment as will be discussed herein.

Structural and corrosion problems with the existing filter complex are well documented in the Corrosion Engineering Evaluation Report completed by HAE Engineers in January 2012. These structural and corrosion problems cause operational safety concerns for plant staff. The results of the study on the filter complex showed the following.

- Corrosion of multiple filter operational components, including the influent flume, influent distributor, air wash valves and piping, backwash valves (Figure 3), valve controllers, etc.
- Corrosion of many structural elements including stainless steel columns (Figure 4) and ladder braces.
- Deterioration and exposed aggregate on the concrete.

Figure 3
Valve Corrosion

Figure 4
Corrosion on Valve Control Rod Housing

The Corrosion Report also documents more than 70 photos of the filter complex and provides recommendations for improvements. The City of Santa Barbara has enlisted a contractor to make structural repairs to the filter complex so that plant staff can safely operate and maintain the units. These repairs will be completed in 2012.

In addition to the repairs noted in the Corrosion Report, plant staff has also expressed concern about maintenance access. The underdrain access is limited in the existing filters and only achieved through four 24" manholes located at each filter. This difficult confined-space entry creates operational challenges for assessing and maintains the filter underdrain and backwash system. There are also safety concerns entering this tight confined-space. Figure 5 is a photograph of the underdrain access point.

Figure 5
Underdrain Access Point

The filter media has not had a complete replacement in recent memory according to plant staff. Although filter media has been added periodically, this has not been a frequent occurrence. Therefore, the quality of the current filter media is questionable because filter media is typically inspected and replaced on a routine basis.

The filter effluent turbidity is variable and results in required blending with potable water to meet recycled water turbidity permit limits. Previous studies have shown that improvements to the secondary system are needed to improve filtered water quality due to the particle size that is leaving the secondary system and passing through the filters. Secondary improvements are currently in design at El Estero.

Filter effluent water quality may also be limited by the backwash process with the current filters. The existing liquid backwash system is limited in head to only the head available from the effluent chamber, instead of a separate backwash pumping system. This will frequently not provide the bed disruption needed to properly clean the filter for the next filter run.

Finally, one of the greatest challenges to operations is the instrumentation and controls with the existing filter complex. In recent years, the online instrumentation and automated backwashing has not been effective. As a result, plant operators will typically have to perform manual backwash cycles when the filters are running. Additionally, the control panel for backwashes is located in the middle of the structure. For operator safety, this should be located outside of the structure so that the operators do not need to walk on over-water walkways and platforms to access this important control panel. Access to control instrumentation such as level sensors is limited as well.

Filtration Alternatives

This section analyzes filtration technologies that meet Title 22 and permit limits including gravity deep bed filters, upflow continuous backwash media filters, cloth or disk filters, and microfiltration (MF). These alternatives are being evaluated to determine the best approach moving forward for filtration at El Estero. The overall selection process for filtration and demineralization is described in TM1. There is a description of each technology, water quality considerations, and a description of the proposed improvements for El Estero.

For the technologies listed, it is assumed that the planned secondary improvements will be implemented prior to installation of the filtration alternative. Table 4 provides the assumed secondary effluent quality that will be influent to the filters.

Table 4 Assumed Secondary Effluent Quality After Secondary Improvements at El Estero

Parameter	Level
Biochemical Oxygen Demand (BOD)	10 mg/L
Total Suspended Solids (TSS)	10 mg/L
Turbidity	<10 NTU

Filtration will be prior to any proposed demineralization. TM 5 provides a full alternative analysis for demineralization. For the purposes of this filtration analysis, it is assumed that reverse osmosis (RO) is the preferred alternative for demineralization. For any flow going through the RO, MF pretreatment is highly preferred. For the first four technologies listed (gravity deep bed filters, upflow continuous backwash media filters, cloth or disk filters), a sidestream of MF will be required prior to the RO. For the full MF alternative, no additional sidestream RO pretreatment is required.

Flow requirements for filtration are detailed in TM1. For the filtration alternative, it is assumed that the design capacity of the product water after filtration and demineralization is 2.7 mgd.

Retrofit of Existing Gravity Deep Bed Filters

Description of technology

Gravity deep bed filters typically have a media depth of greater than 40”. The required filtration loading rate to meet Title 22 is less than 5 gpm/sf. The existing filters are considered gravity deep bed filters. A full description of the operation of the existing deep bed gravity deep bed filters is provided in the review of the existing system. The existing deep bed filters meet these criteria.

Water quality considerations

As previously stated, the improvements to the secondary process at El Estero will be necessary in order to use gravity deep bed filters for filtration. This is because, based on pervious studies, turbidity and, particularly, the particle sizes currently coming out of the existing secondary clarifiers results in a filtration influent that is difficult to filter with the current gravity deep bed

filters. This is further evidenced by the limited operation of the existing filters due to high effluent turbidity. For the purposes of this evaluation, it is assumed that the secondary improvements will be completed to meet a TSS of less than 10 mg/L out of the secondary clarifiers on an average basis.

Media selection is important in a gravity deep bed filter based on treating influent and meeting effluent water quality requirements. The selection of single or dual media should be evaluated during design if this technology is selected. In a dual media filter, a coarser media for a slight contact clarification step first would be preferred where the coagulated water hits the media. A finer media below could help with reducing turbidity. A full depth monomedia needs to meet both objectives. However, a dual media filter will result in more headloss. A pilot study would be recommended to optimize chemical pretreatment and media configuration. In addition, a pilot filter could be retained to facilitate future chemical pretreatment optimization evaluations in the future.

As previously stated, the existing liquid backwash system is limited in head to only the head available from the effluent chamber. Although this is a simple backwash system as it does not require a separate pump, it frequently will not provide the bed disruption needed to properly clean the filter. As an improvement, backwash water supply should be provided from the filtered water clearwell using backwash pumps. This will improve ongoing water quality and filterability.

If demineralization is required, a sidestream MF system would be needed following the gravity deep bed filters because the RO would need MF for pretreatment (see TM No. 4 for additional information).

Description of improvements

An extensive restoration of the existing gravity deep bed filters is recommended as an improvement to accomplish operations, safety, and water quality goals. The following improvements would be recommended for the retrofit of the existing filters.

- Demolition as needed for replacements of structures listed below.
- Replace influent flume, influent distribution structure, pipe, and valves. Note that the influent distribution structure may need to be custom-made to match the existing structure.
- Replace backwash troughs.
- Replace the walkway.
- Replace all backwash to waste piping and backwash air piping.
- Replace filter media.

- Replace filter feed pumps.
- Replace underdrain with a new underdrain system that is low profile and will improve overall air and water distribution. Alternatives include M-block style as well as monolithic underdrains using a nozzle system. Consideration to the height required for the underdrain and plenum would need to be considered.
- Add new pumps for pressurized backwash water flow. Two backwash pumps (one duty, one standby) are recommended in the effluent channel. The backwash header should be piped such that the effluent plenum each individual filter can be pressurized to provide backwash. The existing waste backwash system should be retained but all the backwash valves should be replaced.
- Provide adequate coating in the tank, flume, through and walkway supports to protect against future corrosion.
- Relocation/replace the control cabinet. The control cabinet is currently located in the center of the filter structure. This should be relocated to the side of the filter so that operators do not need to walk on the platform to access the control panel.
- Provide maintenance to the stainless steel shaft and replace piping/valve and motors.
- Replace and relocate filter instrumentation. Filter instrumentation, including level sensors and turbidity monitors, should be replaced and relocated so that they are easily accessible by plant operators.

Projected costs
Capital costs for the rehabilitation to the existing filters include the improvement items listed above. The estimated capital cost to rehabilitate the existing gravity deep bed filters is $3M. The annual costs for the existing filters include power required for influent pumping and backwash air and water flow as well as chemical pretreatment for coagulation. The annual cost for the existing filters is estimated at $40,000.

The estimated capital cost for a sidestream MF as a pretreatment for RO is $1.9M. Annual cost for the sidestream MF is an additional $40,000. The sidestream MF is described in the Media Filtration section of this TM.

The total 20-year lifecycle cost for the rehabilitation to the existing filters with sidestream MF as a pretreatment to RO is $6.1M.

Upflow Continuous Backwash Filters

Description of technology
The upflow continuous backwash filter is a Title 22 approved granular medium sand filter technology. The system is an upflow, deep bed, continuously backwashing filter. The criteria for

these system in the Title 22 approved technology list is for a filtration rate of less than 5 gpm/sf, along with 40-inch of sand media.

A flow distribution system is needed to distribute flow to each filter cell equally with isolation valves needed to take a cell offline. Influent flows into the base of the sand filter beds and subsequently flows upward through a sand media bed that is concurrently moving in a downward direction. Filtered effluent is removed from the top of the filter cells and is combined into a common effluent header. Schematics of the upflow continuous backwash filters are shown in Figure 6.

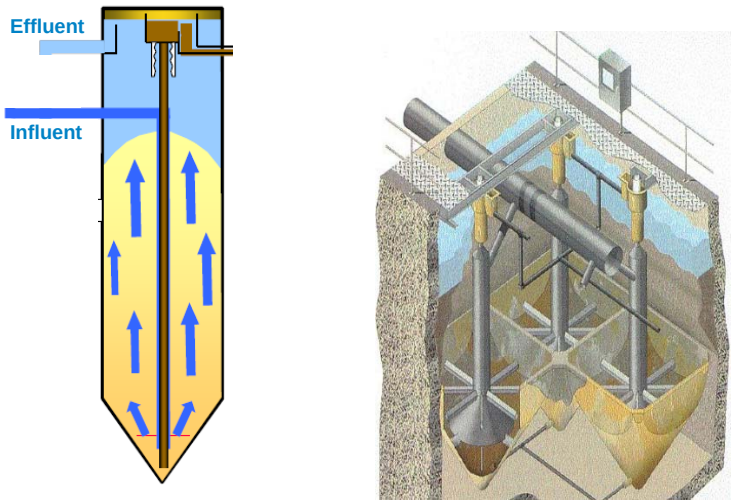


Figure 6
Upflow continuous backwash filter schematics

The filters are designed to allow for simple isolation of individual filter cells. There are no local pumps, blowers, or actuated valves required for operation of the filters, and there are low power loadings only due to a compressor that is required for continuous backwashing. The minimization of ancillary components such as automatic valves, blowers, and pumps provides energy efficiency, reduces facility maintenance, and minimizes electrical end rush loadings associated with starting and stopping equipment to perform backwashes.

Solids are continuously backwashed due to the constant recirculating airlift located in the center of each filter module. The airlift is generated by a common air compressor for the entire filter gallery. Sand media is pulled into the airlift and is continuously scoured within the airlift pipe thereby removing solids from the sand media. Solids are carried to the top of the airlift pipe and conveyed to waste while the clean sand is returned to the top of the downwardly moving sand bed.

The filters are protected from sunlight and debris via a fine grating located on the top of the filter structure that also provides access for maintenance staff.

Water quality considerations

As previously stated, the improvements to the secondary process at El Estero will be necessary in order to use upflow continuous backwash filters for filtration. This is because the upflow continuous backwash filter is a media filter, and will likely perform similarly to the existing gravity deep bed filters in terms of water quality. The continuous backwash filter, which is continuously backwashing, can improve filter run time and treated water quality. For the purposes of this evaluation, it is assumed that the secondary improvements will be completed to meet a TSS of less than 10 mg/L out of the secondary clarifiers on an average basis. These filters may be able to accommodate a wider range of influent conditions than the gravity deep bed filters due to the continuous backwashing, but secondary improvements will still be needed.

If demineralization is required, a sidestream MF system would be needed following the gravity deep bed filters because the RO would need MF for pretreatment (see TM No. 4 for additional information).

Description of improvements

Continuous backwash filters can be configured to fit into the site footprint of the existing structure or in a new structure. This will require that the existing filters be taken out of service during construction. If configured into the existing structure, the internal components of the structure would be demolished and replaced with the new filters.

Projected Costs

The estimated capital cost for upflow continuous backwash filters retrofit into the existing filter structure is $2.9M. The annual costs for the upflow continuous backwash filters include power required for influent pumping and backwash as well as chemical pretreatment for coagulation. The annual cost for the upflow continuous backwash filters is estimated at $40,000.

The estimated capital cost for upflow continuous backwash filters in a new structure is $6.6M. The annual costs is the same as in the existing structure.

The estimated capital cost for a sidestream MF as a pretreatment for RO is $1.9M. Annual cost for the sidestream MF is an additional $40,000.

The total 20-year lifecycle cost for the upflow continuous backwash filters retrofit into the existing filter structure with sidestream MF as a pretreatment to RO is $6M.

The total 20-year lifecycle cost for the upflow continuous backwash filters in a new filter structure with sidestream MF as a pretreatment to RO is $7.8M.

Disk Filters

Description of technology

Disk filters are set up in a series of disks using cloth media. Typical configurations are 8 to 12 disks per channels. The filters operate with the cloth media completely submerged. The disks are

typically stationary. Flow can either operate on an inside-out or outside-in configuration. In the inside-out configuration, flow enters the inside of the disk and flows to the outside where it is collected for reuse. Solids collect in the center for removal. In the outside-in configuration, flow is in the overall channel and filtered effluent is collected in the center of the disks.

Filter media can be woven (Figure 7) or pile (Figure 8) media. Both technologies are Title 22 approved, although the woven media can provide more consistent filtered water quality due to the consistent size of the openings. However, the pile media allows solids to accumulate, which results in longer times between backwashes as compared with the woven media.

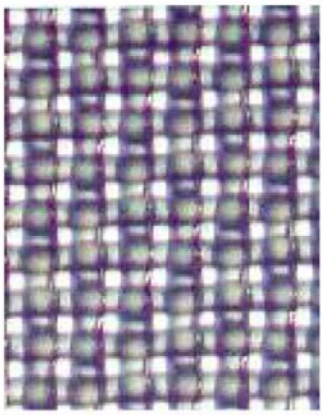


Figure 7 – Woven Media

Figure 8 – Pile Media

Solids are backwashed from the cloth media surface via pumps that pull suction on the cloth surface, thereby removing accumulated solids from the cloth surface. The disks slowly rotate during a backwash cycle, with two disks backwashing at a time. The backwash process can be intermittent or continuous depending on influent water quality and loading rate. The filter backwash can be initiated either by a timer or by the water level in the filter basin. Because solids accumulate at the bottom of the channel, the filters can be backwashed without interrupting filter operation.

Figure 9 is a configuration of a typical disk filter, and Figure 10 shows a disk filter installed, without water in the basin. When operating, the disks are covered with water.

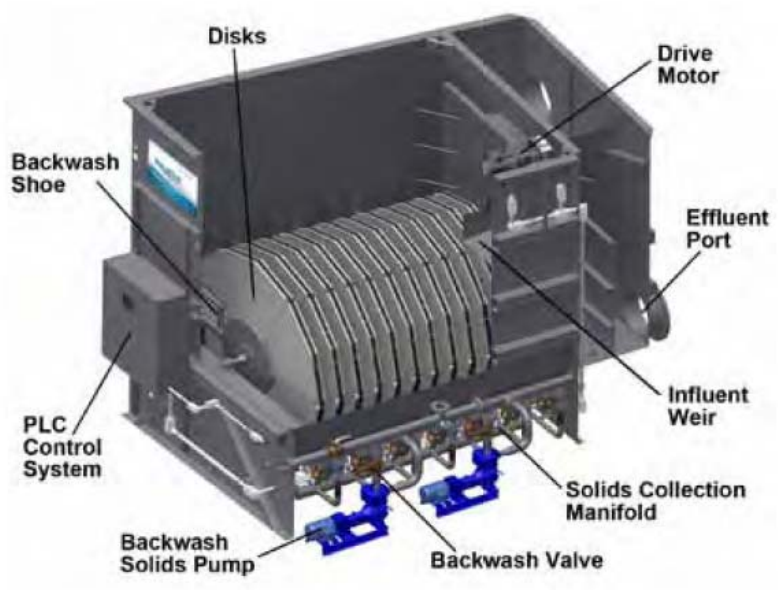


Figure 9. Typical disk filter configuration (Aqua Aeorbics AquaDisk® technology used for example)

Figure 10. Installed disk filter

Water quality considerations
There are water quality limitations on the influent to the disk filters to provide Title 22 required effluent turbidity. These requirements are typically more stringent than the media filter technologies (i.e. gravity deep bed filters or upflow continuous backwash filters). For example, for the AquaDisk filters, the secondary effluent turbidity must not exceed 5 NTU for more than 15 minutes and never shall exceed 10 NTU. In addition, there must be the ability to automatically activate chemical addition or divert wastewater from the filter if the influent turbidity exceeds 5 NTU for more than 15 minutes.

Description of improvements
Disk filters can be configured to fit into the site footprint of the existing structure or in a new structure. If configured into the existing structure, the internal components of the structure would be demolished and replaced with the new filters.

Projected Costs
The estimated capital cost for a retrofit of cloth or disk filters in the existing filter structure is $2.6M. The annual costs include power required for pumping for the influent and backwash as well as chemical pretreatment for coagulation. The annual cost for the existing filters is estimated at $40,000.

The estimated capital cost for a sidestream MF as a pretreatment for RO is $1.9M. Annual cost for the sidestream MF is an additional $40,000.

The total 20-year lifecycle cost for a retrofit of cloth or disk filters in the existing filter structure with sidestream MF as a pretreatment to RO is $5.8M.

Membrane Filtration

Description of technology
Microfiltration (MF) and Ultrafiltration (UF) are the two processes that are most often associated with the term “membrane filtration” and are alternatives to the media or cloth/disk filters discussed previously. These membranes provide a physical barrier, resulting in more complete rejection of particles greater than a specified size (on the order of 0.1 μm for MF and on the order of 0.01 μm for UF). Membranes of this kind remove particles down to such small sizes that they both remove pathogens and also particles that adversely affect the aesthetic appearance of the water. Membrane filtration has been successfully employed for several years in the treatment of secondary effluent to make it suitable for reverse osmosis.

In recent years, competition among manufactures and increasing number of successful installations has dramatically decreased both initial and long-term costs of membrane filtration.

Polymeric membranes are formed using either cellulose acetate (CA) or synthetic polymers, such as polypropylene (PP), polyvinylidene fluoride (PVDF), polysulfone (PS), or polyethersulfone (PES). The various membrane materials have different properties, including pH and oxidant

sensitivity, and hydrophobicity (see Table 5). Most synthetic polymeric membranes are naturally hydrophobic and only upon surface modifications do they become hydrophilic. Therefore, these membranes have a special storage requirement -- they must be stored wet or filled with a wetting agent. If allowed to dry, they may experience a change in structure resulting in a loss of membrane permeability.

Table 5 Characteristics of Selected Membrane Materials

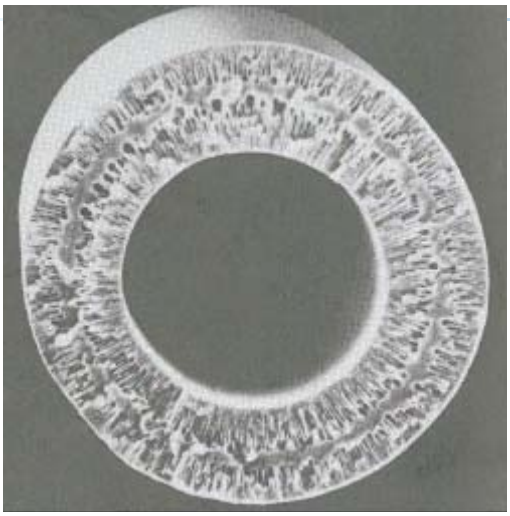
Membrane Material	Membrane Classification	Hydrophobicity	Oxidant Tolerance	pH Range	Fouling Resistance/ Cleanability
Polyvinylidene fluoride (PVDF)	MF/UF	Modified hydrophilic	Very High	2-11	Excellent
Polypropylene (PP)	MF	Slight hydrophobic	Low	2-13	Acceptable
Polyethersulfone (PES)	UF	Very hydrophilic	High	2-13	Very good
Polysulfone (PS)	UF	Modified hydrophilic	Moderate	2-13	Good
Cellulose acetate (CA)	UF	Naturally hydrophilic	Moderate	5-8	Good

(Adapted from Microfiltration and Ultrafiltration Membranes for Drinking Water, Manual of Water Supply Practices, M53)

Although polymeric MF/UF membranes are found in many configurations (hollow fiber, spiral wound, flat sheet, plate and frame), hollow fiber is recommended. These fibers have an inside diameter ranging from 0.4 to 1.0 mm and a wall thickness ranging from 0.07 to 0.6 mm (see Figure 11). The physical strength of the fibers allows them to be backwashed.

Hollow-fiber membranes are operated in either an inside-out or outside-in mode. During inside-out operation, the feed enters the fiber lumen and passes through the fiber wall to generate filtrate (Figure 11b). During outside-in operation, the filtrate is collected in the fiber lumen after the feed is passed through the membrane.

The pressure that is used to drive water through the membrane material is termed as transmembrane pressure. Depending upon the way membrane modules are pressurized, they are available in two basic configurations: pressure-vessel systems (Figure 12) and submerged systems (Figure 13). Pressure systems are operated under positive pressure (between 3 to 50 psi) and submerged system are under negative pressure (between -1 to -12 psi). Submerged systems tend to accommodate larger modules than pressure vessel systems and eliminate the need for pressure vessels to house the membranes. Additionally, submerged systems generally require fewer valves and piping connections with large facilities (greater than 10-20 mgd). Pressure vessel systems are generally more advantageous for facilities smaller than 10 mgd, have a greater degree of competition in the market, and are recommended for El Estero..



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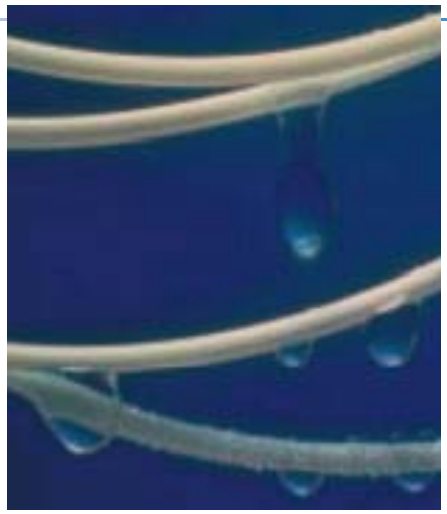

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Figure 11
Hollow Fiber Membranes:
(A) Scanning electron microscope image of end view with cacrovoids for water passage,
(B) Example of a hollow fiber module
(C) Water permeating through hollow fibers

Figure 12
Pressure Vessel Configuration Membrane Filtration (Pall Corporation System)

Figure 13
Submerged configuration membrane filtration (Siemens Water Technologies)

Table 6 provides a list of key low-pressure membrane manufacturers in the USA. Most membrane filtration manufacturers currently produce membranes in the ultrafiltration size range rather than the microfiltration, however, there are very little differences observed in the performance or water quality that can be attributed to the classification as either UF or MF. For the remainder of this discussion, the term MF will be used to connote both types of membrane filtration.

Table 6 List of Key Low-Pressure Membrane Manufacturers in the USA

Manufacturer	Representative product name	Product specification
Pall Corporation	Microfiltration module (Microza hollow fiber USV modules)	Hollow fiber, pressurized system, outside-in flow, 0.1 micron pore size, PVDF material
Siemens	Microfiltration or Ultrafiltration modules (Memcor XP and CMF)	Hollow fiber, pressurized or submerged system, outside-in flow, 0.04-0.1 micron pore size, PP or PVDF material
X-Flow (Pentair)	Ultrafiltration modules (Aquaflex)	Hollow fiber, pressurized system, inside-out flow, 0.025 micron pore size, PES material
Zenon (GE Water & Process Technologies)	Ultrafiltration modules (ZeeWeed® 500 and ZeeWeed® 1000)	Hollow fiber, submerged or pressure system, outside-in flow, 0.02-0.1 micron pore size, PVDF material
Toray	Ultrafiltration modules (HFU and HSU)	Hollow fiber, pressurized system, outside-in flow, 0.01-0.02 micron pore size, PVDF material
Dow	Ultrafiltration modules (SFD)	Hollow fiber, pressurized system, outside-in flow, 0.02 micron pore size, PVDF material

Membrane Cleaning

Two types of chemical cleaning regimens are typically performed: (1) chemically enhanced backwashes (CEBs) to maintain the day by day membrane permeability, and (2) chemical clean-in-place (CIP) to restore the membrane permeability between phases or when the TMP reaches the terminal value (approximately 35 psi).

CEBs are preventive cleans performed in place at specified regular intervals to maintain the permeability of the membrane at an acceptable level. Typically, CEBs occur once every 1 to 7 days. During these types of cleanings, the membranes will be exposed to chemicals such as sodium hypochlorite, citric acid, and caustic soda, for a short period of time (<15 minutes). Other chemicals including strong acids may be used depending on the supplier's membrane chemical compatibility and foulants of concern. Chemical concentrations will depend on the severity of the organic or inorganic membrane fouling. Before resuming production, chemical residuals must be flushed out from the membrane tank. Typically, the equipment supplier is responsible for providing input for the optimization of the CEB cleaning regimen.

CIP cleans are an intensive chemical cleaning used to restore the membrane permeability to pre-fouled conditions. This intensive cleaning are typically performed roughly once every 30 days as needed, although longer cleaning intervals may be used if reliable operation is maintained. The chemicals used for recovery cleanings will depend on the severity of the organic or inorganic membrane fouling, and can include sodium hypochlorite, sodium hydroxide, and citric acid or other comparable acids. This cleaning is performed in place, requires a significant soaking or recirculation time (>4 hours), and typically uses higher chemical concentrations than CEBs.

Water quality considerations
As previously stated, MF can be used as a pretreatment to RO. MF filtered water quality is typically very consistent in terms of removal of suspended solids (measured as turbidity). The turbidity will be less than 0.1 NTU during operation, regardless of the quality of source water to the membranes. MF also achieves higher removals of bacteria and other viable microorganism, which significantly reduces the biofouling potential of the RO feedwater.

MF can typically handle a wider range of influent water quality (i.e. secondary effluent water quality at El Estero) than the granular media or cloth filter technologies. In the case of MF, it is likely that secondary improvements will not be necessary prior to filtration to provide high effluent quality for recycled water.

Description of improvements
MF would be installed on the same site at the existing filters. The MF units along with tankage for chemicals would be required and can fit in the existing filter footprint.

Projected Costs
The estimated capital cost for a full MF system is $6.5. The annual costs include power required for pumping the influent and backwash as well as chemicals for pretreatment and cleaning. The annual cost for the MF system is estimated at $100,000.

The total 20-year lifecycle cost for a full MF system is $7.9M.

A sidestream MF system would be implemented as a pretreatment to RO if other alternatives are selected. The flow for a sidestream MF will meet only the flow that must go through RO. The estimated capital cost for a sidestream MF as a pretreatment for RO is $1.9M. Annual cost for the sidestream MF is an additional $40,000. The life-cycle costs for sidestream MF are evaluated in other alternatives.

Filtration Alternatives Evaluation

In order to evaluate filtration alternatives, criteria were developed and scored during an April 9, 2012 workshop with City staff. The purpose of this workshop was to develop criteria to compare filtration alternatives. The process started with brainstorm to identify list of criteria. The list was narrowed down to the 6 most important criteria. Each meeting attendee then prioritize this list with weights, where 1 = low priority, and 5 = high priority. The weights were averaged and discussed to develop the final criteria and weights, provided in Table 7.

Table 7 Evaluation Criteria

Criteria	Weight
Increase ease of O&M and safety for plant staff	5
Optimize site layout	3
Minimize recycled water system shutdowns	4
Improved water quality: reduce turbidity & TDS	5
Minimize blending	4
Life-cycle cost	4

Note: 1 = low priority, 5 = high priority

This section analyzes filtration technologies against the evaluation criteria listed.

Gravity Deep Bed Filters – Retrofit of Existing Filters

Table 8 is a summary of the scores for the alternative of retrofitting the existing filters but keeping the same basic layout and technology. Included are both the scores as well as a description of the rationale behind the score. The weighted scores are the scores times the weights provided in Table 6 for the evaluation criteria

Table 8 Evaluation Summary for Gravity Deep Bed Filters with Sidestream MF

Criteria	Rationale	Score	Weighted Score
O&M and safety	• Continued difficult underdrain access, even with improvements • Regular starts and stops for backwashing	3	15
Optimize site layout	• Ongoing use of full existing site, while total flow may result in less site footprint required if alternatives were chosen	2	6
Minimize shutdowns	• Requires consistent, good secondary effluent quality	3	12
Reduce turbidity & TDS	• Turbidity will be less than 2 NTU, but not as low as full MF • Does not reduce TDS without sidestream MF and RO	3	15
Minimize blending	• With sidestream MF and RO, blending will be minimized	5	20
Life-cycle cost	• Twenty-year lifecycle cost = $6.1M	4	16
		Total Weighted Score	**84**

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Upflow Continuous Backwash Filters

Two evaluation summaries are provided for the upflow continuous backwash filters. The first, provided in Table 9, is for the technology retrofit into the existing filter structure. The second, provided in Table 10, is for the technology in a new filter structure.

Table 9 Evaluation Summary for Upflow Continuous Backwash Filters in Existing Filter Structure with Sidestream MF

Criteria	Rationale	Score	Weighted Score
O&M and safety	• Potentially awkward configuration in an attempt to retrofit in existing filter structure • Common technology, typically automated and operator friendly • No requirement for shutdowns due to backwash cycles	3	15
Optimize site layout	• Ongoing use of full existing site, while total flow may result in less site footprint required if alternatives were chosen	2	6
Minimize shutdowns	• Requires consistent, good secondary effluent quality, but could accommodate a wider range than the gravity deep bed filters due to the continuous backwashing	4	16
Reduce turbidity & TDS	• Turbidity will be less than 2 NTU, but not as low as full MF • Does not reduce TDS without sidestream MF and RO	4	20
Minimize blending	• With sidestream MF and RO, blending will be minimized	5	20
Life-cycle cost	• Twenty-year lifecycle cost = $6M	4	16
		Total Weighted Score	**93**

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Table 10 Evaluation Summary for Upflow Continuous Backwash Filters in a New Filter Structure with Sidestream MF

Criteria	Rationale	Score	Weighted Score
O&M and safety	• Common technology, typically automated and operator friendly • No requirement for shutdowns due to backwash cycles	4	20
Optimize site layout	• Filters can typically be in a small footprint, but cloth filters and MF typically require less overall footprint	3	9
Minimize shutdowns	• Requires consistent, good secondary effluent quality, but could accommodate a wider range than the gravity deep bed filters due to the continuous backwashing	4	16
Reduce turbidity & TDS	• Turbidity will be less than 2 NTU, but not as low as full MF • Does not reduce TDS without sidestream MF and RO	4	20
Minimize blending	• With sidestream MF and RO, blending will be minimized	5	20
Life-cycle cost	• Twenty-year lifecycle cost = $7.8M	3	12
		Total Weighted Score	**97**

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Disk Filters

Table 11 is a summary of the scores for the alternative of retrofitting disk filters into the existing filter structure. Included are both the scores as well as a description of the rationale behind the score.

Table 11 Evaluation Summary for Disk Filters in Existing Filter Structure with Sidestream MF

Criteria	Rationale	Score	Weighted Score
O&M and safety	• Potentially awkward configuration in an attempt to retrofit in existing filter structure • Common technology, typically automated and operator friendly • No requirement for shutdowns due to backwash cycles	4	20
Optimize site layout	• Ongoing use of full existing site, while total flow may result in less site footprint required if alternatives were chosen	4	12
Minimize shutdowns	• Requires consistent, good secondary effluent quality • Will require shutdowns if secondary effluent quality is poor	3	12
Reduce turbidity & TDS	• Turbidity will be less than 2 NTU, but not as low as full MF • Does not reduce TDS without sidestream MF and RO	3	15
Minimize blending	• With sidestream MF and RO, blending will be minimized	5	20
Life-cycle cost	• Twenty-year lifecycle cost = $5.8M	4	16
		Total Weighted Score	**95**

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Membrane Filtration (MF)

Table 12 is a summary of the scores for the full MF alternative. Included are both the scores as well as a description of the rationale behind the score.

Table 12 Evaluation Summary for MF with Sidestream MF

Criteria	Rationale	Score	Weighted Score
O&M and safety	• Completely enclosed MF vessels • Skid shutdowns required due to backwash cycles • Chemicals onsite for MF CIP	4	20
Optimize site layout	• Can fit into tight site footprint • Does not require an additional sidestream MF system	4	12
Minimize shutdowns	• Can accommodate variations in secondary effluent water quality • Consistently provides excellent effluent water quality	5	20
Reduce turbidity & TDS	• Provides best turbidity of all the filtration options • Provides additional bacteria removal as compared with other filtration options • Does not reduce TDS without sidestream RO	5	25
Minimize blending	• With sidestream RO, blending will be minimized	5	20
Life-cycle cost	• Twenty-year lifecycle cost = $7.9M	3	12
		Total Weighted Score	**109**

Note: 1 = lowest score or least benefit, 5 = highest score or greatest benefit

Evaluation Summary

In summary, five alternatives were analyzed. These include the following.

- Gravity deep bed filters (i.e. rehabilitation of existing filters) with sidestream MF
- Upflow continuous backwash media filters in the existing filter structure with sidestream MF
- Upflow continuous backwash media filters in a new filter structure with sidestream MF
- Disk filters in the existing filter structure with sidestream MF
- MF for the full filtration flow

Table 13 summarizes the cost evaluation of the various alternatives.

Table 13 Lifecycle Cost Evaluation Summary

	Rehab Existing Filters/ Sidestream MF	Upflow in Existing / Sidestream MF	New Upflow/ Sidestream MF	Disk Filters in Existing/ Sidestream MF	Full MF
Capital Cost	$4.9M	$4.8M	$6.6M	$4.6M	$6.5M
Yearly O&M Cost	$0.08M	$0.08M	$0.08M	$0.08M	$0.1M
20-Year Life-cycle cost	$6.1M	$6M	$7.8M	$5.8M	$7.9M
Life-cycle cost score*	4	4	3	4	3

Table 14 provides the complete filtration assessment scores for each alternative.

Table 14 Evaluation Summary

Criteria	Weight	Rehab Existing Filters/ Sidestream MF	Upflow in Existing / Sidestream MF	New Upflow/ Sidestream MF	Disk Filters in Existing/ Sidestream MF	Full MF
O&M and safety	5	3	3	4	4	4
Optimize site layout	3	2	2	3	4	4
Minimize shutdowns	4	3	4	4	3	5
Reduce turbidity & TDS	5	3	4	4	3	5
Minimize blending	4	5	5	5	5	5
Life-cycle cost	4	4	4	3	4	3
Total Score		84	93	97	95	109

Recommendation

Based on the evaluation criteria and filter scores, the full MF alternative is the recommended technology to proceed with for preliminary design. MF will provide excellent water quality for recycled water users and is a sufficient pretreatment for sidestream RO.

Figure 14 shows a conceptual site layout for the full MF system, with a sidestream of RO treatment in the solids handling building.

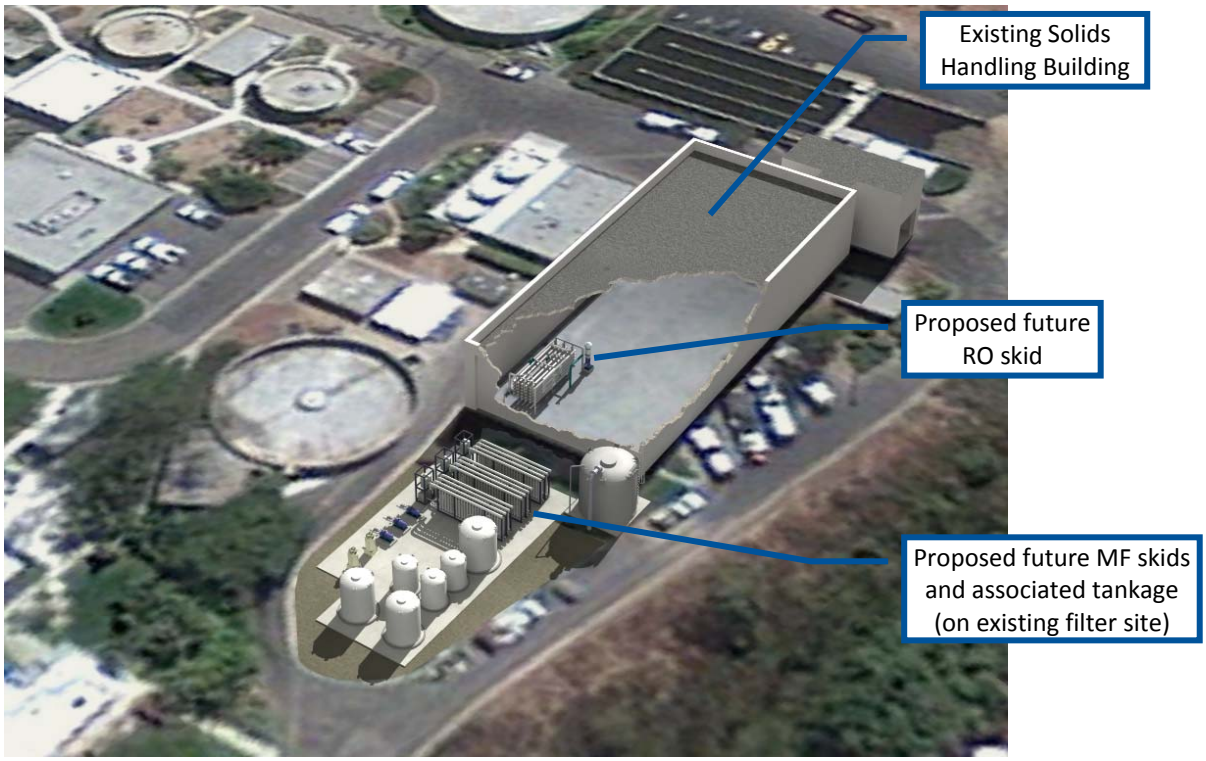

Figure 14. Conceptual MF layout

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