City of Santa Barbara

RECYCLED WATER MARKET ASSESSMENT REPORT

FINAL | September 2022

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Abbreviations

ac-ft	acre-feet
AFY	acre-feet per year
ADD	average day demand
ADWF	average dry weather flows
ALs	action levels
AOP	advanced oxidation process
AWPF	advanced water purification facility
AWTOs	advanced water treatment operators
BAC	biologically enhanced activated carbon
CAPEX	capital expenditures
Carollo	Carollo Engineers, Inc.
CEC	contaminants of emerging concern
CEQA	California Environmental Quality Act
City	City of Santa Barbara
Corp. Yard	the City's Corporation Yard
DBP	disinfection byproduct
DDW	Division of Drinking Water
DPR	direct potable reuse
El Estero	El Estero Water Resource Center
EPA	Environmental Protection Agency
ft	feet
gpcd	gallons per capita day
gpm	gallons per minute
HOA	homeowners' association
hp	horsepower
lf	linear feet
MCL	maximum contaminant level
MDD	maximum day demand
MG	million gallons
mgd	million gallons per day
MMD	maximum month demand
MSD	Montecito Sanitary District
MWD	Montecito Water District
NDMA	N-Nitrosodimethylamine
NL	notification level
NOAA	National Atmospheric and Oceanic Administration

NPR	non-potable reuse
O&M	operations and maintenance
OPEX	operating expenditures
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
PHD	peak hour demand
RO	reverse osmosis
SBCAG	Santa Barbara County Association of Governments
SLR	sea level rise
SWP	State Water Project
SWRCB	State Water Resource Control Board
TOC	total organic carbon
UF	ultrafiltration
UV	ultraviolet
WRP	water reclamation plant
WWTP	wastewater treatment plant
WTP	water treatment plant

Section 1

INTRODUCTION AND EXISTING RECYCLED WATER SYSTEM

1.1 Introduction and Study Purpose

The City of Santa Barbara (City) is located between the Pacific Ocean and the Santa Ynez Mountains in Santa Barbara County, about 90 miles north of Los Angeles. The City is a coastal community of approximately 90,000 residents, encompassing 21 square miles, with varied topography ranging from steep mountain terrain to an ocean basin. The City maintains an 11 million gallons per day (mgd) wastewater treatment plant (WWTP) known as El Estero Water Resource Center (El Estero), which provides non-potable recycled water service to 119 sites, primarily for irrigation use. Recycled water, distributed to non-potable reuse (NPR) customer sites, is a key resource in the City to offset demands on the City's potable water supply.

In addition to recycled water, the City maintains a diverse water supply portfolio which includes the following sources:[1]

- **Surface Water:** The City receives potable water supply from Lake Cachuma, the Gibraltar Reservoir, and Devil's Canyon Creek. Surface water from these sources is treated at Cater Water Treatment Plant (WTP) which has a 37 mgd capacity. Cater WTP also provides treated drinking water to Montecito Water District (MWD) and Carpinteria Valley Water District.
- **State Water Project (SWP):** The City's SWP allocation is 3,300-acre-feet per year (AFY). This water is treated at Cater WTP.
- **Groundwater:** The City pumps groundwater from three hydrogeologic basins. Pumping from groundwater is generally used during periods of drought when surface water supplies are diminished.
- **Desalinated Water:** The City's Charles E. Meyer desalination facility was constructed as a drought supply in the late 1980s. During the recent drought, the facility was reactivated and can produce up to 3,125 AFY. A policy change in the City's 2020 Enhanced Urban Water Management Plan changed desalinated water from a drought supply to a regular component of the City's water supply portfolio.

The purpose of this study is to identify possible expansion options to serve non-potable recycled water to existing potable customers, evaluate cost effectiveness for recycled water system expansion options, and provide a cost effectiveness and uncertainty comparison for non-potable recycled water expansion versus potable reuse or desalination. The report is organized as follows:

- Section 1 – Existing Recycled Water System.
- Section 2 – New Recycled Water Demand.
- Section 3 – Recycled Water Cost Effectiveness Analysis.
- Section 4 – Potable Reuse.

[1] Water Systems Consulting (2020), *2020 Enhanced Urban Water Management Plan.*

- Section 5 – Uncertainty Evaluation.
- Section 6 – Conclusions and Recommendations.

1.2 Treatment and Distribution

Tertiary treated recycled water is produced at El Estero. Based on flow data analyzed from 2017 to 2021, the average influent flow to El Estero is 6.15 mgd, well below the design capacity of 11 mgd. The average daily recycled water demand from 2017 through 2021 is 0.6 mgd. The maximum rate of production of recycled water is limited to 4.3 mgd due to capacity constraints in the El Estero disinfection system and onsite storage. The City's recycled water treatment and distribution system consists of:

- El Estero.
- Four pump stations.
- Two storage reservoirs.
- Approximately 14 miles of distribution piping, ranging in diameter from 4- to 18-inches.

Figure 1 shows the existing recycled water users and distribution system.

1.3 Existing Demand

In 2021, the City provided approximately 756 acre-feet (ac-ft) of recycled water to 119 sites and 12 recycled water fill stations for metered trucks to use for street sweeping, dust control, wastewater main cleaning, and other uses. In addition, the recycled water produced is also used at El Estero for process water and routine cleaning and washdown of plant processes. Plant process water is the largest single use of recycled water in the City's system. Currently, approximately 300 AFY of produced recycled water is used for process water at El Estero. The following uses were considered when quantifying existing recycled use in this assessment:

- **El Estero plant process water:** Monthly recycled water use data from 2017 through 2021 were provided by the City. However, due to plant upgrades and associated adjustments to process water use that occurred in 2017 and 2018, data from 2019 through 2021 was considered the average anticipated recycled water use at El Estero. Plant staff also noted that conservation may be feasible in the future by use of secondary effluent water in lieu of recycled water for plant processes. This potential for conservation was accounted for when quantifying the existing recycled water use.
- **Existing user accounts:** Monthly recycled water use data from 2017 through 2021 was provided by the City. Recycled water use for each month was totaled and averaged over the time period of available data.
- **La Cumbre Country Club:** The City recently entered into a water sales agreement with La Cumbre Mutual Water Company (La Cumbre) to provide recycled water to La Cumbre Country Club. Deliveries to La Cumbre began in March 2022. While no historical water use data is yet available, the contract provided anticipated monthly recycled water use. These monthly totals were incorporated into the existing system demands.

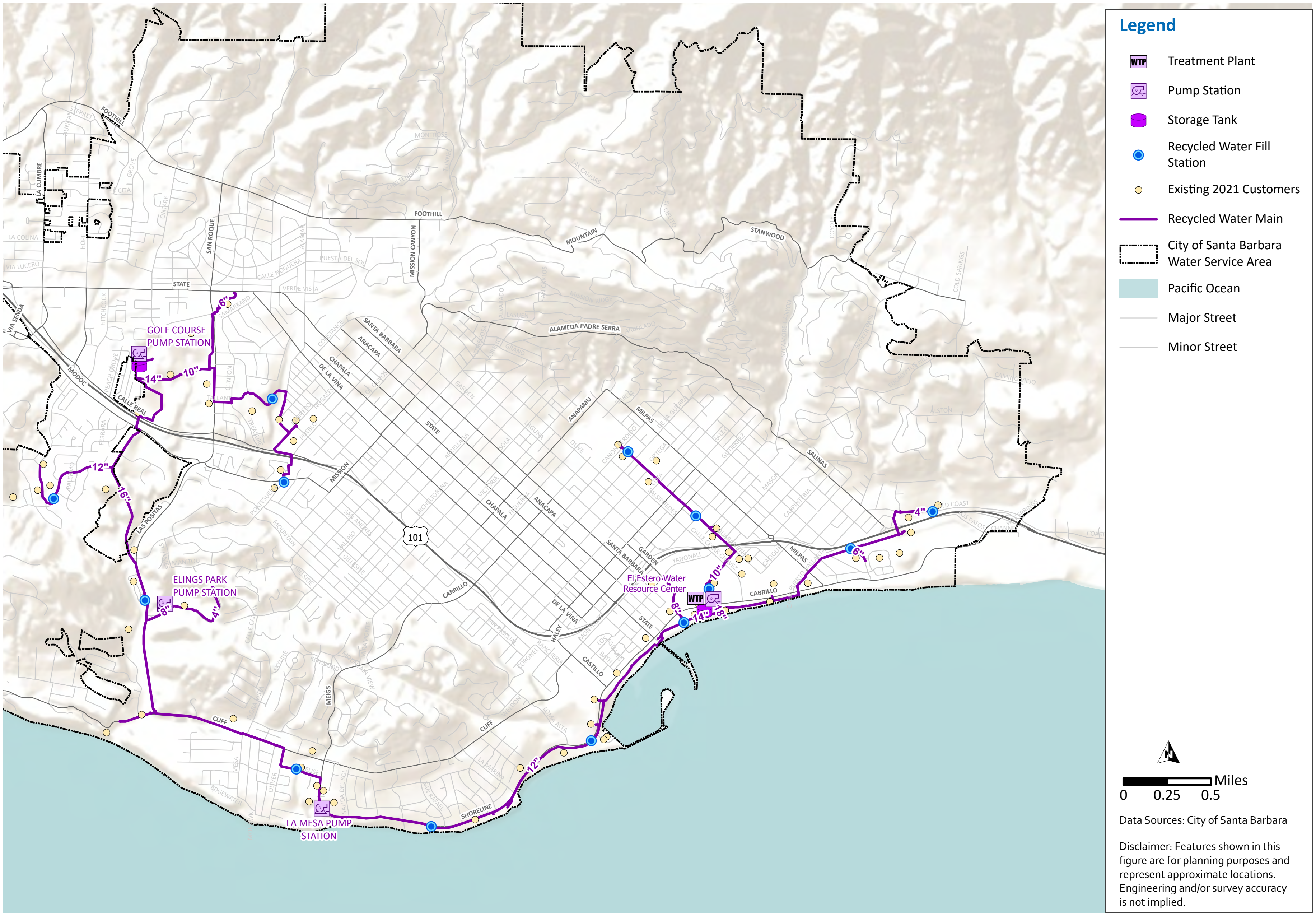

Figure 1 Existing Recycled Water System and Users

Table 1 shows the existing recycled water demands for the El Estero process water, the top ten existing user accounts, La Cumbre Country Club, and the remaining user accounts in the recycled water system.

Table 1 Existing Annual Recycled Water Use

Customer	2017 to 2021 Average Annual Demand (AFY)	
	Total With El Estero Process Water Update	Total Without El Estero Process Water Update
El Estero Process Water[(1)]	191	301
Montecito Country Club	203	
Santa Barbara Golf Club	147	
La Cumbre Country Club[(2)]	111	
Santa Barbara Community College	35	
Valle Verde (retirement community)	32	
Elings Park	24	
Hilton Santa Barbara Beachfront Resort	20	
Santa Barbara Junior High	20	
Pershing Park	18	
La Cumbre Junior High School	16	
Santa Barbara High School	15	
Remaining Accounts	170	
Total	**1,002**	**1,112**

Notes:
(1) The low end of the process water range accounts for 3 million gallons (MG) (approximately 9 AF) per month of tertiary-treated recycled water conservation by using secondary effluent for tank filling and blower cooling water. The high end of range is the average demand from 2019-2021 data.
(2) La Cumbre demand is expected demand, not historical demand.

Figure 2 shows the historical monthly uses of the existing recycled water users, plant process water, and recycled water production. Note that La Cumbre Country Club water is not included in these quantities, as these demands are not yet reflected in the El Estero production data.

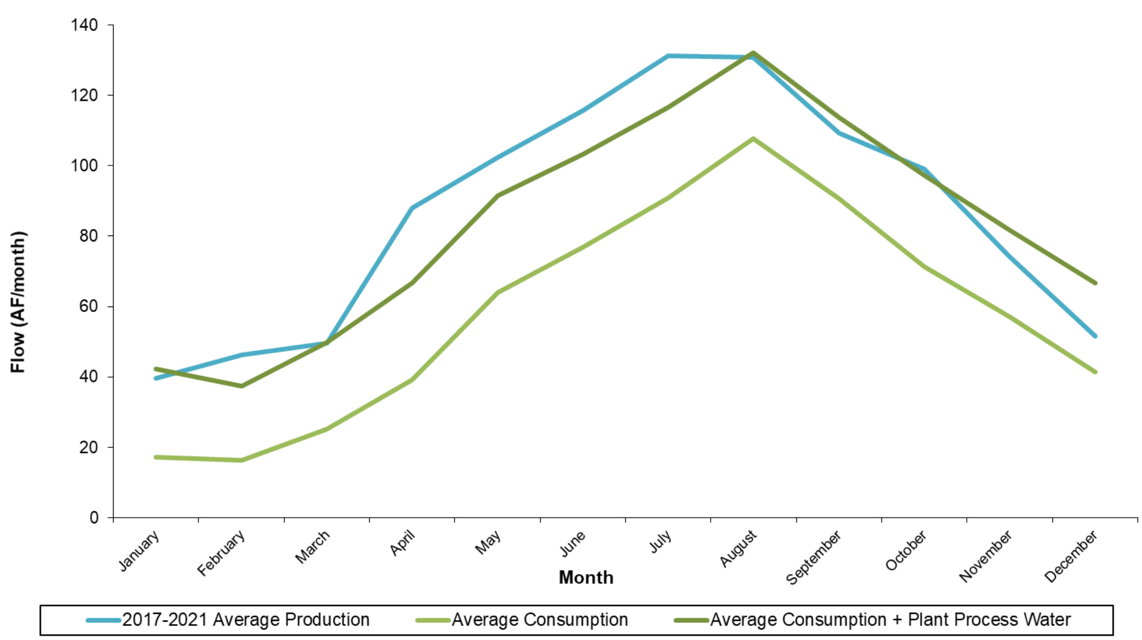

Figure 2 Monthly Recycled Water Production and Consumption

Recycled water at El Estero is produced to meet system demands. On average, the deficit between production and consumption is around 5 percent of total production, which is reflective of typical recycled water system loss. There are portions of the year where it appears that consumption and plant process water use exceeds production which is likely due to a difference in timing of when production meters are read and when customer meters are read.

1.4 Recycled Water Available for New Customers

Recycled water is produced in response to existing demands. Storage (670,000 gallons) and potable blend water, when needed, are used to accommodate hourly fluctuation in demand. The capacity for recycled water production is 4.3 mgd, based on the capacity of the El Estero disinfection system and onsite storage.

Figure 3 shows the recycled water use by month for 2017 to 2021 for the existing user accounts and El Estero process water. La Cumbre Country Club was not connected in these years and is thus not accounted for in the demands.

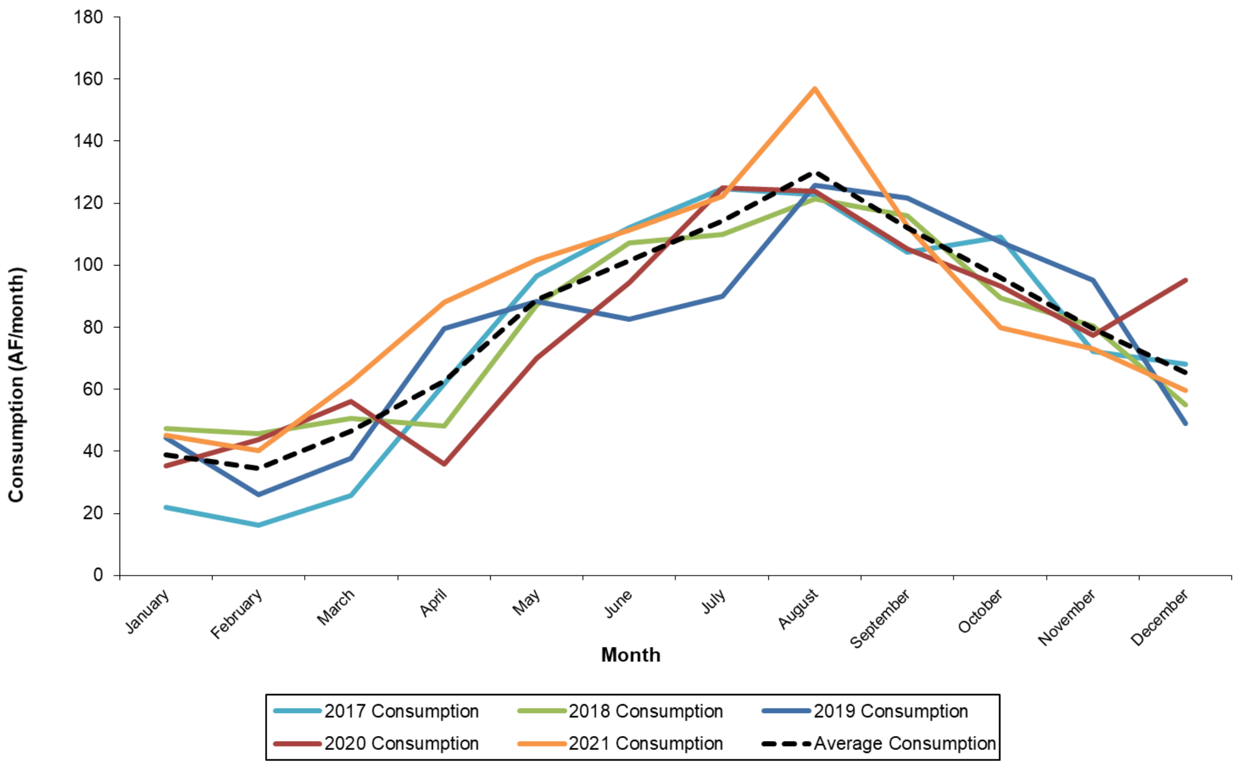

Figure 3 Existing Recycled Water Use

Interannual variance is primarily due to fluctuating irrigation needs in response to climate variability. For example, 2021 was a particularly dry year and thus has greater recycled water use compared to previous years in the dataset. The average annual demand is about 1,100 AFY, with peak monthly demands occurring in August. Peak demands in August are approximately 2.1 times the average consumption throughout the year. Table 2 depicts the corresponding average annual, maximum month, maximum day, and peak hour demands (PHD) for the major existing recycled water use categories and the anticipated La Cumbre Country Club use. Maximum month demand (MMD) are the average demands in the peak month (August). Maximum day demand (MDD) and PHD were developed using typical peaking factors discussed in greater detail in Section 2.2.

Table 2 Existing Recycled Water User Peak Demands

User	Average Annual Demand (AFY)	MMD (ac-ft)	MDD (mgd)	PHD (gpm)
El Estero Process Water	301	24.5	0.54	-(1)
La Cumbre Country Club	111	20.7	0.46	-(1)
Other Irrigation Customers	700	107.7	2.38	4,950
Total	**1,112**	**152.9**	**3.38**	**-**

Note:
Abbreviation: gpm – gallons per minute.
(1) Water used for El Estero and La Cumbre Country Club is assumed to be approximately constant throughout the day so there is no PHD added.

The MDD of the existing users is used to quantify the remaining capacity for new recycled water users as this is, in theory, the highest demand the system would experience in a given day. The total MDD of the existing system is 3.37 mgd, lower than the recycled water production capacity of 4.3 mgd, leaving approximately 0.9 mgd of peak demand capacity for new recycled water users to be added. Note that additional capacity is available in off-peak months that could be used to meet the needs of customers that do not follow typical seasonal irrigation patterns. The highest flows are represented by PHD. These can be accommodated and buffered by the existing recycled water storage at El Estero.

Section 2

NEW RECYCLED WATER DEMAND

2.1 Potential New Customer Screening

An initial screening identified potential new recycled water customers through the following methods:

1. Potable Water Billing Data: Potable water billing data from 2017 through 2021 were compiled to find customers using more than 10 AFY of water.
2. City Identified: Sites identified through City recommendation or through user interest.

Initially, over 50 potential new recycled water users were identified. Users were grouped by customer type and assigned a percentage, based on engineering judgement and experience with similar systems, to identify an approximate proportion of their potable water usage that could be converted to non-potable recycled water supply. For example, irrigation uses could be supplied entirely by non-potable recycled water, but a much smaller portion of a school's demands could use non-potable water. Table 3 shows the anticipated recycled water use percentages for each identified user type. Note that typical single family residential customers are not considered as candidates for conversion to recycled water since their demand is usually too low to justify extension of and connection to the recycled water system and since residential customers are not equipped to implement all of the regulatory requirements of a recycled water user.

Table 3 Recycled Water Percentages

Customer Type	Potential Recycled Water Use Percentage
Irrigation(1)	100%
Garden(2)	80%
Commercial Laundry(3)	90%
Institution	30%
Cooling Tower	10%
Public Laundromat(3)	0%
Healthcare	0%
Apartment	0%

Notes:
(1) Irrigation customers and the associated anticipated 100 percent recycled water use percentages are for irrigation-only meters.
(2) Garden customer type includes the Santa Barbara Zoo.
(3) The California Title 22 Recycled Water Code allows for commercial laundry facilities to use recycled water for operations. Public-use laundromats are prohibited from using recycled water and were thus removed from consideration. Note that this would be a new recycled water use within the City and may require additional education.

The recycled water percentages screened out certain types of users, such as healthcare facilities and apartment buildings, from consideration altogether as these users are assumed to not have a significant amount of irrigation or other Title 22 recycled water-approved non-potable water use. In addition, four identified sites were eliminated due to distance from the existing recycled water infrastructure and elevation. Each of these eliminated sites were over a mile away from the existing recycled water transmission mains, and at least 200-feet elevation above sea level. Providing recycled water service to these sites would require a significant amount of additional piping and/or pumping. By contrast, the sites carried forward for consideration were less than a mile from the existing pipeline and 75-feet elevation above sea level, on average.

Figure 4 shows the users selected for further analysis for potential recycled water conversion.

2.2 Peaking Factors

The following peaking factors were assumed based on analysis of existing billing records and industry standards for non-potable recycled water systems:

- Average Day Demand (ADD): Developed using existing billing records, based on monthly water use.
- MMD: Based on historical recycled water billing data.
- MDD = 2.1 x ADD and 1.2 x MMD, based on typical MDD for industry.
- Peak Hour Demand = 2.0-3.0 x MDD:
  - 3.0 assumes approximately 8-hour recycled water use per day (e.g., irrigation).
  - 2.0 assumes approximately 12-hour recycled water use per day (e.g., commercial laundry sites).

An example calculation for a potential irrigation user is shown below.

- ADD = 9.4 AFY = 0.008 mgd.
- MDD = 2.1 x 0.008 mgd = 0.018 mgd.
- PHD = 3.0 x 0.018 = 0.053 mgd = 36.6 gpm.

2.3 Selected Potential New Customers and Demands

Table 4 shows the selected potential recycled water customers carried forward for further consideration.

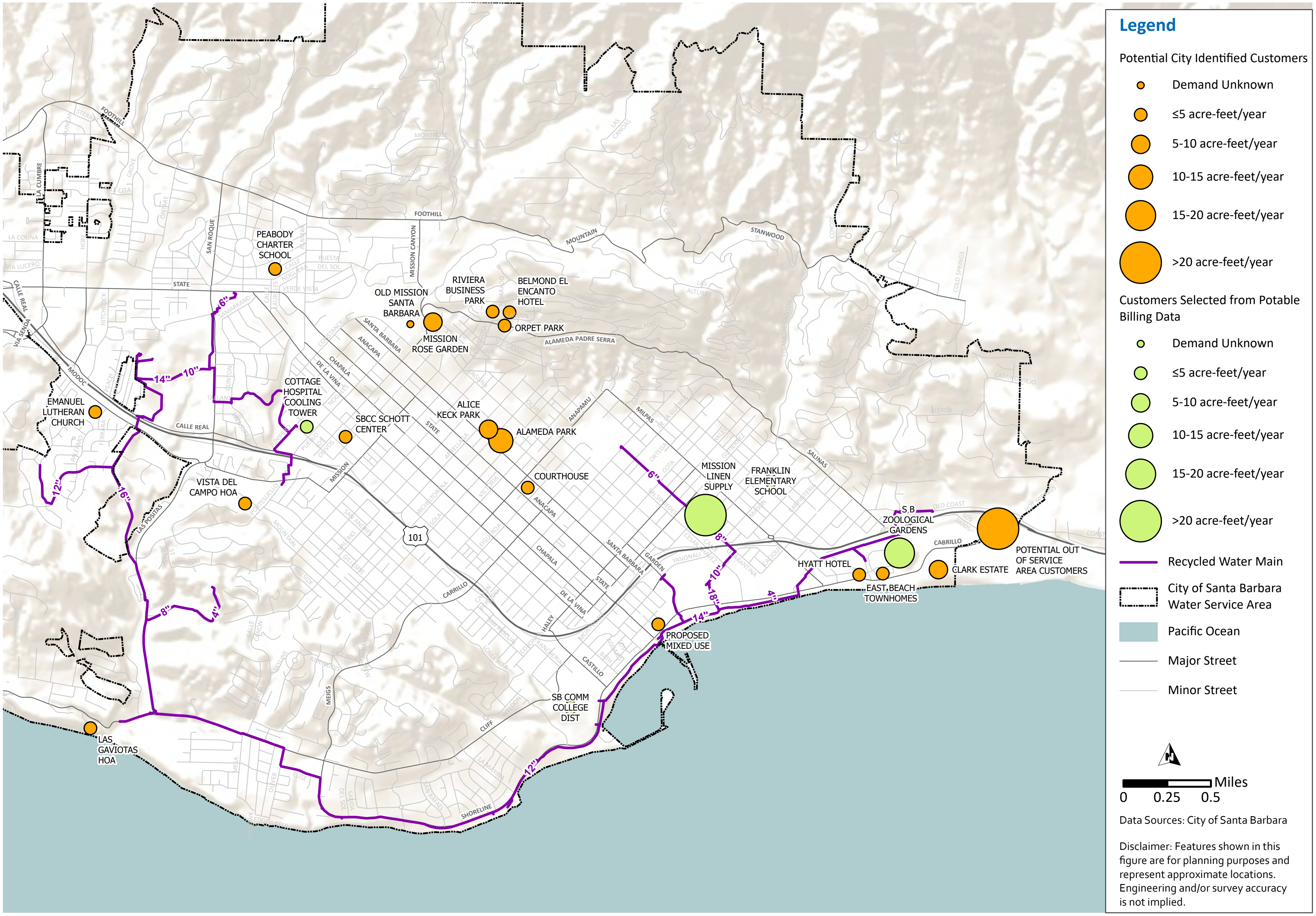

Figure 4 Selected Recycled Water Users

Table 4 Potential New Recycled Water Customers

Customer Name	Customer Type	Annual Potable Water Usage (AFY)	Recycled Water Use Percentage	Annual Recycled Water Usage (AFY)	Recycled Water MDD (mgd)	Recycled Water PHD (gpm)
Potential Out of Service Area Customers(1)	Irrigation	Unknown	100%	45.0	0.08	175.69
Mission Linen Supply	Commercial Laundry	35.0	90%	31.5	0.06	81.98
Mission Santa Barbara	Garden	19.2	80%	15.4	0.03	59.94
Santa Barbara Zoo(2)	Garden	18.7	80%	15.0	0.03	58.39
Alameda Park	Irrigation	12.5	100%	12.5	0.02	48.80
Courthouse	Irrigation	9.4	100%	9.4	0.02	36.56
Riviera Business Park	Irrigation	6.9	20%	6.9	0.01	26.77
Mission Rose Garden	Irrigation	6.4	100%	6.4	0.01	24.86
Cottage Hospital	Cooling Tower	55.0	10%	5.5	0.01	21.47
Alice Keck Park Memorial Gardens	Irrigation	5.4	100%	5.4	0.01	21.21
Peabody Charter School	Institution	4.5	100%	4.5	0.01	17.53
Franklin Elementary School	Institution	11.0	30%	4.1	0.01	16.01
Clark Estate	Irrigation	3.8	100%	3.8	0.01	14.71
East Beach Townhomes	Irrigation	3.6	100%	3.6	0.01	14.02
SB Community College(2)	Institution	11.2	30%	3.4	0.01	13.15
El Encanto Hotel	Irrigation	3.1	100%	3.1	0.01	12.10
Hyatt Hotel	Irrigation	2.8	100%	2.8	0.01	10.84
Orpet Park	Irrigation	2.1	100%	2.1	0.004	8.12
Vista Del Campo HOA	Irrigation	1.7	100%	1.7	0.003	6.61
Las Gaviotas HOA	Irrigation	0.9	100%	0.9	0.002	3.38
Emanuel Lutheran Church	Institution	2.3	30%	0.7	0.001	2.66
Schott Center	Institution	2.0	30%	0.6	0.001	2.33
			TOTAL	**183.9**	**0.34**	**677.14**

Notes:
Abbreviation: HOA = homeowners' association.
(1) Potential Out of Service Area recycled water users and associated estimated recycled water demand derived from the Montecito Recycled Water Facility Plan (Woodard & Curran, 2019).
(2) Customer is already served recycled water and has the potential for expanded recycled water service.

Section 3

COST EFFECTIVENESS ANALYSIS

3.1 System Expansion Segments

To evaluate the feasibility of expanding the City's non-potable recycled water system, several pipeline segments were conceptually routed to serve recycled water to the potential recycled water customers shown in Table 4. These pipeline segments were developed with the objective of cost-effectiveness, by serving the largest volume of recycled water with the shortest possible distribution system extension.

Note that while they would not require extensions of the existing recycled water system, the Santa Barbara Zoo and Community College, both existing customers, were identified as customers for whom recycled water service could be expanded without extensive modifications to the existing recycled water distribution system. Because expanding service to these customers would not require the construction of additional pipelines, they have not been included in any expansion segments. However, expanding service to these customers is likely one of the most cost-effective methods of expanding the existing recycled water system, particularly if one of these customers undertakes a major capital improvement project which also allows for the incorporation of additional recycled water.

Each recycled water system expansion segment is described below, shown in Figure 5, and summarized in Table 5. All pipeline segments extend the existing recycled water main to reach one or more new customers.

- Segment 1A extends from the recycled water main along North Quarantina Street to East Yanonali Street to serve Mission Linen Supply. This segment consists of approximately 200 feet of pipeline and would serve an estimated 32 AFY of recycled water demand to Mission Linen.
- Segment 1B extends from the recycled water main along North Quarantina Street to East Yanonali Street to serve Mission Linen Supply and then continues up East Yanonali Street to serve Franklin Elementary School. This segment consists of approximately 3,200 feet of pipeline and would serve an estimated 36 AFY of recycled water to customers.
- Segment 2 extends from the recycled water main along Ninos Drive to serve the Hyatt Hotel and the East Beach Townhomes. It then turns along East Cabrillo Boulevard to serve the Clark Estate, and potential out-of-service-area customers that border the City's service area. This segment consists of approximately 5,400 feet of pipeline and would serve an estimated 55 AFY of recycled water to customers.
  - Note that serving customers outside of the City's existing water service area require special considerations. Serving recycled water to these customers would necessitate an agreement with their current water provider.
- Segment 3A extends from the current recycled water main terminus on North Quarantina Street by turning on to East Cota Street and then turning on to Santa Barbara Street to serve the Courthouse, Alameda Park, and Alice Keck Park Memorial Gardens. This segment consists of approximately 5,700 feet of pipeline and would serve an estimated 27 AFY of recycled water to customers. Implementation of this segment may require the construction of a new pump station.
- Segment 3B includes Segment 3A and continues on along East Cota Street, where it would eventually bifurcate, with one branch going up East Pedregosa Street to serve the Belmond El

Encanto Hotel, Orpet Park, and the Riviera Business Park and the other branch going up East Los Olivos Street to serve the Old Mission Santa Barbara and the Mission Rose Garden. This segment consists of approximately 13,200 feet of pipeline and would serve an estimated 61 AFY of recycled water to customers. Implementation of this segment would also require the construction of a new pump station.

- Segments 4A-4D are all relatively short pipeline segments that extend off of the northwest portion of the existing recycled water system to each serve one or two customers. These segments could be implemented as a group or independently. Implementation of any of these segments may require the construction of new pump stations.
  - Segment 4A would branch off from the existing recycled water main on Veronica Springs Road and go up Modoc road to serve Emanuel Lutheran Church. This segment consists of approximately 1,300 feet of pipeline and would serve 1 AFY of recycled water to Emanuel Lutheran Church.
  - Segment 4B would continue from the existing recycled water main terminus on State Street and then turn on West Calle Laureles to serve Peabody Charter School. This segment consists of approximately 1,400 feet of pipeline and would serve an estimated 5 AFY to Peabody Charter School.
  - Segment 4C would extend from the existing recycled water main terminus down Oak Park Lane and then would turn on West Padre Street to serve the Santa Barbara Community College's Schott Center. This option also includes expanding service to the Santa Barbara Cottage Hospital for cooling tower use, which would require a relatively short additional segment of pipe for the existing service line to the hospital. This segment consists of approximately 2,400 feet of pipeline to serve an estimated 6 AFY of recycled water to customers.
  - Segment 4D would extend from the existing recycled water main terminus down Portesuello Avenue to serve the Vista Del Campo HOA. This segment consists of approximately 1,300 feet of pipeline and would serve an estimated 2 AFY of recycled water to the Vista Del Campo HOA.
- Segment 5 would extend from the existing recycled water main terminus on Cliff Drive to serve the Las Gaviotas HOA. This segment consists of approximately 1,200 feet of pipeline and would serve an estimated 1 AFY of recycled water demand to the Las Gaviotas HOA. Implementation of this segment may require the construction of a new pump station.

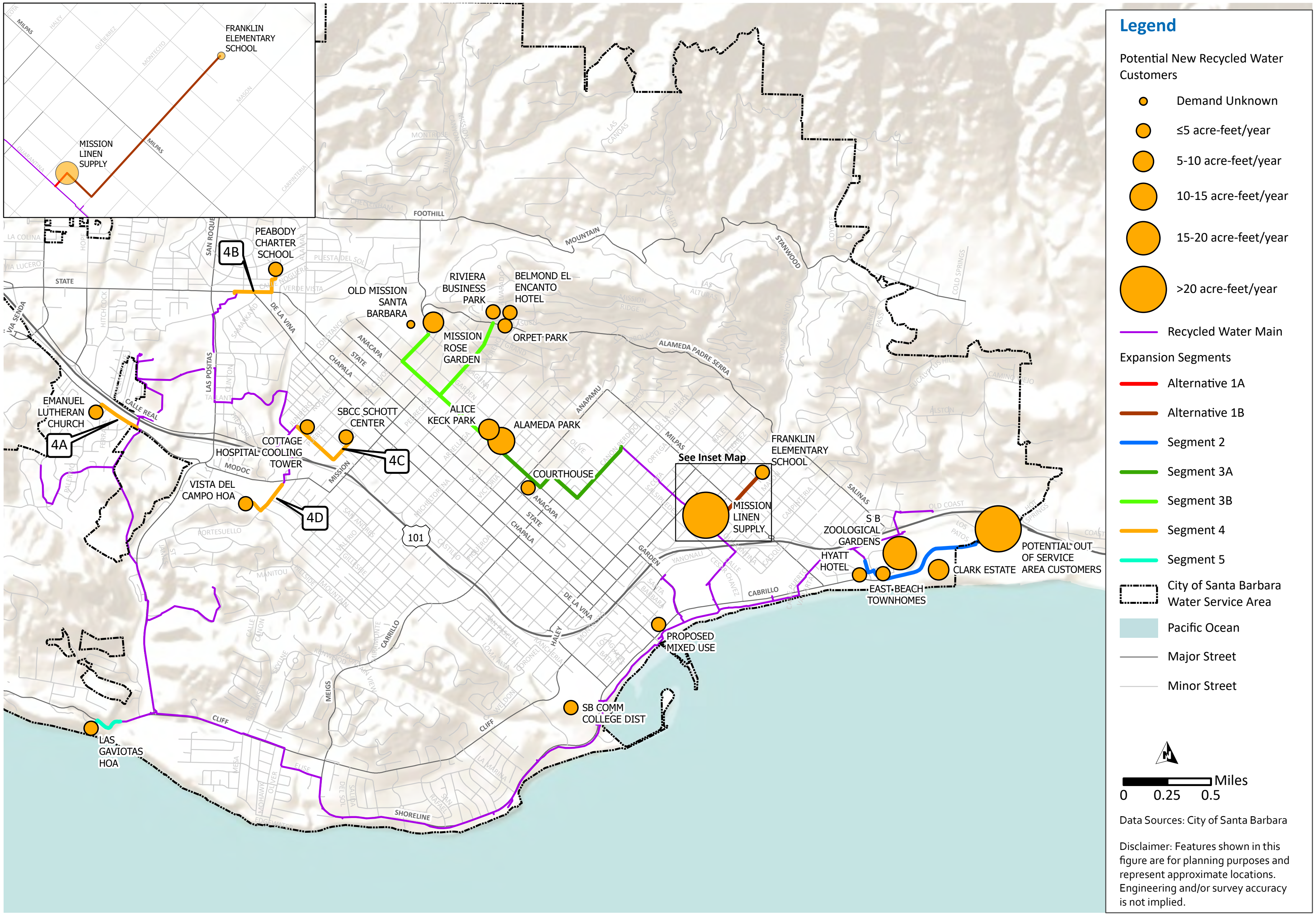

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Table 5 Potential Recycled Water Users, Total Demand, and Pipeline Length by Segment

Customer Name	Estimated Recycled Water Demand (AFY)	Segment									
		1A	1B	2	3A	3B	4A	4B	4C	4D	5
Potential Out of Service Area Customers[(1)]	45.0			✓							
Mission Linen Supply	31.5	✓	✓								
Mission Santa Barbara	15.4					✓					
Alameda Park	12.5				✓	✓					
Courthouse	9.4				✓	✓					
Riviera Business Park	6.9					✓					
Mission Rose Garden	6.4					✓					
Cottage Hospital	5.5								✓		
Alice Keck Park Memorial Gardens	5.4				✓	✓					
Franklin Elementary School	4.1		✓								
Peabody Charter School	4.5							✓			
Clark Estate	3.8			✓							
East Beach Townhomes	3.6			✓							
El Encanto Hotel	3.1					✓					
Hyatt Hotel	2.8			✓							
Orpet Park	2.1					✓					
Vista Del Campo HOA	1.7									✓	
Las Gaviotas HOA	0.9										✓
Emanuel Lutheran Church	0.7						✓				
Santa Barbara Community College Schott Center	0.6								✓		
Total Potential Recycled Water Demand (AFY)	166	32	36	55	27	61	1	5	6	2	1
MDD (mgd)	0.31	0.06	0.07	0.10	0.05	0.11	0.001	0.01	0.01	0.003	0.002
PHD (gpm)	606	82	98	215	107	239	3	18	24	7	3
Total Pipeline Length (ft)	-	200	3,200	5,400	5,700	13,200	1,300	1,400	2,400	1,300	1,200

Note:
(1) Potential Out of Service Area Customers and associated estimated recycled water demand derived from the Montecito Recycled Water Facility Plan (Woodard & Curran, 2019).

3.2 Segment Sizing and Cost Estimating Assumptions

The potential new recycled water pipeline segments would be comprised of 4-inch and 6-inch diameter pipes as determined for each segment through hydraulic calculations considering the estimated demand served, pipeline distance, system pressure at connection point, and elevation change from the connection point to the customer.

The assumed unit costs of these pipes as well additional costs associated with connecting additional customers are included in Table 6, and construction cost markup assumptions are listed in Table 7. The operations and maintenance (O&M) unit cost included in this analysis considers the recycled water O&M cost from 2017 through 2021 and includes salaries and benefits for O&M staff, equipment repairs, and general facility O&M. During this time, the City served approximately 700 AFY of recycled water to customers off site from El Estero for an average cost of approximately $1,036,000 per year. This results in a unit O&M cost of $1,500 per ac-ft.

While the annual unit O&M cost ($1,500/AF) is used for comparative costs associated with adding new customers to the recycled water system, the full cost associated with recycled water production should consider anticipated capital costs to keep the system operational. This annual "fully loaded" unit cost for recycled water production is approximately $3,050/ac-ft and accounts for O&M costs in addition to previous and anticipated treatment and pump station capital costs. Additionally, the cost to replace the entire existing recycled water distribution system is estimated to be approximately $22 million and will need to be planned for in future capital budgets. These annual unit costs are based on the current average recycled water demand delivered to customers of approximately 700 AFY.

Table 6 Construction Unit Cost Assumptions

Component	Unit Cost(1)
Pipelines	
4-in diameter ($/lf)	$153
6-in diameter ($/lf)	$200
8-in diameter ($/lf)	$210
10-in diameter ($/lf)	$258
12-in diameter ($/lf)	$269
16-in diameter ($/lf)	$360
20-in diameter ($/lf)	$452
Pump Stations(2)	
100 hp and smaller ($/hp)	$15,100
100 hp – 600 hp ($/hp)	$9,700
Other	
NPR Connection Cost per Customer	$14,000

Note:
Abbreviations: lf – linear feet; hp – horsepower.
(1) Pipeline and pump station unit costs are escalated from the Water Distribution Infrastructure Plan (Carollo Engineers, Inc., 2021) using an Engineering News Record Construction Cost Index Greater Los Angeles of 13,341 (April 2022).
(2) Pump station costs are included in DPR system cost calculations.

Table 7 Construction Cost Markup Assumptions

Markup	Percentage
Contingency	30%
Construction Cost Adders	
Engineering	10%
Construction Management	10%
Environmental and Legal	7.5%
Construction Cost Markup	27.5%
Total Compounded Mark-up Coefficient(1)	**66%**

Note:
(1) Total markup is calculated by compounding the construction cost adders on top of the total project cost + contingency.

3.2.1 Recycled Water Expansion Segment Cost Estimates

The total and unit cost, expressed in dollar per ac-ft, for each recycled water expansion segment was calculated using the cost estimate assumptions listed above. Construction costs were amortized over 15- and 30-year periods using a discount rate of 3.5 percent. The amortized construction cost are added to annual O&M costs to calculate annual life cycle unit costs. The estimated total capital cost, annual O&M cost, and life cycle unit cost estimate for each segment is summarized in Table 8.

Table 8 Segment Unit Costs

Segment	Demand (AFY)	Capital Cost ($M)	O&M Cost $1500/ac-ft ($/Year)	30 Year Amortized Annual Cost (3.5%) ($/Year)	30 Year Unit Cost ($/ac-ft)	15 Year Amortized Annual Cost (3.5 %) ($/Year)	15 Year Unit Cost ($/ac-ft)
1A	32	$0.08	$47,800	$4,300	$1,600	$6,900	$1,700
1B	36	$1.11	$53,800	$60,400	$3,200	$96,400	$4,200
2(1)	55	$1.91	$82,200	$103,800	$3,400	$165,800	$4,500
3A(2)	27	$1.96	$40,400	$106,600	$5,400	$170,200	$7,800
3B(2)	61	$4.57	$91,200	$248,500	$5,600	$396,800	$8,000
4A(2)	1	$0.36	$1,500	$19,600	$21,100	$31,300	$32,800
4B(2)	5	$0.38	$7,500	$20,700	$5,600	$33,000	$8,100
4C(2)	6	$0.66	$9,000	$35,900	$7,500	$57,300	$11,000
4D(2)	2	$0.36	$3,000	$19,600	$11,300	$31,300	$17,100
5(1)	1	$0.33	$1,500	$17,900	$19,400	$28,700	$30,100

Notes:

(1) Note that Segment 2 includes out-of-service-area customers that would require alternative payment arrangements that are not calculated in this assessment. Therefore, the unit cost for this segment may not be directly comparable to the other segments. The out-of-service-area customers represent over 80 percent of the anticipated recycled water use of this segment; thus, serving only customers within the service area would further increase the unit cost of this segment, making it less cost effective.

(2) These segments may require additional pumping and would thus incur additional costs. Pumping needs and costs were not evaluated for these segments, as their unit costs without pumping already exceed $5,000 per ac-ft. No additional pumping is needed for Segments 1 or 2.

As shown in Table 8, Segment 1A is the most cost-effective option at approximately $1,700 per ac-ft over a 15-year amortization period. Most other options range from $4,000 per ac-ft to over $30,000 per ac-ft. All of Segments 4 and 5 are estimated to cost over $8,000 per ac-ft since they serve relatively small demands and are thus very expensive to build additional pipeline for. Except for Segment 1A, all NPR expansion segments are significantly more expensive than alternative water supplies, such as desalination ($3,126 per ac-ft at the current rate of production).

Section 4

POTABLE REUSE

4.1 Introduction

In 2017, a Potable Reuse Feasibility Study was conducted to evaluate the replacement of the City's desalinated water supply with various combinations of NPR and direct potable reuse (DPR). In this study, potable reuse is assumed to be used to supplement the current water supply mix, including ocean desalination.

The efforts of this study build upon Alternative 1B identified in the 2017 Potable Reuse Feasibility Study. This alternative provides DPR via raw water augmentation at the Lauro Reservoir. In this alternative, a new advanced water purification facility (AWPF) would be constructed at El Estero and advanced treated water (purified recycled water) would be conveyed to the Lauro Reservoir, then to the Cater WTP.[2] Key infrastructure needs are as follows and depicted on Figure 6 and Figure 7:

- A new AWPF to be located at the City Yard on Yanonali Street.
- Conveyance piping to transfer DPR treated water to Lauro Reservoir.
  - Approximately 4.5 miles of the existing NPR transmission main will be repurposed to convey advanced treated water, with a 1.7-mile parallel pipeline installed along in one section of the existing NPR transmission main for added capacity.
  - 2.2 miles of new conveyance piping will be installed to convey DPR treated water from the new City Golf Course pump station to Lauro Reservoir.

A range of DPR production capacities was evaluated in a study being completed in parallel to this assessment for Montecito Sanitary District (MSD) and MWD. The largest possible AWPF capacity (6.2 mgd) uses the maximum feed flow rate from the combined MSD and El Estero average dry weather flows (ADWFs), while the lowest production evaluated (3.7 mgd) is calculated based on winter potable water demand and future desalination production capacity.

Finally, this section also evaluates the feasibility of maintaining some or all of the existing recycled water (or NPR) system while DPR is implemented.

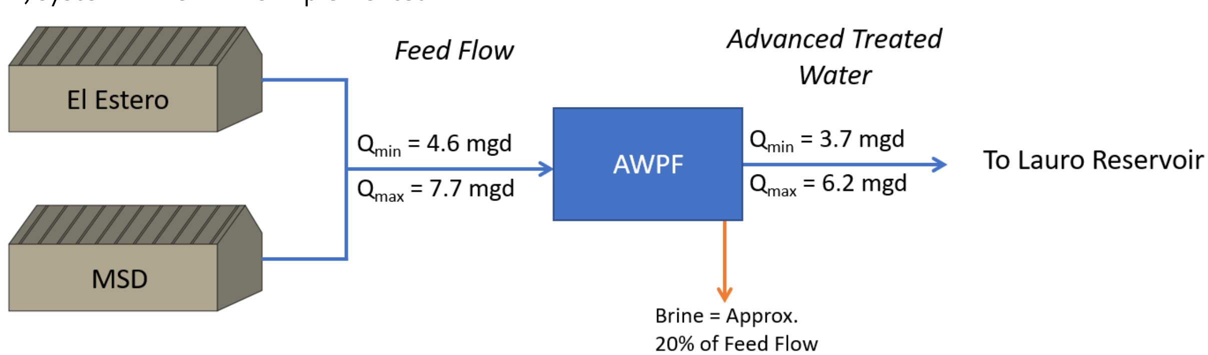
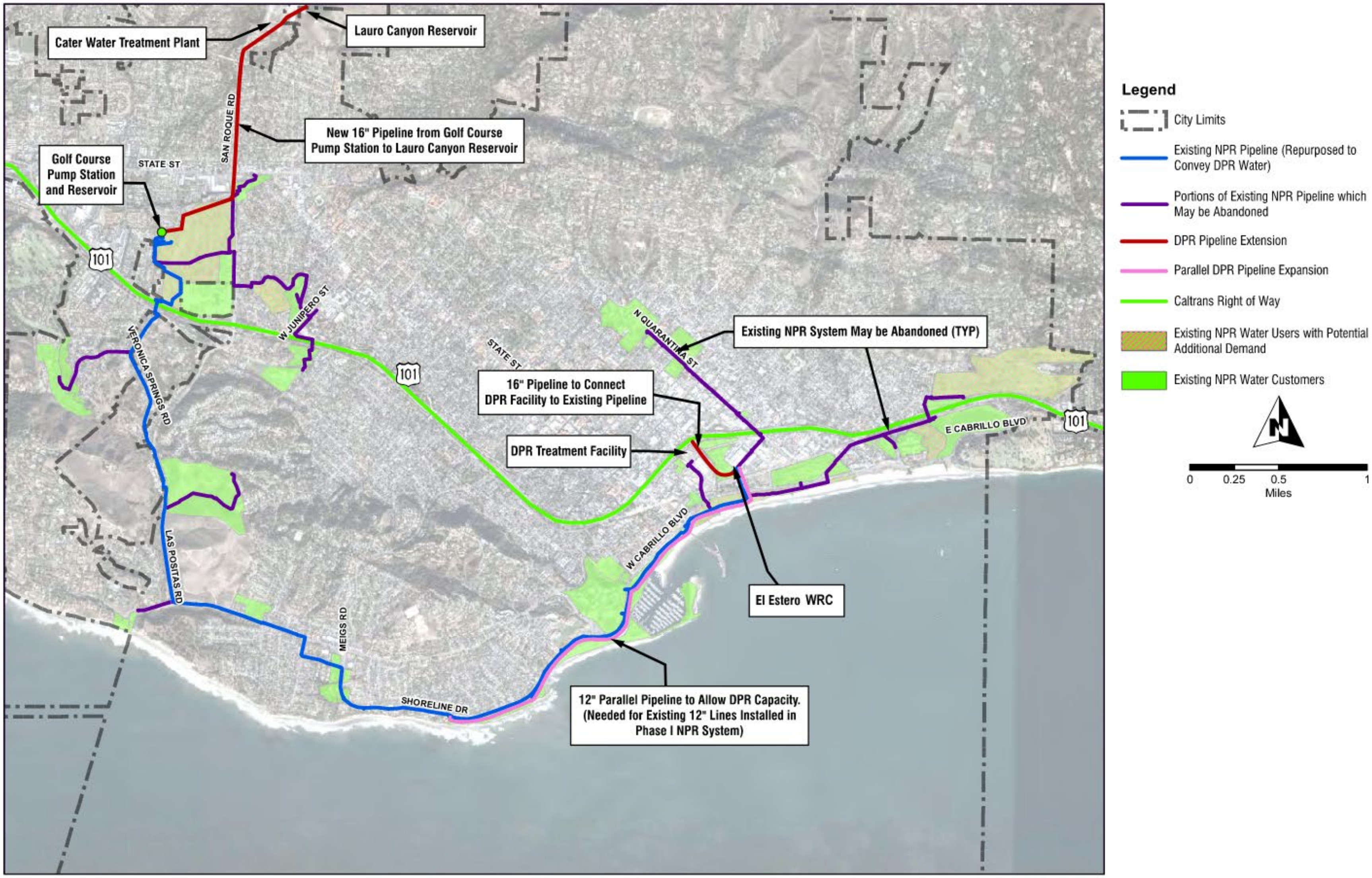


Figure 6 Proposed DPR Schematic

[2] Carollo Engineers (2017), *City of Santa Barbara Potable Reuse Feasibility Study.*



Note: Pipeline diameters shown are for flows evaluated in 2017, recently updated flows are larger and thus will require larger pipelines. Detailed infrastructure needs are discussed in following sections.

Figure 7 Proposed DPR System Map (Source: City Potable Reuse Feasibility Study (Carollo Engineers, 2017)

4.2 DPR Regulations

A key consideration when planning for DPR implementation is tracking and understanding evolving DPR regulations. The State of California Division of Drinking Water (DDW) is in the process of developing uniform DPR regulations. In 2021, the State Water Resource Control Board (SWRCB) published a first and second draft of DPR treatment and monitoring criteria. The second draft of the criteria was submitted to an expert panel in August 2021. The criteria are still under an iterative process of review and revision by DDW and the expert panel. Key components of the current draft regulations (subject to potential changes in the final regulation) are as follows:

Enhanced Source Control: An enhanced source control program must be implemented by the wastewater management agency to limit contaminants in wastewater used in DPR projects. The source control program has several required elements, including investigation and monitoring of State Board-specified chemicals and contaminants and an outreach program to industrial, commercial, and residential dischargers within the service area contributing to the DPR project. In addition, a sewershed surveillance program must be implemented to provide early warning of a potential occurrence that could adversely impact DPR treatment. It must include online monitoring that may indicate a chemical peak resulting from an illicit discharge, coordination with the pretreatment program for notification of discharges above allowable limits, and monitoring of local surveillance programs to determine when community outbreaks of disease occur.

Feed Water Monitoring: Prior to operation, the feed water to a DPR project must be monitored monthly for a minimum of 24 months for regulated contaminants (i.e., those with a maximum contaminant level [MCL]), priority pollutants, notification levels (NLs), a specific list of solvents, disinfection byproducts (DBPs), and DBP precursors.

Pathogen Control: Treatment and monitoring systems must be designed and validated to attain 20, 14, and 15-log reduction credit for virus, *Giardia*, and *Cryptosporidium*, respectively. The treatment train must consist of at least four separate treatment processes for each pathogen type (a single process can receive credit for multiple pathogens), and each credited process must demonstrate at least 1-log reduction of the target pathogen. For each treatment process that is proposed to receive pathogen reduction credit, a validation study must be conducted and a report of the results must be submitted to the State Board. The regulations contain specific requirements for what must be provided in the validation study to verify the proposed pathogen credit and the proposed online surrogate monitoring for ongoing demonstration of process performance.

Treatment Train: In addition to reverse osmosis (RO) and an advanced oxidation process (AOP), as required for IPR, the treatment train for DPR must include ozone/biologically enhanced activated carbon (BAC) ahead of RO[3]. It must also include ultraviolet (UV) disinfection with a dose of at least 300 millijoules per square centimeter, noting that much higher UV doses are needed to attain the advanced oxidation and N-Nitrosodimethylamine (NDMA) destruction requirements for a project. The system must be designed to meet certain response time requirements to ensure that diversion and/or shutoff can occur in the event of a failure to meet the pathogen and/or chemical control requirements.

[3] The latest version of the draft regulations has included a provision that allows for a treatment train without ozone/BAC, provided that the purified water comprises 10 percent or less of total water supplied on a continuous basis. Partial ozone/BAC treatment is allowable if purified water will comprise up to 50 percent of the total water supplies. For example, if the purified water were going to make up 25 percent of the water supplied, then approximately 75 percent of the purified water would need to be treated through ozone/BAC.

Chemical Control: DPR systems must meet several requirements for chemical control.

- Finished water must meet all current drinking water standards, including MCLs, DBPs, and action levels (ALs). Monthly monitoring in the product water is required.
- The total organic carbon (TOC) shall not exceed 0.5 milligrams per liter prior to distribution.
- Nitrate and nitrite must be continuously monitored in the RO permeate. Continuous monitoring of lead and/or perchlorate may also be required if the required weekly grab samples indicate that it is justified. The control system must be designed to automatically divert purified water if there is an exceedance of the TOC limit, the nitrate MCL, and potentially levels for perchlorate and lead.
- In order to address a potential chemical peak, the system must provide sufficient mixing at some point prior to distribution to attenuate a one-hour elevated concentration of a contaminant by a factor of ten. This dilution can occur at any point in the treatment and distribution process before the water is consumed. Examples include:
  - Blending within a WWTP, such as occurs with return activated sludge recycle streams.
  - Blending in an equalization basin, such as primary equalization or secondary effluent equalization.
  - Blending within a distribution system, such as blending within a water storage reservoir before distribution to customers.
- DBP formation must be evaluated by characterizing chemicals to evaluate precursors, byproduct production, and options to minimize DBP formation.

Additional Monitoring: Extensive chemical monitoring is required on an ongoing basis in the feed water to the DPR project, the effluent from the AOP, and the finished water prior to entering distribution[4]. In each location, monthly sampling is required for all MCLs, secondary MCLs, NLs, priority toxic pollutants, alert levels, DBPs and DBP precursors, and specified solvents. Weekly sampling is required for nitrate, nitrite, perchlorate, and lead. In addition, quarterly sampling is required for chemicals known to cause cancer or reproductive issues for at least three years.

Operations: The draft DPR regulations contain new requirements for advanced water treatment operators (AWTOs). The AWTO certification goes from grade 3 to grade 5. In order to obtain AWTO certification, a grade 3 water or wastewater treatment operator certification is needed. There must be one chief and one shift operator that are AWTO Grade 5 certified. An AWTO Grade 5 must be present on site at all times[5]. All operators at the advanced treatment facility must be AWTO certified (can be Grade 3, 4, or 5).

WTP Considerations: Draft DPR language allows for full treatment credit for an existing WTP. A project can choose to incorporate pathogen credits from the WTP into the overall analysis.

[4] DDW may allow for the finished water sampling location to be used to satisfy the requirement for the post-oxidation sampling point.

[5] The latest version of the draft regulations does allow for some degree of remote operations after 12 months of staffed operation. A project must submit an operations plan that demonstrates an equivalent degree of operational oversight and reliability with either unmanned operation or operation under reduced operator oversight. The chief or shift operator must still be able to monitor operations and exert physical control over the treatment facility within a maximum of one hour.

4.3 DPR Capacity Analysis

Based on the DPR study completed for MSD and MWD, two different treatment capacities were used in this analysis as follows:[6]

- **Production Capacity 6,928 AFY (6.2 mgd)** – This production rate is based on the maximum feed flow rate that could be accomplished through equalization of the combined MSD and El Estero ADWFs. The average monthly influent flow to El Estero is 7.0 mgd, while the average anticipated maximum ADWF from MSD is 0.7 mgd. Hence, the maximum feed flow to advanced purification is assumed to be 7.7 mgd, resulting in 6.2 mgd of advanced treated water production after the assumed 20 percent losses in treatment. This scenario represents the maximum purified water that could be produced using wastewater from MSD and El Estero rather than on demand or availability of other water supply sources; thus an alternate use of potable water may need to be identified during the wet season as purified water production would exceed potable water demands.
- **Production Capacity 4,120 AFY (3.7 mgd)** – The low-end production rate is based on the wet season potable water use (average monthly use from 2015 through 2021 during November through February) minus the amount of water produced by desalination at buildout (5,000 AFY). The result from the analysis is 4,120 AFY of purified water production, equating to 3.7 mgd.

4.4 DPR Treatment Needs and Cost

The DPR concept considered herein, producing advanced treated water to augment the City's raw water supply source to Cater WTP, is designated as raw water augmentation under the Draft California Water Reuse Regulations. The treatment assumed to be implemented for this concept includes the following treatment processes in this order:

- Treated effluent El Estero.
- Full stream ozone.
- BAC.
- Ultrafiltration (UF).
- RO.
- UV disinfection with AOP.
- Free chlorination.

It should be noted that due to variability in the raw water supply of the Cater WTP, the DPR source water could make up 100 percent of the supply to Cater WTP at certain times during the year. It is anticipated that a 100 percent purified water feed may impact the conventional WTP performance. Ongoing research by the Water Research Foundation has documented no WTP impacts at up to a 50/50 blend, but the concern exists that WTP turbidity reduction may be impacted as the water becomes "too pure". Additional pilot work would be needed to characterize the treatability and impacts of this configuration on the WTP.

[6] Carollo Engineers (2022), *Draft TM-8 (Recycled Water Treatment Options at MSD) of Enhanced Recycled Water Feasibility Analysis for MSD and MWD*.

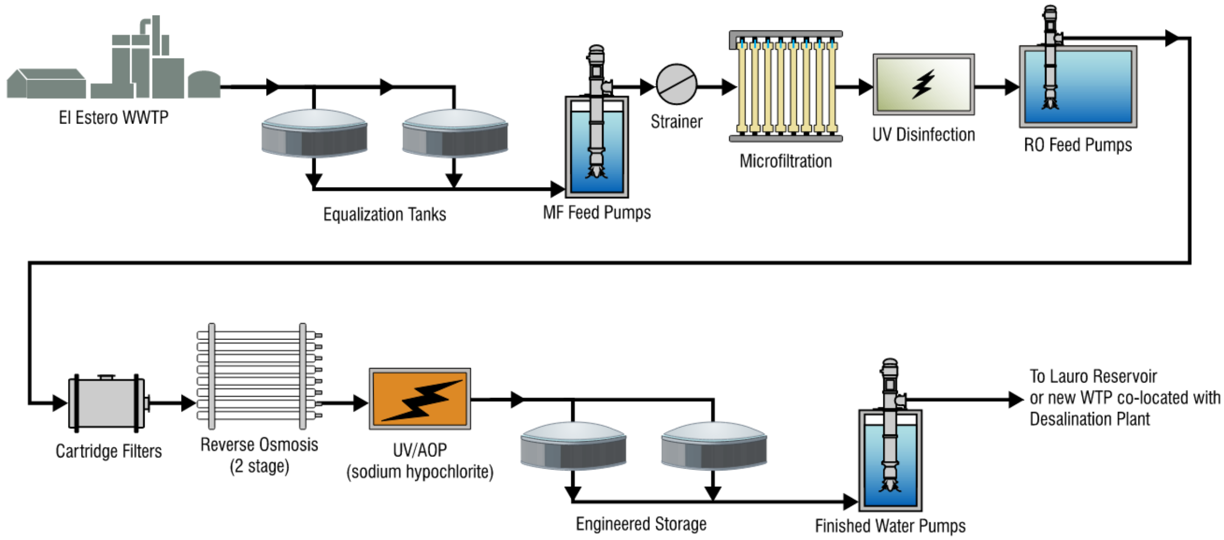
The pathogen removal credits that would be sought for each treatment process compared to the requirements are summarized in Table 9.

Table 9 Pathogen Log Removal Values per Process for DPR at Santa Barbara

Process	Pathogen Log Removals by Pathogen Category		
	Virus	Giardia	Cryptosporidium
Treatment Train 7 (WRP with Dissolved Air Flotation)			
WRP(1)	0+	0+	0+
Ozone/BAC(2)	6	6	1
UF(3)	0	4	4
RO(4)	2+	2+	2+
UV AOP	6	6	6
Chlorination(5)	2+	0	0
Cater WTP	4	3	2
Total	**20+**	**21+**	**15+**
Required	**20**	**14**	**15**

Notes:
Abbreviation: WRP – water reclamation plant.
(1) Pathogen removal through the WWTP would need to be evaluated and confirmed through a 3 to 12 months study including evaluation of a broad range of pathogens and surrogates.
(2) Based on United States Environmental Protection Agency (EPA) protocols with a contact time of 6.24 mg-min/L, the project will result in the credits assigned to Pure Water San Diego, shown here.
(3) UF systems can remove virus (2 to 4+ log removal valves) but currently are not credited due to the lack of a reliable surrogate to be used daily to verify performance (e.g., pressure decay tests are used daily to verify protozoa removal).
(4) Can receive up to 1 log credit during permitting for EC as a monitoring surrogate; 1.5 log credit for TOC, and 2 for strontium. An additional half log can typically be gained once the facility is operational.
(5) Chlorination credits based upon the Australian WaterVal analysis, which has been approved by the State of California for up to 6 log reduction of virus. The low log removal valves shown here is representative of a relative contact time (Value 9 mg-min/L, based upon a t10 contact time of 6 minutes, and a minimum wastewater temperature of 15 degrees Celsius, and a pH of <8.5). Sampling for pH and temperature could allow for lower contact time values to meet the target credits. Higher residuals could also be applied to result in increased pathogen credits.

The layout at the City's Corporation Yard (Corp. Yard) for a DPR treatment train with a purified water production rate of 6.2 mgd is shown in Figure 8. As shown, it is assumed that the full site of the Corp. Yard would be available for use for an AWPF. For the smaller DPR option with a production rate of 3.7 mgd, the layout would be smaller than what is shown here. These layouts do not include storage tanks to achieve the 10:1 required dilution of a one-hour chemical peak. For this analysis, it is assumed that the dilution would be achieved in Lauro Reservoir, upstream of Cater WTP. The reservoir has a capacity of 640 ac-ft (208 MG), which would be sufficient to achieve 10:1 dilution of a one-hour flow in the 6.2 mgd production scenario (260,000 gallons per hour).



Note: This treatment train was developed during the 2017 Potable Reuse Feasibility Study. There have been changes and developments in treatment technology since preparation of this report.

Figure 8 AWPF Treatment Train (Source: City Potable Reuse Feasibility Study (Carollo Engineers, 2017)

The total project costs, annual O&M costs, and unit costs for each treatment train are summarized in Table 10.

Table 10 Summary of AWPF Treatment Cost(1)

DPR Scenario	Purified Water Production (mgd)	Total Project Cost ($M)	Annual O&M Cost ($M/yr)	Unit Cost ($/ac-ft)(2)
Maximum Capacity	6.2	$112.8	$7.0	$1,900
Minimum Capacity	3.7	$76.3	$6.0	$2,450

Notes:
(1) Source: Draft TM-8 (Recycled Water Treatment Options at MSD) of Enhanced Recycled Water Feasibility Analysis for MSD and MWD (June, 2022).
(2) Calculated using the annualized capital cost, annual O&M cost, and assuming the facility is running at capacity 365 days per year. Annualized capital cost calculated assuming an interest rate of 3.5 percent and annualized over 30 years.

4.5 DPR Infrastructure Needs and Cost

The sizing of the new conveyance pipeline to move the advanced treated water from the new AWPF to Lauro Reservoir is summarized in Table 11. Two sections of new pipeline are needed: a 2.2-mile section from El Estero along Cabrillo Boulevard and Shoreline Drive to San Rafael Avenue, which parallels the existing NPR pipeline, and a 1.7-mile section from the Golf Course Pump Station to Lauro Reservoir. The associated capital cost estimates are summarized in Table 12. The cost estimates are based on the unit construction cost consistent with the City's Water Distribution Infrastructure Plan, as well as the construction cost markups, both shown in Table 6 and Table 7.

Table 11 Summary of New Infrastructure Conveyance Needs(1)

Description	Size for DPR at 3.7 mgd	Size for DPR at 6.2 mgd	Unit
2.2-Mile Parallel Pipeline Along Cabrillo Boulevard	10	16	inches
1.7-Mile Pipeline Along From Golf Course to Lauro Reservoir	16	20	inches
New Pump Station at Golf Course	350	600	hp

Note:
(1) Sizing is a high-level estimate only, the sizing of these components have not been verified with the City's recycled water hydraulic model.

Table 12 Summary of New Infrastructure Conveyance Costs(1)

Description	Capital Cost, DPR at 3.7 mgd ($M)	Capital Cost, DPR at 6.2 mgd ($M)
2.2-Mile Parallel Pipeline Along Cabrillo Boulevard	$5.0	$8.8
1.7-Mile Pipeline Along From Golf Course to Lauro Reservoir	$5.5	$7.9
New Pump Station at Golf Course	$5.6	$9.7
Total	**$16.1**	**$26.3**

Note:
(1) Costs presented in 2022 dollars.

4.6 DPR and Desalination Cost Comparison

The City's Charles E. Meyer Desalination Plant was reactivated in 2017 in response to drought conditions, and a new policy in the City's 2020 Enhanced Urban Water Management Plan made desalination a regular component of the City's diverse water supply portfolio. The plant currently has a 3 mgd capacity (3,125 AFY) and makes up approximately 30 percent of the City's water supply. There is a planned expansion to increase capacity of the desalination plant to 5,000 AFY in total to increase the City's supply capacity. The costs for this proposed expansion of desalination are compared with DPR options in this section.

The cost of DPR in 2022 dollars at both 6.2 and 3.7 mgd capacity is summarized in Table 13.

Table 13 Summary of Costs for DPR at 3.7 and 6.2 mgd

Description	DPR at 3.7 mgd	DPR at 6.2 mgd	Unit
Annual Production	4,120	6,928	AFY
Average Production	3.7	6.2	mgd
DPR Treatment Cost	$2,450	$1,900	$/ac-ft
Infrastructure CAPEX(1)	$257	$153	$/ac-ft
Infrastructure OPEX(2)	$4	$4	$/ac-ft
Total DPR Cost	**$2,711**	**$2,057**	$/ac-ft

Notes:
Abbreviations: CAPEX = capital expenditures; OPEX = operating expenditures.
(1) Cost includes new pipelines and pump station as listed in Table 12.
(2) Includes O&M costs for the new pipeline and pump station, as well as the energy cost to pump treated water at the new DPR pump station from the Golf Course roughly 9,200 feet to Lauro Reservoir. Annual O&M of pipelines is assumed to be 1 percent of capital cost.

Based on information provided by the City, the estimated cost for ocean desalination is currently $3,126/ac-ft, in 2022 dollars based on a production rate of 3,125 AFY. The cost is expected to reduce to approximately $2,450/ac-ft in 2022 dollar when production is expanded to 5,000 AFY.

As shown in Table 14, the average cost of DPR for the two capacities analyzed herein is comparable to ocean desalination. Implementation of DPR at the maximum capacity of 6.2 mgd (6,928 AFY) is estimated to be about $393 per ac-ft less than ocean desalination, while DPR could be $261/ac-ft more expensive when only delivering 3.7 mgd (4,120 AFY). Hence, the economy of scale benefits maximizing DPR production, although the unit costs of both DPR production rates are comparable with ocean desalination.

Table 14 DPR and Desalination Cost Comparison

Description	DPR at 3.7 mgd	DPR at 6.2 mgd	Unit
Annual Production	4,120	6,928	AFY
Average Production	3.7	6.2	mgd
DPR Cost	**$2,711**	**$2,057**	**$/ac-ft**
Ocean Desalination Cost	$2,450	$2,450	$/ac-ft
Difference ($/ac-ft)	**$261**	**$(393)**	**$/ac-ft**

4.7 DPR and NPR

In addition to implementing DPR within the City, the cost effectiveness and feasibility of maintaining some or all of the City's existing NPR system was also evaluated. Based on the results of the cost-effective analysis presented in Section 3, this analysis considers only existing recycled water users.

4.7.1 DPR with all Existing NPR Customers

This alternative would maintain the existing non-potable recycled water customers while implementing a 6.2 mgd AWPF and associated infrastructure. Previously presented DPR options repurpose a portion of the existing NPR piping to convey water to the Golf Course Pump Station from El Estero. To maintain service to all existing NPR customers, approximately 4.5 miles of additional 16-inch piping paralleling the existing NPR pipeline would be required (since this piping could not be repurposed from NPR to DPR uses, as discussed above), adding over $17 million in capital costs. Because this significant added expense would almost double the total capital cost of the project, this alternative was not evaluated further.

4.7.2 DPR with East Branch NPR Customers

This alternative would maintain NPR service on the eastside of the existing system, known as the "East Branch." This alternative allows existing NPR infrastructure in the western portion of the system to be repurposed for DPR conveyance while maintaining service to 39 existing recycled water accounts in the eastern portion of the system, serving 355 AFY of demand on average as well as maintaining the use of recycled water for plant process water at El Estero (301 AFY) for a total of 656 AFY. Figure 9 shows the East Branch recycled water users. Table 15 shows the anticipated NPR and DPR flows as well as unit costs for the combined system. For the purposes of this analysis, it was assumed the 6.2 mgd DPR system would be constructed.

Table 15 Summary of DPR and NPR System Costs

Description	DPR with East Branch NPR Customers
NPR Demand (ADD – MDD), mgd(1)	0.6 – 0.9
DPR Design Capacity, mgd	6.2
Maximum DPR Production, mgd	5.3
Treatment Cost, $/ac-ft	$1,900

Description	DPR with East Branch NPR Customers
Infrastructure CAPEX, $/ac-ft(2)	$179
Infrastructure OPEX, $/ac-ft(3)	$5
Total DPR Cost, $/ac-ft	**$2,084**
Existing NPR O&M Cost, $/ac-ft	**$1,500**
Weighted Average Combined System Cost, $/ac-ft	**$1,995**

Notes:
(1) NPR demand includes East Branch customers and El Estero process water. El Estero process water is assumed to be constant throughout the day and a MDD peaking factor was not applied.
(2) Cost includes new pipelines and pump station consistent with the 6.2 mgd DPR system as listed in Table 12.
(3) Includes O&M costs for the new pipeline and pump station, as well as the energy cost to pump treated water at the new DPR pump station from the Golf Course roughly 9,200 feet to Lauro Reservoir. Annual O&M of pipelines is assumed to be 1 percent of capital cost.

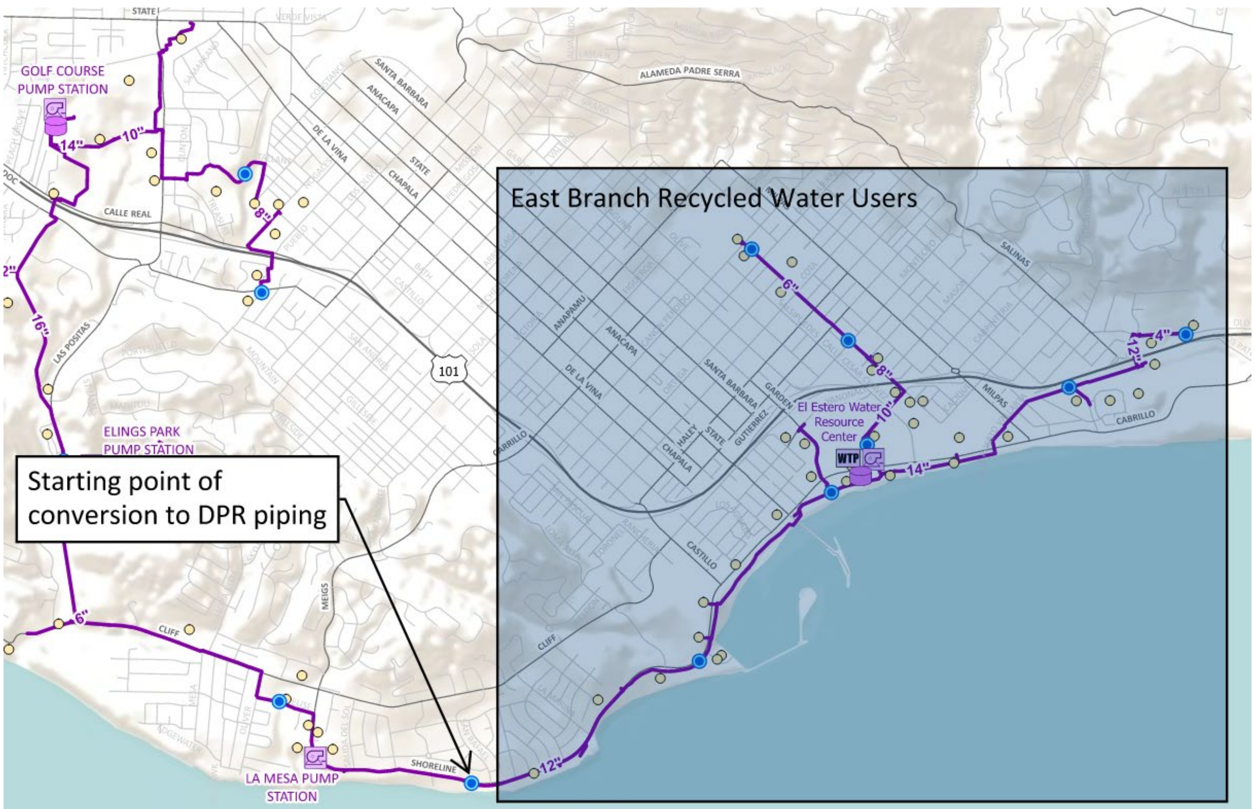


Figure 9 East Branch Recycled Water Users

Implementing a hybrid NPR/DPR system in the City may be the most cost-effective approach to consider, at least until the East Branch NPR system reaches the end of its useful life. This will allow much of the existing NPR users to continue service, thus avoiding costs associated with converting this portion of the system to potable water supply. Note that this hybrid option would require decommissioning the western portion of the existing NPR system in order to use that transmission main for DPR. This would include additional costs to convert western NPR customers back to a potable system and require an assessment of the potable system's capacity to serve these current NPR customers.

Section 5

UNCERTAINTY EVALUATION

5.1 Introduction

The uncertainty evaluation described in this section is a qualitative sensitivity analysis intended to identify future uncertainties associated with key planning issues affecting recycled water supply and demand. The relative uncertainty and the potential impact of the identified factors on potential future NPR and DPR systems are described below.

5.2 Types of Uncertainties

A key reliability consideration when comparing implementing DPR and expanding the existing NPR system is understanding the uncertainties, such as regulatory changes and public perception, associated with both options. The following uncertainties are described in the following subsections:

- Persistent drought.
- Sea level rise (SLR).
- Environmental impacts.
- Regulatory changes.
- Population growth.
- Water conservation.
- Economic factors.
- Public perception.

5.2.1 Persistent Drought

Droughts occur when there is a deficiency in precipitation over an extended period, resulting in a water shortage. While the definition for the period of time that constitutes a drought varies from place to place, it is typically at least a season and may continue for multiple years. Different levels of drought, as defined by the United States Drought Monitor, are shown in Figure 10.[7]

Note: This graphic was developed for the Agricultural Sector, not all bullet items are applicable to an urban system. Graphic is for context on drought conditions only.

Figure 10 United States Drought Monitor Drought Levels

[7] National Integrated Drought Information System (2022), *Drought Conditions for Santa Barbara County*, https://www.drought.gov/states/California/county/Santa%20barbara

California, including Santa Barbara County, regularly experiences severe or worse drought conditions. As shown in Figure 11, Santa Barbara County has experienced severe drought in 11 of the last 22 years, extreme drought in 8 of the last 22 years, and exceptional drought in 3 of the last 22 years. This indicates that drought is a frequently recurring concern for water utilities in the Santa Barbara region that may adversely impact water supply.

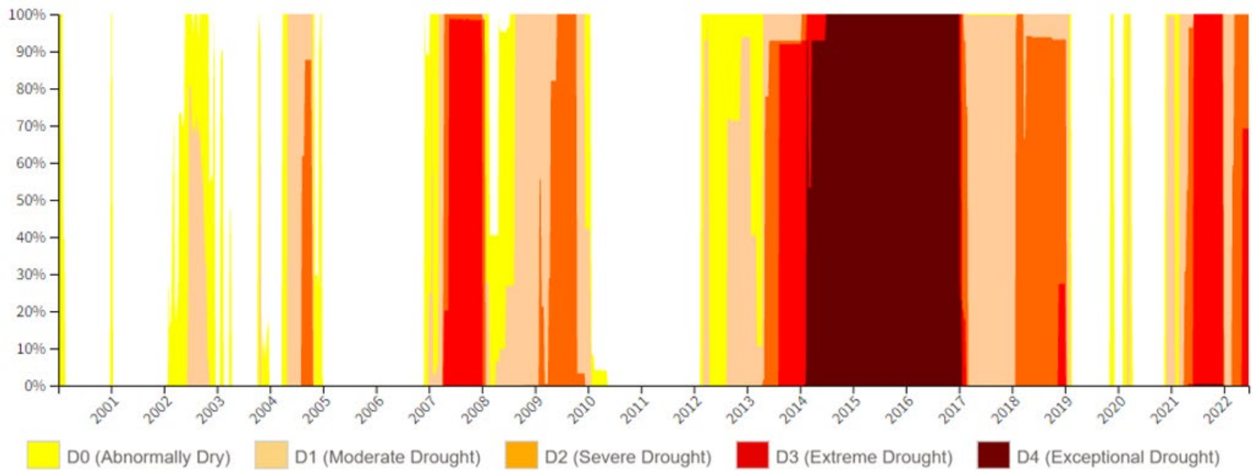


Figure 11 Santa Barbara County Drought Levels Since 2000

Droughts are generally expected to become more frequent and severe in the future due to climate change. However, there is significant uncertainty surrounding when droughts will occur, their severity, and their duration. While both expanding NPR and implementing DPR would help mitigate the effects of drought, since reusing wastewater is considered a drought-resistant supply, the extent to which each option would bolster the City's water supply differs. In the event of extreme or exceptional drought, the City's traditional water supplies from local surface water, groundwater, and imported water from the SWP are likely to be strained, reduced, or potentially eliminated. In this case, supply from DPR is more valuable to the City as a direct replacement for other potable supplies, rather than NPR as a potable offset for less essential uses such as irrigation.

5.2.2 Sea Level Rise

The City's service area includes approximately six miles of shoreline, which is vulnerable to increasing coastal flooding and wave impacts due to SLR. The State of California 2018 Sea-Level Rise Guidance prepared a range of SLR projections for coastal communities in the state for time spans ranging from 2030 to 2150. These projections are based on different levels of risk aversion (low, medium-high, and extreme). The report recommends using the medium-high risk-averse approach to develop longer lasting resilience projects. The following are key medium-high risk aversion SLR projections for the City. These projections have a 1 in 200 chance of occurring.

- 2030: 0.7 feet.
- 2060: 2.5 feet.
- 2100: 6.6 feet.

The 2021 City Sea-Level Rise Adaptation Plan uses these anticipated SLR projections to understand vulnerabilities in the City. El Estero is located on a higher property than the surrounding areas, though it is anticipated that the treatment plant will be inoperable by 2100 due to tidal inundation and storm flooding. SLR is anticipated to impact some areas of collection system piping flowing into El Estero by 2060. Figure 12 shows anticipated water depth in areas of the City at 7-feet of SLR according to the National Atmospheric and Oceanic Administration (NOAA) SLR viewer. El Estero is shown to be surrounded by flooded area, making plant operations difficult at best.

As El Estero is a key facility for providing both NPR and DPR supply, potential impacts to the plant and the surrounding areas from SLR could affect the reliability of both types of supply. The consequence of decreased DPR reliability is more significant than the decreased NPR reliability due to the more essential nature of potable supply.

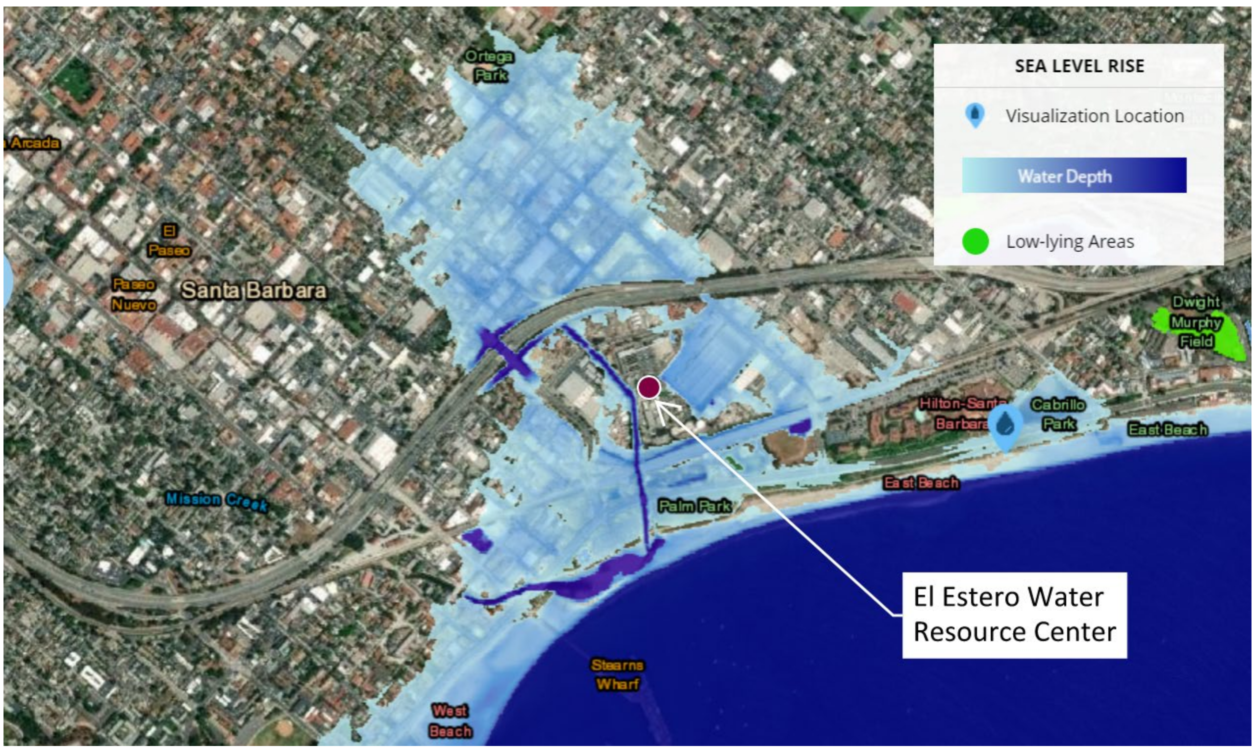


Figure 12 NOAA Sea Level Rise Map

5.2.3 Environmental Impacts

Construction of new facilities will require a number of environmental permitting and mitigation efforts including:

- **California Environmental Quality Act (CEQA) Permitting**: Permitting process to inform the public about potential environmental impacts of proposed activities to prevent environmental damage. This is required for a majority of new construction activities within the State.
- **Ocean Outfall Water Quality Requirements:** All flows discharged to the ocean need to comply with the California SWRCB Ocean Plan. The Ocean Plan establishes water quality standards and objectives to ensure ocean discharges do not degrade marine wildlife or pose a threat to public health. The most direct impact to future water supply diversification through the implementation of DPR would be the use of RO-based advanced treatment. RO generates a brine concentrate with a

salt concentration several times higher than that of the influent concentration. Studies and implemented projects on this topic along the California coast have demonstrated that National Pollutant Discharge Elimination System compliance can be maintained but may require a re-evaluation of dilution/mixing in the outfall. Mitigation through RO concentrate treatment is also an option, should it be needed.

Given that implementing DPR would require more construction activities as well as create additional concentrated brine discharge, it's more likely to be impacted by consideration of environmental effects than NPR.

5.2.4 Regulatory Changes

Federal and state water quality regulation updates may impact the feasibility for NPR or DPR water supply within the City. The most notable regulatory updates concern contaminants of emerging concern (CECs) and permitting requirements for DPR water.

5.2.4.1 Contaminants of Emerging Concern

The United States EPA office of Water and SWRCB have been increasing monitoring requirements for CECs such as microplastics, pharmaceuticals and personal care products, and nanomaterials. Most notably, the EPA has been imposing increasingly stringent health advisory limits on per- and polyfluoroalkyl substances (PFAS).

PFAS are manmade chemicals that have been used in a variety of industries since the 1940s, including but not limited to aerospace, automotive, chemical, electronics, metal coatings and plating, and textile industries. They do not degrade easily in the environment or human body. Elevated exposure to specific PFAS compounds (primarily by way of ingestion of drinking water) have been associated with developmental effects during pregnancy such as low infant birth weights and skeletal variations; effects on the immune system such as changes in antibody production and immunity; liver effects including tissue damage; cancer; and thyroid hormone disruption.[8] In June 2022, the EPA issued health advisory limits for two PFAS compounds, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) to 0.004 parts per trillion and 0.02 parts per trillion, respectively[9]. The EPA press release states that EPA is moving forward with proposing a PFAS National Drinking Water Regulation in fall 2022. While health advisories are not regulation, and are not legally enforceable standards, they are used to assist federal and local regulators and government officials in considering public health impacts and if local actions are needed. For RO based purification, PFAS is anticipated to be fully removed, which does result in PFAS in the RO concentrate. Treatment of RO concentrate for PFAS is possible but comes at a cost.

Increasingly stringent limits on PFAS compounds, and other identified CECs, will require additional treatment for drinking water supply (but well handled by RO based purification, as noted above). Implications on PFAS limitations for wastewater treatment are less known at this time, though it is anticipated there may be limits on discharges to the ocean or to the environment.

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[8] EPA (2022). *EPA Announces New Drinking Water Health Advisories for PFAS Chemicals, $1 Billion in Bipartisan Infrastructure Law Funding to Strengthen Health Protections*. https://www.epa.gov/newsreleases/epa-announces-new-drinking-water-health-advisories-pfas-chemicals-1-billion-bipartisan

[9] SWRCB (2020). *Response Levels Lowered for Water Systems Statewide as PFAS Investigation Continues.* https://www.waterboards.ca.gov/press_room/press_releases/2020/pr02062020_pfoa_pfos_response_levels.pdf

Future CEC regulations will impact both NPR and DPR supply. Much of the NPR supply in the City is used for irrigation and may be subject to future wastewater CEC limitations because these flows are returning to the environment. However, it is far more likely that DPR supply will see CEC limitations sooner and more stringent since this will be a potable water supply with more direct impacts on public health.

5.2.4.2 DPR Permitting

The EPA has developed regulatory recommendations for DPR on the national level; and New Mexico, Texas, and Arizona have developed regulatory guidance for DPR within their respective states. California, Florida. and Colorado are each in the process of developing DPR regulations.

In October 2017, the State of California passed Assembly Bill 574, *Potable Reuse*. The bill dictates that the SWRCB adopt uniform water recycling criteria for DPR through raw water augmentation. In 2018, the SWRCB published a framework for that regulatory development, and followed it up with a second edition framework in 2019. The second edition framework explained that treated drinking water augmentation would also be covered within the uniform water recycling criteria.

In 2021, the SWRCB published a first and second draft of the criteria. The second draft of the criteria is currently under review by an expert panel. As discussed in Section 4.2, key components of the draft regulations include enhanced source control, feedwater monitoring, and a required treatment train.

While the development of DPR regulations is progressing, the regulations have not been finalized and the permitting process has not yet been undertaken by any other entities in the state. Thus, the process for implementing a DPR project has significantly higher uncertainty from a permitting and regulatory standpoint than expanding the City's NPR system, which the City has done before.

5.2.5 Population Growth

Population growth will impact demand for both potable and non-potable water supply sources in the City's service area. Population growth in the City and County of Santa Barbara has historically been slower than the rest of the state. In recent decades, the population growth rate has remained positive, but slowing. A 2018 regional growth forecast report prepared by the Santa Barbara County Association of Governments (SBCAG), states that the growth rate of County population ranged from 0.5 to 1.0 percent between 1991 and 2020.[10] SBCAG predicts that by 2026, the countywide growth rate will decrease to less than 0.5 percent annually. Similar trends have been noted on the citywide scale as well. According to the 2022 Housing Element of the City's General Plan, the population growth rate has slowed and ranged from -0.02 percent to +0.03 percent in the past five years.[11]

While changes in future population are uncertain and can be difficult to plan for, the anticipated stability in the City's population indicates that uncertainty in this factor is not likely to have a significant impact to either implementing DPR or expanding the NPR system.

5.2.6 Water Conservation

In 2018, the State of California passed Senate Bill 606 and Assembly Bill 1668, which establish a road map for water conservation. The bills establish the following indoor water use per capita water conservation goals:

- A standard of 55 gallons per capita day (gpcd) until January 2025.
- Reduction to 50 gpcd by 2030.

[10] SBCAG (2018), *Regional Growth Forecast 2050, Santa Barbara County.*
[11] City of Santa Barbara (2022), *City of Santa Barbara General Plan, Housing Element, 2023-2031*.

In response, many cities and communities have implemented their own initiatives for water conservation, such as rebates for more water efficient appliances and irrigation systems as well as turf replacement programs. The City's Water Conservation Strategic Plan estimate a savings of at least 2,615 AFY of water in the City by 2050. Commercial, irrigation, residential, and community water conservation efforts outlined in the Plan are shown in Figure 13.[12] Indoor per capita water use reduction will decrease flows to El Estero as well as increase the concentration of solids loading to the plant. This may trigger the need for more treatment to continue to meet effluent permit requirements as well as decrease supply for downstream NPR or DPR.

Figure 13 City Water Conservation Efforts (Source: Water Conservation Strategic Plan (Maddaus Water Management, Inc., 2020))

5.2.7 Economic Factors

Different sources of water have different costs associated with producing them, which may change over time as conditions and technology changes. As the cost analysis in Section 4 suggests, the current cost estimated to produce DPR, potentially in combination with NPR, is similar to the cost to produce ocean desalinated water. The relative cost of these supply options, as well as costs of other supplies like SWP water and groundwater, may change in the future, making it more or less attractive and feasible to implement DPR or expand NPR. The cost-effectiveness of DPR is also dependent on capacity of the system implemented. Implementing the smaller of the two DPR capacities presented is likely not as economically advantageous as the larger (6.2 mgd) DPR.

As more communities look to diversify their water supplies, energy costs fluctuate, and treatment technology evolves, costs for each of these options may shift. Should desalination become cheaper or more energy efficient, it would be more economically advantageous to expand desalination instead of implementing DPR.

5.2.8 Public Perception

Water reuse has been met with mixed public perception since its integration as a non-potable irrigation supply was first pioneered in the mid-20th century. While non-potable recycled water, or "purple pipe" has been around long enough to be normalized and accepted throughout California, potable reuse applications, in particular DPR applications, have been met with varying degrees of reluctance in communities.

[12] Maddaus Water Management Inc. (2020), *City of Santa Barbara Water Conservation Strategic Plan*.

In general, potable reuse is beginning to receive less scrutiny than in prior years and will become a critical component of the future of California's water supply. Regardless, implementing a new DPR system in a community will require an extensive public outreach and education strategy to avoid and overcome any negative perceptions associated with water reuse and to secure support for the project.

5.3 Uncertainty Assessment

The vulnerability of either implementing DPR or expanding the NPR system was evaluated by qualitatively scoring each uncertainty described previously. For both the DPR and NPR scenarios, both the likelihood of each uncertainty occurring and the consequence of each uncertainty occurring was scored on a qualitative 5-level scale, as shown in Table 16.

Scores were assigned to each source-uncertainty pair based on discussions with the City and the project team's understanding of the current recycled water system, future infrastructure needs to implement a DPR system, professional judgment, and water supply planning experience.

Table 16 Likelihood and Consequence Scale for Scoring Source-Uncertainty Pairs

Likelihood Scale	
●	Impacts from uncertainty almost certain
◕	Impacts from uncertainty very likely
◑	Impacts from uncertainty possible
◔	Impacts from uncertainty less likely
○	Impacts from uncertainty very unlikely
Consequence Scale	
●	Catastrophic consequences
◕	Significant consequences
◑	Moderate consequences
◔	Little consequences
○	No significant consequences

The likelihood and consequence scores for each source-uncertainty pair are shown in Table 17, with uncertainties shown in the first column followed by scores for DPR and NPR water supply options, and notes providing the basis for scores.

Table 17 Uncertainty Analysis Scores

Uncertainty	Consideration	NPR	DPR	Notes
Persistent Drought	Likelihood	◕	◕	Increasing, and more consistent drought conditions due to climate change are almost certain to happen.
	Consequence	◔	◔	Drought is unlikely to negatively impact the implementation of DPR or expansion of NPR. Note that DPR is more valuable to the City in the event of extreme drought than NPR.
SLR	Likelihood	◑	◑	SLR is certain to happen and impact the El Estero site due to climate change.
	Consequence	◑	◕	SLR risk is the same for both facilities. While NPR and DPR production will both be at the El Estero site, the consequence for impacts to the DPR source will be higher as an essential potable supply.
Environmental Impacts	Likelihood	◔	◕	Environmental regulations are more likely to occur for a new DPR facility, because it involves new construction and introduces a new concentrated brine stream.
	Consequence	◔	◕	Future limits to the ocean discharge and/or an extensive CEQA process could slow or limit implementation of a DPR facility.
Regulatory Changes	Likelihood	◔	◑	High potential for additional CEC regulations for drinking water sources in the near-future. Regulations for wastewater discharges may follow.
	Consequence	◔	◑	Uncertainty in future DPR regulations. High level of unknowns make it difficult for definite planning of DPR implication
Population Growth	Likelihood	◔	◔	Population growth is likely to slow or flatten in the foreseeable future for the service area.
	Consequence	◔	◔	Population changes are not anticipated to significantly impact the implementation or efficacy of DPR or NPR.
Water Conservation	Likelihood	◕	◕	Statewide and local conservation efforts are already showing decreased wastewater flows in municipalities across the state, including Santa Barbara.
	Consequence	◔	◔	Indoor water conservation decreases flows to WWTPs which impacts supply availability for both NPR and DPR.

Uncertainty	Consideration	NPR	DPR	Notes
Economic Factors	Likelihood	◑	◑	As treatment technology evolves, it is likely that costs for NPR, DPR, and desalination could evolve and change the favorable supply option.
	Consequence	◑	◑	Consequence equal for both, as lowering desalination cost would mean neither are implemented further.
Public Perception	Likelihood	◔	◕	DPR implementation will certainly require an extensive outreach process to gain public support. NPR may need additional outreach should the NPR system expand to new user types such as commercial laundry.
	Consequence	◑	◕	Failure to gain public support for DPR would effectively eliminate this as a potable water supply option for the City.

5.3.1 Vulnerability Assessment

To determine the relative risk of each uncertainty to each potential supply source, the likelihood and consequence scores for each source-uncertainty pair were considered together. Threats with a high likelihood and a significant consequence were considered to pose the greatest risk. The risk results are shown in Table 18, each source-uncertainty pair is color-coded as follows:

- Red = Uncertainty poses a significant risk to the ability to implement reuse option.
- Yellow = Uncertainty poses a moderate risk to the ability to implement reuse option.
- Green = Uncertainty is a lower risk to the ability to implement reuse option compared to the other source-uncertainty pairs, but still poses some degree of risk.

Table 18 Source Vulnerability for Uncertainty Analysis Results

Uncertainty	NPR	DPR
Persistent Drought	Yellow	Yellow
SLR	Yellow	Red
Environmental Impacts	Green	Red
Regulatory Changes	Green	Yellow
Population Growth	Green	Green
Water Conservation	Yellow	Yellow
Economic Factors	Yellow	Yellow
Public Perception	Green	Red

In general, implementing DPR compared to expanding NPR comes with much more uncertainty that may pose a risk to successful implementation. DPR is a newer, not yet formally regulated process in the state and will require considerably more infrastructure to implement. DPR would be a new potable supply source for the City, and, as a result, the potential consequences to the City from SLR and regulatory changes are more impactful than those to an NPR system. NPR is an established process already in use within the City and across California, so the risks are comparatively low.

Section 6

CONCLUSIONS AND RECOMMENDATIONS

This study identified possible expansion options to serve non-potable recycled water to existing potable customers, evaluated the cost effectiveness for recycled water system expansion options, and provided a cost effectiveness and uncertainty comparison for non-potable recycled water expansion versus potable reuse or desalination. The conclusions and recommendations stemming from this analysis are:

- Explore expanding non-potable recycled water service as shown in Segment 1A to serve a commercial laundry facility. Since commercial laundry would be a new recycled water use type for the city, additional internal and external education may be necessary to implement this option.
- Expanding non-potable recycled water service to all other potential segments is not cost-effective.
- Work with the Santa Barbara Zoo and Community College to explore options for expanding non-potable recycled water service to these existing customers.
- Upon implementation of official DPR regulations, the City should consider pursuing DPR implementation at the maximum feed flow rate (6.2 mgd). DPR production at this scale is more cost effective than production at smaller scales. Implementing DPR also provides significantly more supply than cost-effectively expanding NPR.
- It may be preferable to continue to serve non-potable recycled water to customers in the eastern portion of the City's existing NPR system for the duration of the expected life of existing facilities following the implementation of a DPR system. Note that this conclusion assumes that NPR O&M costs stay similar to historical values.
- DPR implementation is more sensitive to many risks than expanding the NPR system, including SLR, environmental impacts, regulatory changes, and public perception. However, the apparent economic feasibility of a new DPR supply make it the next best reliable water supply alternative after ocean desalination (once the regulations have been approved) for the City.