Water Partnerships between Cities and Farms in Southern California and the San Joaquin Valley

Technical Appendix A. Water Supply and Demand Planning in Southern California

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Introduction

This appendix provides supplemental information, data sources, and methods used to describe Southern California water supply and demand planning analysis as summarized in the main report.

In the following sections, we first describe the general context of the region. Then we examine water demand, including past demand and future projections. Next, we describe the evolution of the water supply portfolio and plans for future supplies. Finally, we describe the development of storage infrastructure by the Metropolitan Water District of Southern California (MWD) both within and beyond its service area.

General Context

We define Southern California as the seven counties south of the Tehachapi Mountains, which include four coastal counties (Ventura, Los Angeles, Orange, and San Diego) and three inland counties (San Bernardino, Riverside, and Imperial). Together they form one of the most populous urban areas in the United States, which is home to 56 percent of California's population. Although we provide some information for the whole region, we focus our analysis on the South Coast hydrologic region, where most people live, and in particular the area covered by the Metropolitan Water District of Southern California (MWD), a vast wholesale water network that serves about 19 million residents, in every county but Imperial.

MWD is a cooperative of 26 members—14 cities and 12 special districts—supplying roughly half of the water supplies within its service area. Southern California has 24 other large wholesalers—some within and some outside of the MWD system—and 207 large water retailers.[1] These entities have developed an extensive water storage and conveyance system, and manage a diverse portfolio of local and imported water supplies (Figure A1).

Three large aqueducts—the California Aqueduct, the Colorado River Aqueduct, and the Los Angeles Aqueduct—import water to the region across long distances. The Los Angeles Aqueduct was completed in 1913; it is owned and operated by the Los Angeles Department of Water and Power (LADWP), and conveys water from the Owens Valley and Mono Lake watershed in the Southern Sierra.[2] The Colorado River Aqueduct, owned and operated by MWD, began its operations in 1939. Finally, the California Aqueduct—a major artery of the state-owned State Water Project—began delivering water from Northern California to the Bay Area in 1962, to the San Joaquin Valley in 1968, and to Southern California in 1973. This aqueduct now also serves some communities in the Central Coast.

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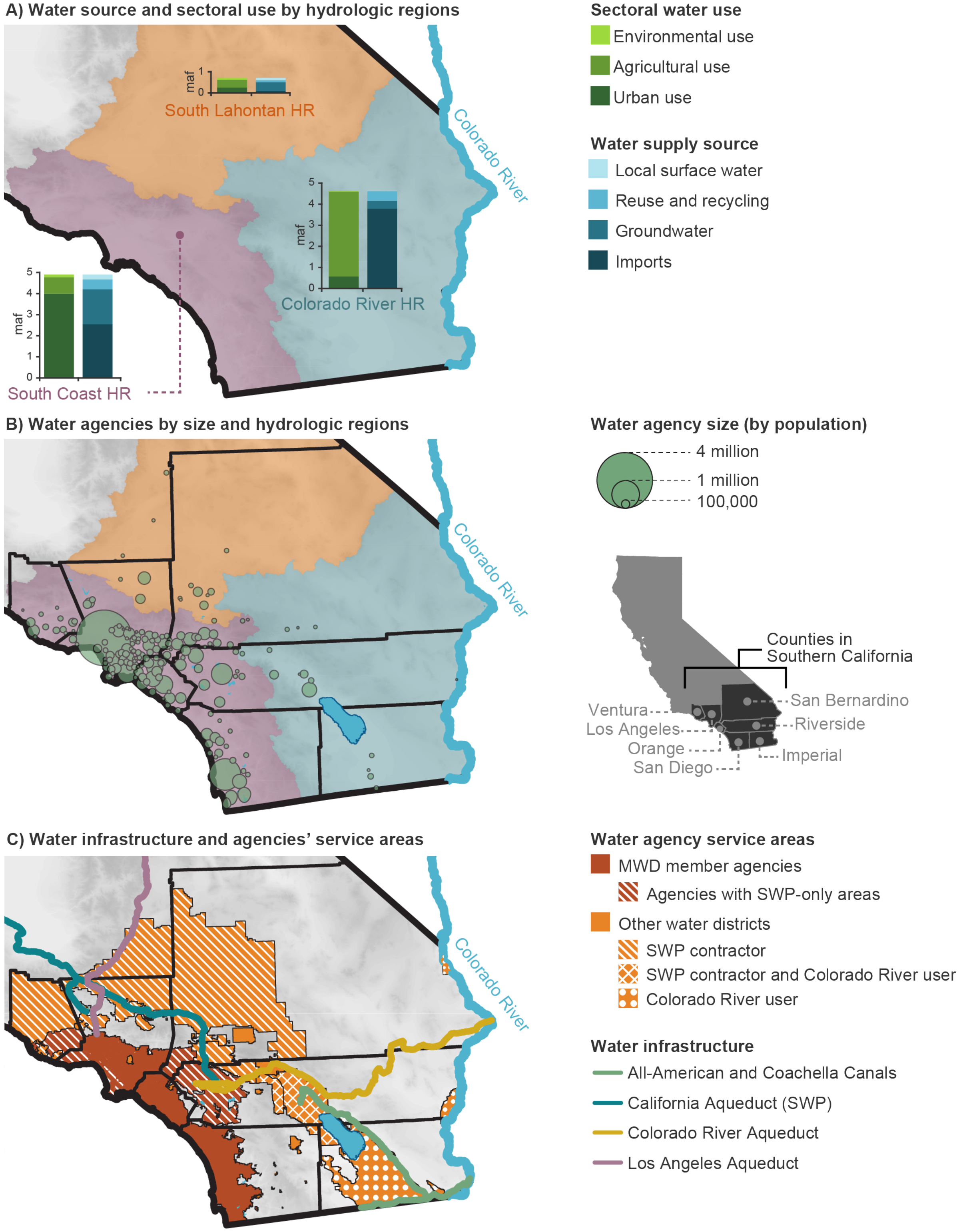
[1] Urban retailers serve at least 3,000 homes and businesses or 3,000 acre-feet (af) of water annually. In California as a whole, these large retailers supply water to about 93 percent of the state's population (Mitchell et al. 2017). In Southern California, given the lower percentage or small rural self-served communities, this percentage might be greater.

[2] The aqueduct was extended in the 1930s to reach the Mono Lake area to increase water imports.

FIGURE A1

Southern California water landscape



SOURCE: Developed by the authors.

NOTES: taf is thousands of acre-feet, and maf, millions of acre-feet. HR is hydrologic region.

Historical and Projected Water Demands

The South Coast hydrologic region is highly urbanized. More than 80 percent of the total supplies are for urban uses—much higher than the statewide average of 20 percent. Most of the remaining water use goes to a small and declining agricultural sector, while water use for environmental purposes—instream flows and wild and scenic rivers—is almost negligible (California Department of Water Resources 2018)

Despite a steady increase in population, total water use peaked in the early 2000s and has been declining since (Figure A4).

Successive droughts have brought increased attention and regulation focused on urban water conservation. Efficiency standards—first introduced in the late 1970s and becoming more stringent over time—and utility-sponsored retrofit programs have resulted in new and remodeled homes having a much smaller "water footprint" than older homes. The Water Conservation Act of 2009 (SB X7-7) required urban water suppliers to reduce per capita water use by 20 percent by 2020 relative to a 10-year historical baseline. And the 2012–16 drought saw the first-ever statewide mandated curtailment of urban water use in April 2015, with various individual restrictions targeting a statewide goal of 25 percent average savings compared to 2013.[3]

Although many Urban Water Management Plans (UWMP) expected a significant rebound in water per capita use after the mandate was lifted, water demands per capita have remained low (Figure A2). Regional water use in 2013 was 161 gallons per capita per day (gpcd), during the conservation mandate it achieved its minimum at 121 gpcd.[4] In 2018, average use in the region was 135 gpcd, and in 2019—a wet year with lower landscape water demand—use fell to 125 gpcd.[5] While some rebound in per capita water use is still possible, the Southern California water agency managers that we spoke with do not expect per capita water demands to go back to pre-drought levels.

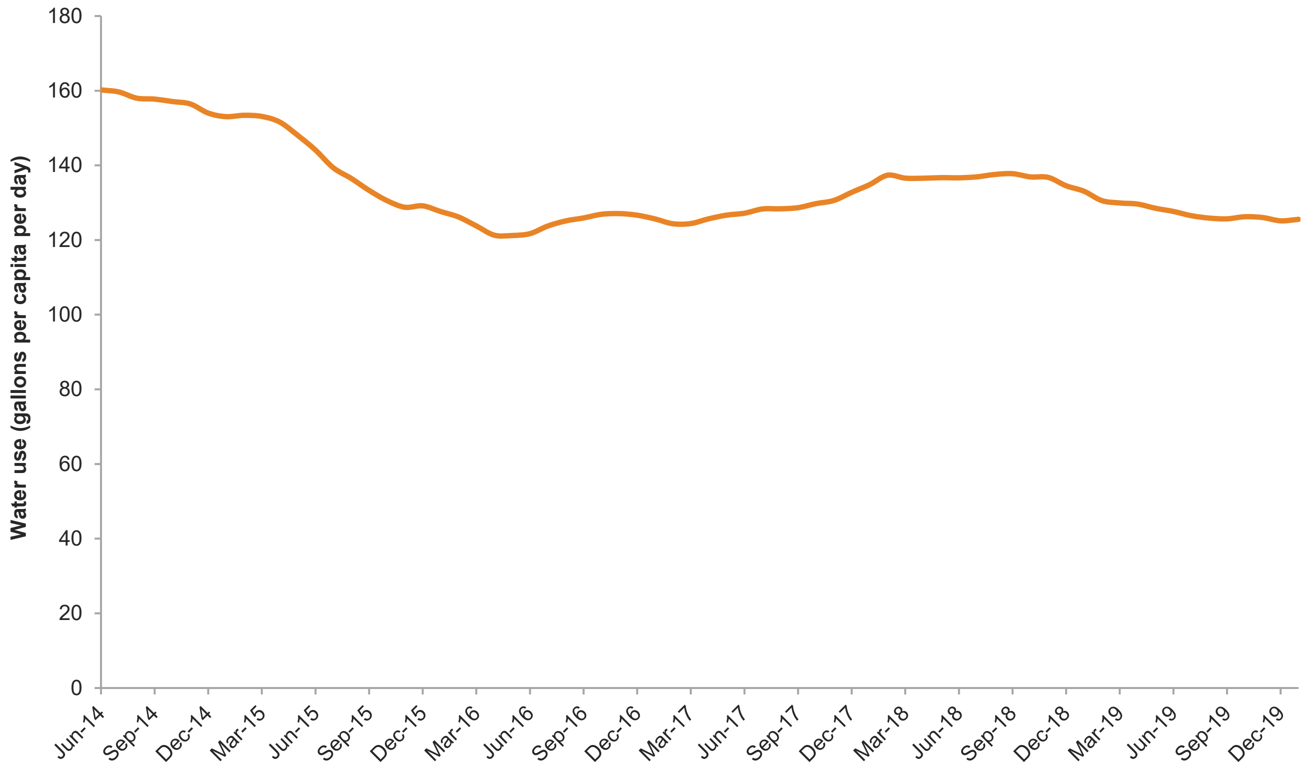
[3] A more detailed analysis of policies related to urban water use can be found in Mitchell et al. (2017).

[4] These values are calculated as 12-month averages to avoid the influence of seasonal differences in water use.

[5] The SWRCB Conservation Reporting Data used calendar year 2013 as a baseline, so these figures present average water use for calendar years to facilitate comparison.

FIGURE A2

Regional per capita water use in Southern California has remained low since the 2012–16 drought conservation mandate



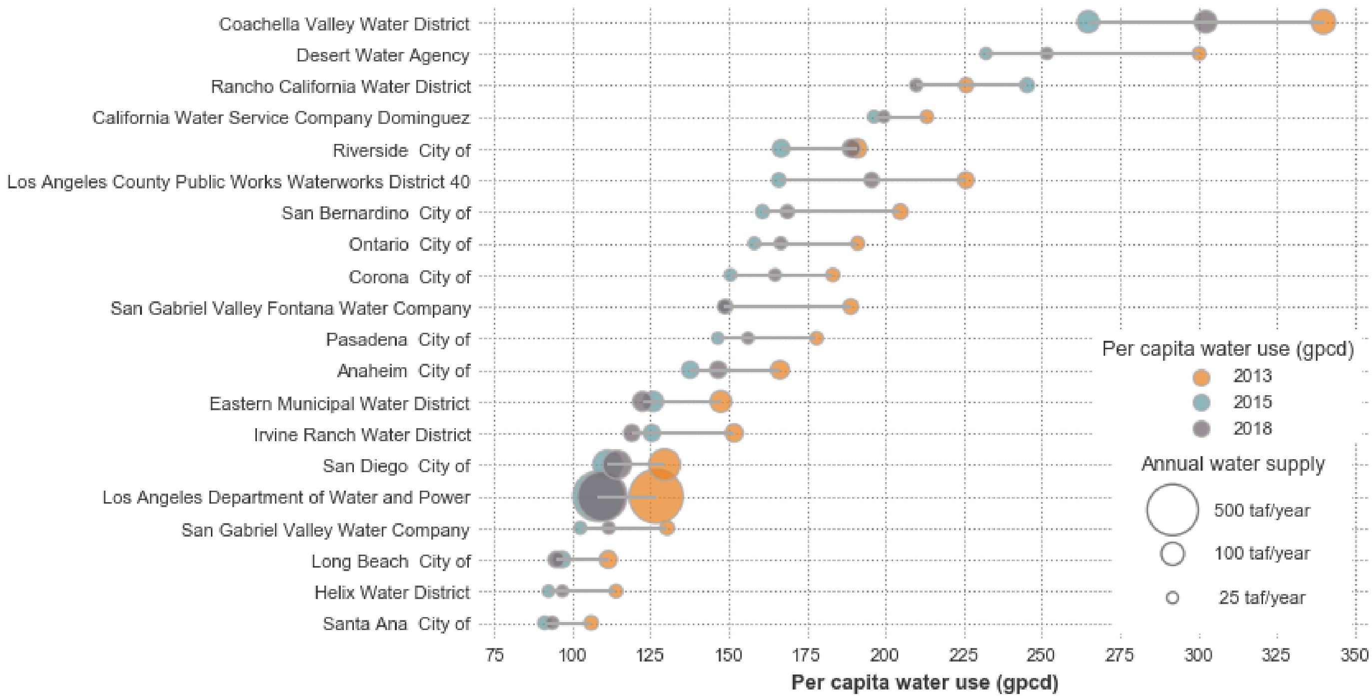
SOURCE: SWRCB Conservation Reporting for water use per capita.

NOTE: Water per capita for each month is calculated as the 12-month rolling average to avoid the influence of seasonal differences in water use. The regional per capita water use results are have been obtained using data for the 139 agencies in the three Southern California hydrologic regions that reported water use every month from June 2014 to February 2020. These agencies represent 82.1% of the total population in the region, and their aggregate water use per capita is slightly lower than the per capita use for all agencies—129.7 gpcd versus 130.3 gpcd in 2015, and 157.5 gpcd versus 158.6 in 2013.

The results for individual agencies are similar. Figure A3 shows per capita use for the 20 agencies with the most water sales, which serve nearly half of the total population in Southern California. By 2018, water use had only fully rebounded to 2013 levels for a few agencies. Others had just modest rebounds, and for some water use was the same or even lower than in 2015 (Figure A3).

FIGURE A3

Water use per capita in 2018 was much lower than in 2013 in most of the major Southern California utilities



SOURCE: State Water Resources Control Board (SWRCB) Conservation Reporting

NOTE: This chart includes the 20 Southern California utilities with the highest overall water use in 2019 for which complete monthly reporting data was available from 2015 to 2018. GPCD is gallons per capita per day. Utilities using greater per capita water use are usually located in hotter, more arid inland regions.
Projecting future demand is an essential piece of the planning process. Two key determinants of future water demand are future population and per capita water use. Both factors have been revisited lately.

Population growth in California has slowed in recent decades (Johnson and Cuellar Mejia 2020), and the last two years have seen the lowest recorded growth rates since 1900 (California Department of Finance 2019). Accordingly, population projections have dropped from almost 44 million by 2030 (Johnson and Cuellar Mejia 2020, using Department of Finance data for 2019) to just 42.3 million (California Department of Finance 2020). Given the new state water conservation requirements adopted in 2018 (described below), and the likelihood that the lower water requirements in new and remodeled houses will keep pushing per capita demands down, overall demands per capita may continue falling.[6]

To demonstrate how demands and demand projections have been shifting, Figure A4 presents actual water demands, projections from past IRPs, and our rough estimates of potential future demands for the six counties served by MWD. Successive IRPs have revised demand projections downward, reflecting ongoing advances in demand management. Our simple demand projections suggest this trend will continue. For the upper end of our range, we assume per capita water demands staying at 2018 levels; this brings total water demands in 2040 down 19 percent (-850,000 af) relative to the projections of the most recent IRP, completed in 2016. For the lower end of our range, we assume a 20 percent per capita reduction by 2040; demands in that year would be 35 percent lower (-1.6 maf) than what was projected in 2016.

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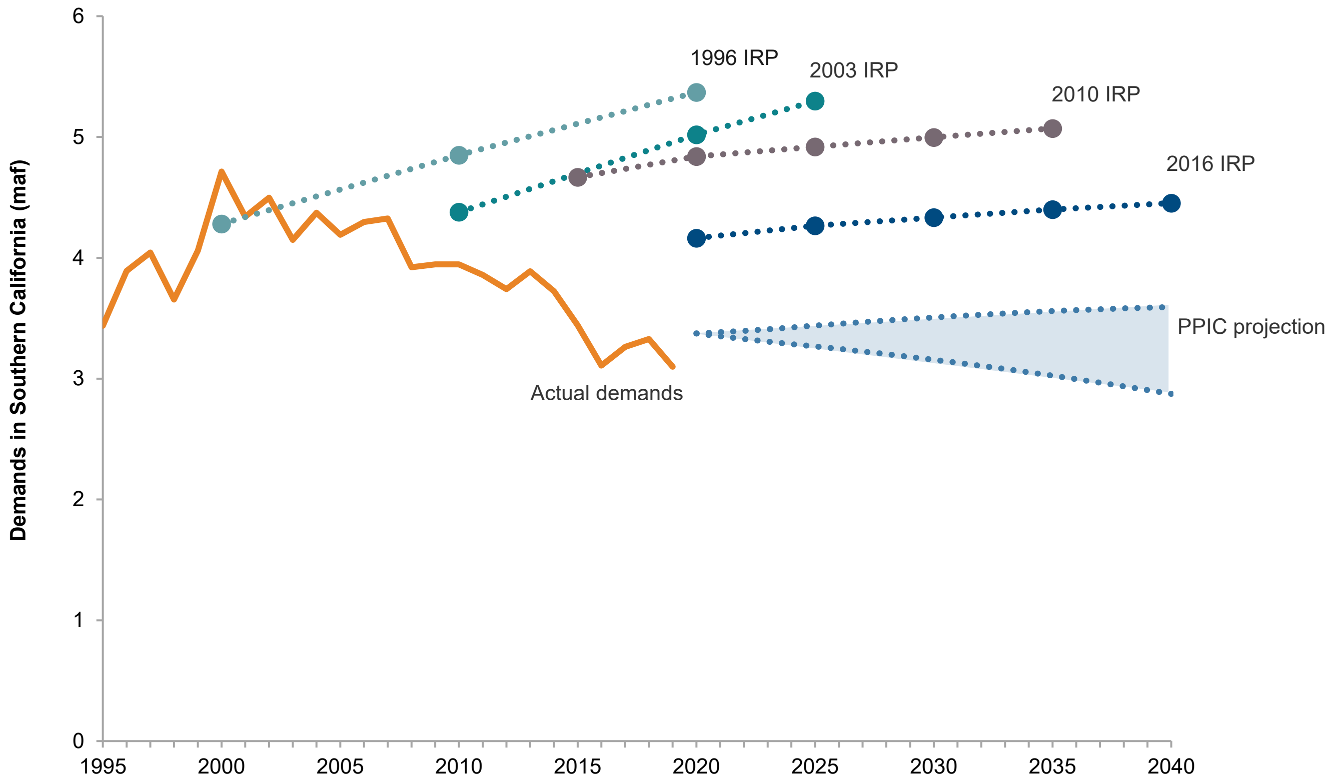
[6] One countervailing factor is the changing climate, which could increase outdoor water demands (Hall et al. 2018, Hopkins 2018), unless there is a systematic shift away from higher-water landscapes like turn grass toward lower-water landscapes.

FIGURE A4

Regional water demand projections have been falling over time



SOURCE: Actual demands from 1995–2015: 2015 Urban Water Management Plan (MWD 2016a); actual demands for 2016–19: State Water Board conservation reporting; demand projections: MWD Integrated Water Resources Plans (IRPs) (1996, 2003, 2010 and 2016) and author estimates.

NOTE: The figure shows actual demand and demand projections for the MWD service area. The PPIC projection spans a high-demand scenario where per capita use remains at 2018 levels (134.5 gpcd) and a low-demand scenario where use falls by 20 percent by 2040 (to 107.6 gpcd). Both scenarios are based on use population growth of nearly 1.5 million by 2040 from the Department of Finance for the six counties served by MWD (from the Department of Finance)

What Is Southern California's Future Water Conservation Potential?

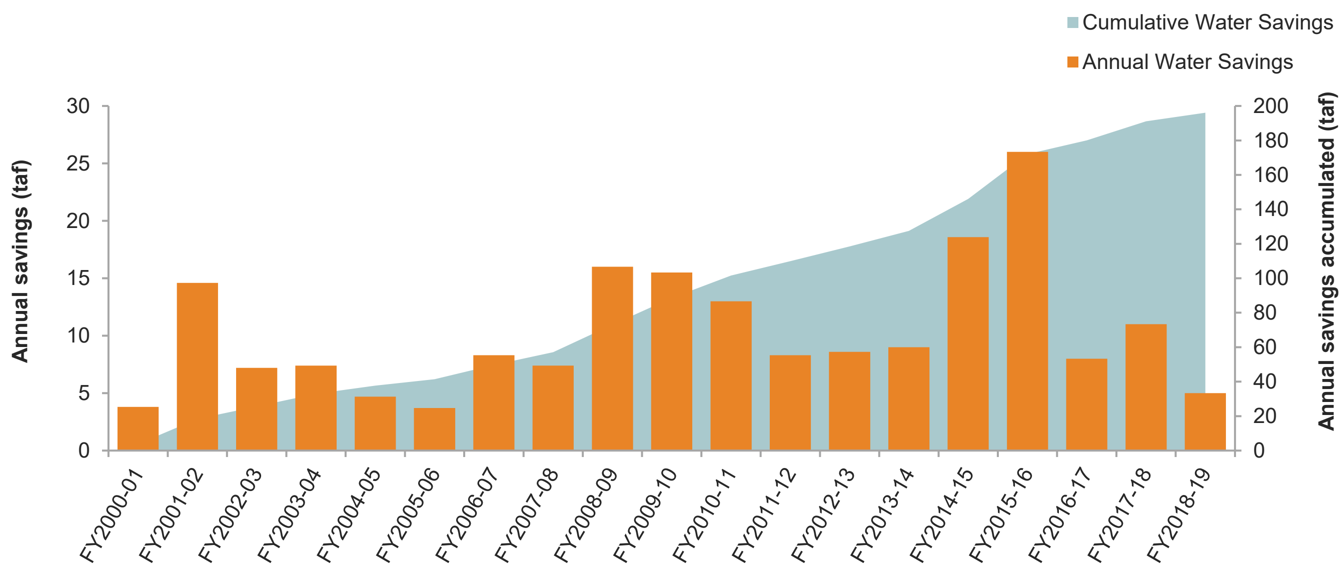
Long-term or "structural" demand management has played a very important role in reducing demands per capita—and total water use—in Southern California. And during droughts, short-term or "emergency" demand management has helped alleviate water shortages, while also accelerating investments in long-term conservation. The limited rebound after the latest drought is somewhat surprising, suggesting that most of the "emergency" water savings may be long-lasting. High precipitation in 2019 was likely a factor in the low water use numbers in that year, since higher rainfall reduces landscape water demand. Both recent trends and conversations with water managers suggest there has been a change in water use after the drought, reflecting both increased investments in long-term conservation measures, as well as long-lasting behavioral changes triggered by the emergency conservation efforts.

Regulatory changes on the horizon may also reduce future water demands. In 2018, a package of post-drought legislation was enacted (AB 1668 and SB 606), focused on promoting additional water conservation and changes in drought planning and reporting. The legislation calls for new state guidelines for efficient indoor and outdoor water use and water losses that urban utilities will need to meet (State Water Resources Control Board 2020). The indoor standard will be 55 gpcd until January 2025, and then will decrease to 50 gpcd in January 2030. Other standards are still under development. It is likely that in some communities, these new standards will increase conservation goals beyond the levels utilities would have set on their own.

To gain some insights on the potential for water savings in the future, we have analyzed MWD conservation programs since 2000.[7] Since that time, MWD and its member agencies have invested more than $1 billion (in 2018 $) in conservation programs, with almost half ($491 million) spent in the two worst years of the drought, 2014 and 2015. MWD estimates that these investments generated annual savings ranging from 5,000 to 26,000 af, for a cumulative total of almost 200,000 af in water savings annually by 2019 (Figure A5).

FIGURE A5

Water savings from conservation projects supported by the Metropolitan Water District and its member agencies



SOURCE: Metropolitan Water District of Southern California.

NOTE: Taf is thousand acre-feet. The cumulative savings were calculated by summing up the "annual water savings" each year.

How much more can be saved in the future given certain reductions in per capita water demands? To provide some additional insights, we explored some intermediate scenarios in addition to the upper and lower bounds of the projected range shown in Figure A4. All using the same population projections of nearly 1.5 million new residents by 2040 from the Department of Finance (2020).

- A "constant per capita use" scenario assumes that per capita water use stays at 2018 levels (135 gpcd). This corresponds to the upper range of our projection in Figure A4.
- A "water neutral growth" scenario assumes that per capita water use falls enough to accommodate population growth without increasing water demand;
- A "mild savings" scenario assumes a 10 percent reduction in per capita water use for each urban utility; and
- An "aggressive savings" scenario assumes a 20 percent reduction in per capita water use. This corresponds to the lower range of our projection in Figure A4.

For the constant per capita use scenario, per capita demand would stay at 135 gpcd, and total regional demand would increase by 6 percent (218,000 af by 2040 to accommodate population growth. For the water neutral

[7] See a detailed explanation of MWD Conservation Program in Technical Appendix B.

growth scenario, demand per capita would need to fall by 6 percent on average relative to 2018 levels of 135 gpcd, to 126 gpcd.[8] For the mild savings scenario, per capita use would have to fall by 10 percent on average, to 122 gpcd. Beyond the water required to accommodate population growth, this scenario would reduce demand by 141,000 af annually. For the aggressive savings scenario, per capita water use would fall by 20 percent on average, to 108 gpcd. This would reduce demand by 501,000 af, beyond water needed to accommodate growth. [9]

Water use per capita has already fallen tremendously since the early 2000s—from more than 180 gpcd to 135 gpcd in 2018, and even lower in the wet year of 2019 (125 gpcd). So the additional reductions in per capita use that would be needed to accommodate population growth without new supplies are not large, and additional savings beyond that point are also possible. These savings would be in line with the savings that MWD and its member agencies have achieved through their conservation programs during the past two decades. However, it is also likely that conservation efforts will become increasingly difficult, as many of the least-cost and easiest investments have already implemented.

Historical and Projected Water Supplies

Urban Southern California has one of the most complex water supply portfolios in the country, and probably in the world. A significant share of the region's water supply is imported from other regions. From 1976 to 2015, the area served by MWD imported an average of 2.2 million acre-feet (maf), nearly 60 percent of all water use (MWD 2016b) (Figure A6). The remainder is supplied from local sources, especially groundwater (more than 80%), but also local surface projects, a growing amount of recycled wastewater, and some desalination.

The supply mix has been evolving. Local supplies—groundwater, surface water, recycled wastewater and desalination—have been growing, from 1.46 maf for the 1976-1995 period, to 1.75 maf for the 1996-2015 period. This increase can be attributed largely to the expansion of recycled water, which now provides over 450 taf of water annually in Southern California, more than all other regions in the state combined (McCann et al. 2018). This represents a growth of 75 taf from 2010, and of 184 taf from 2001 (Downey 2020). The California Water Act in 1991, which set the first recycling goals for the state, may have helped drive this development. But it is also worth noting that statewide annual recycling goals set by this law—700,000 af by 2000, and 1 maf by 2010—have generally not been met. As of 2015, the total amount of water recycled statewide was 714 taf.

Desalination, both of brackish water and seawater, is another component of the supply portfolio. The Carlsbad Desalination Plant, operated by the San Diego County Water Authority, provides up to 56 taf of water annually. The Huntington Beach Desalination Plant, proposed by the Orange County Water District in partnership with the Municipal Water District of Orange County, may supply 56 taf annually by 2023. Other seawater desalination plants are under study. Brackish desalination is also important in some areas where groundwater quality is an issue.

Imports have also evolved. Water through the Los Angeles Aqueduct has decreased, averaging more than 380 taf for the 1976-95 period and 245 taf for the 1996-2015 period, a 36 percent reduction. Supplies from the State Water Project have increased significantly, averaging 710 taf for the first half of the period, and 1.14 maf for the second half, although they have declined again over the past decade because of drought and regulatory changes to environmental flows in the Delta. Finally, water imported from the Colorado River has decreased from 1.01 maf

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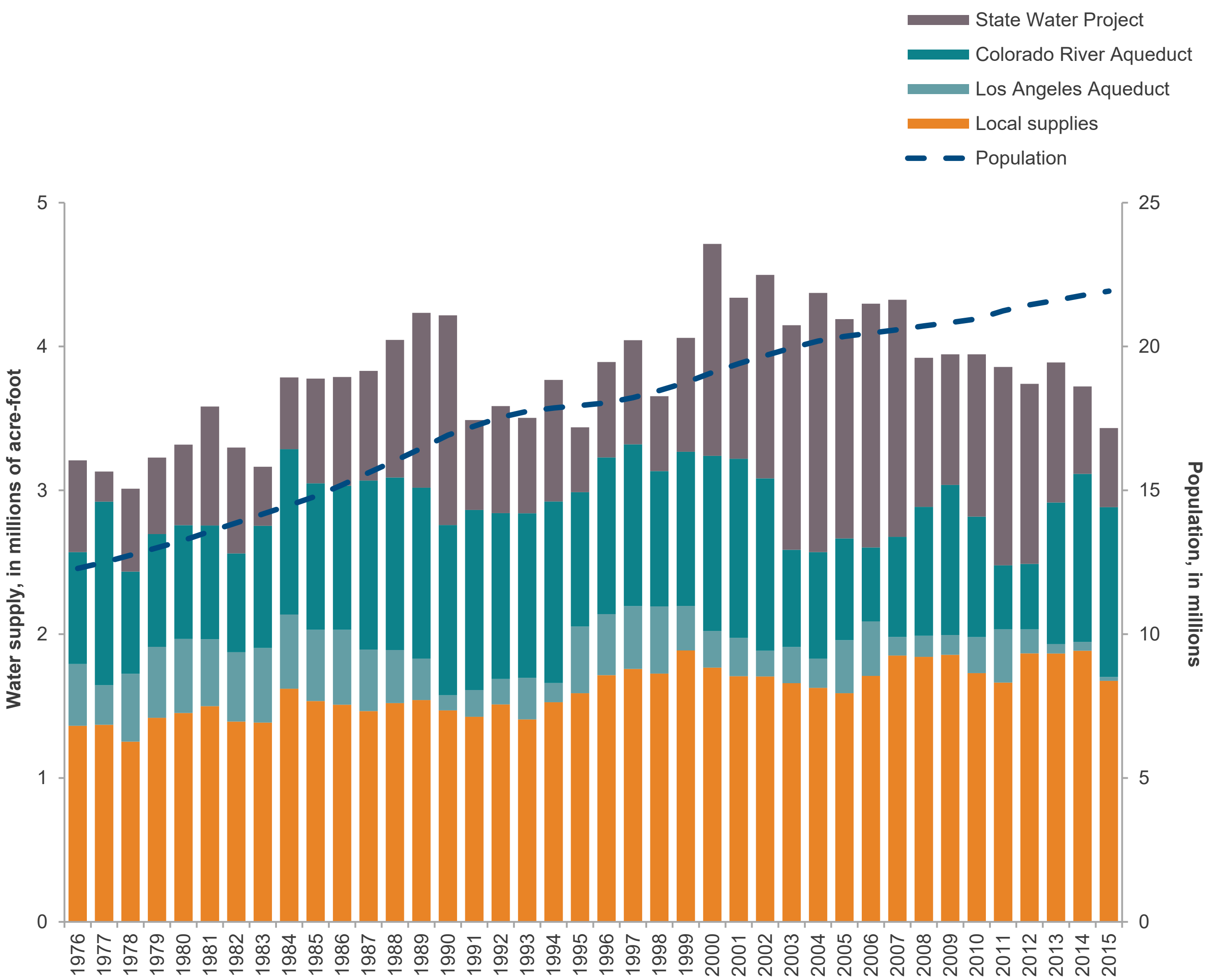
[8] These calculations assume a 6.5 percent increase in population from 2020 to 2040, according to the Department of Finance. The essential 50 gpc use is based on the SWRCB residential standard. Of course that there are other commercial, industrial and institutional uses that are essential, but we are just using this assumption for the example.

[9] The implications of these scenarios for reductions in non-essential water use is also of interest, in light of new state guidelines of 50 gpcd for essential indoor uses for residential customers by 2030 (California Department of Water Resources and State Water Resources Control Board 2018). Reducing overall per capita use by 6, 10, and 20 percent—the levels in the "water neutral growth", "mild savings," and "aggressive savings" scenarios corresponds to 10, 16 and 32 percent reductions in non-essential water uses. respectively

in the first half of the period, to 912 taf in the second half, reflecting California's need to reduce its use of the river under obligations to other basin states and Mexico. Colorado River Aqueduct supplies increase during dry years when SWP imports are low, easing the region's drought response. This is possible given the large storage capacity in the Colorado basin.

FIGURE A6

Local supply sources have increased slightly in MWD's service territory, and imports have recently fallen



SOURCE: 2015 Urban Water Management Plan (MWD 2016b).

NOTE: Local sources of water available to the region include surface water, groundwater, recycled water, and desalination.

Plans for Future Supplies

Table A1 presents the projections for water supplies out to 2040 in the MWD service area for urban retail agencies from the 2015 Urban Water Management Plans (UWMPs) and MWD's 2016 Integrated Water Resources Plan. Both MWD and the retailers anticipate that supply increases will come from three categories:

water recycling, imports, and groundwater.[10] Yet MWD's projections envisage much smaller supply increases, both overall and in each of those categories.

TABLE A1

Expected increase in water supplies by 2040 (in acre-foot)

Water Supply Category	Retailers	MWD
Imports	218,170	36,000
Local surface	2,783	0
Groundwater	197,383	23,000
Recycling	163,719	73,000
Seawater desalination	4,100	0
Total	586,154	132,000

SOURCES: Retailers: 2015 Urban Water Management Plans (UWMP), as reported in the Department of Water Resources online portal; MWD: 2016 IRP.

NOTES: Increases are the difference between the projected supplies by 2020 and 2040, except for MWD imports, where we used the difference between 2016 and 2040 to avoid including the interim reduction of SWP imports anticipated from 2020-30. For retailers, imports includes imports, purchases of water from wholesalers, and exchanges with other agencies. This underestimates anticipated imports since some new groundwater recharge would also rely on imported supplies.

As described in the main report, MWD's plans for imported water focus largely on avoiding further declines in SWP and Colorado River supplies; construction of new conveyance through the Delta is anticipated to slightly increase imports relative to recent levels. In light of the demand reductions the region has experienced since the latest drought, it is likely that the next round of retail agency planning documents will also project more limited supply increases. Our conversations with water managers also pointed to continued interest in alternative supplies, including recycled water, as a priority.

Storage Capacity in the MWD Service Area

To manage droughts, Southern California has invested heavily in water storage. MWD has developed over 6 maf of storage capacity since the 1980s, a 15-fold increase.[11] This storage capacity is distributed across different regions—with roughly two-thirds of the total outside MWD's service area (Figure A7). MWD can store some 1.2 maf of water in-region; more than 2.5 maf in the Colorado Basin, and over 2.2 maf in the San Joaquin Valley and with other SWP contractors in Southern California. Although a significant part of the out-of-region storage is in surface reservoirs—1.75 maf in Colorado River's Lake Mead, and almost a million acre-feet in the SWP's system—a significant portion (over 2 maf) has been developed under groundwater banking partnership agreements with water agencies in both the San Joaquin Valley and Southern California regions.

As of January 1, 2020, MWD had roughly 3.5 maf of water stored—the highest level ever. Slightly over 1 maf were stored in local reservoirs and groundwater accounts, including 750,000 af reserved for an earthquake emergency that is not meant to be used in dry years. Beyond its service area, MWD had record volumes of water

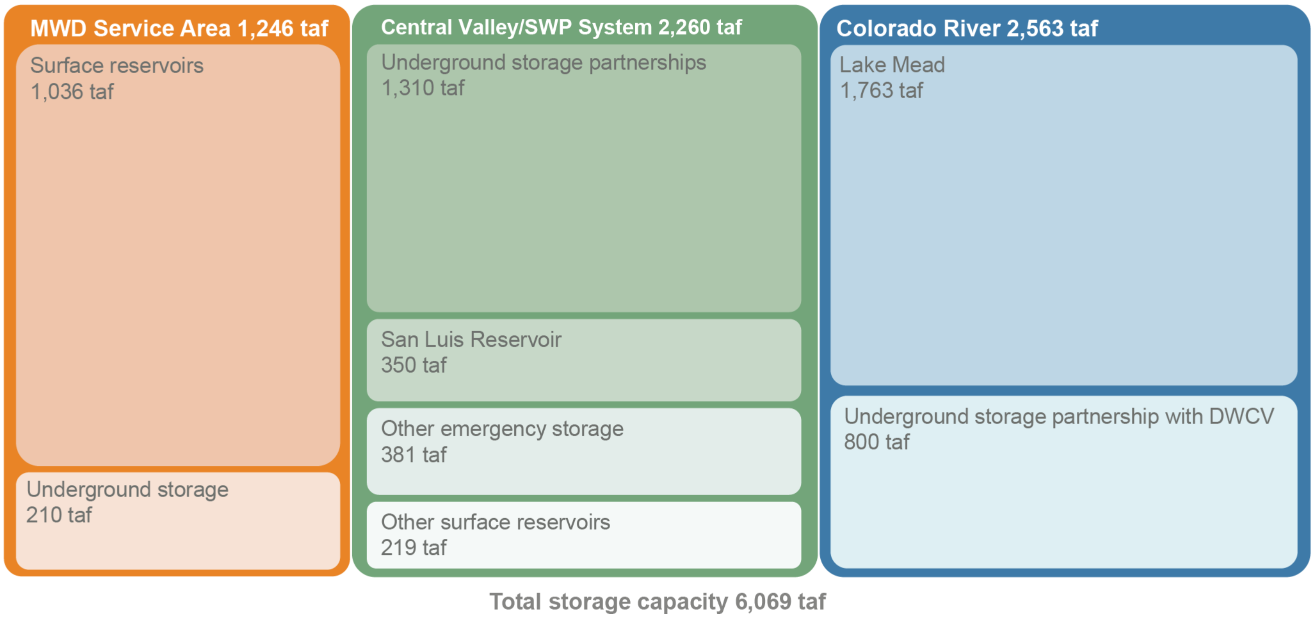
[10] The complexity of management options and the need to categorize the data under a few categories in the UWMPs make the comparison across categories challenging. For instance, some agencies are planning to increase groundwater recharge to enable more groundwater use, and the sources include capturing stormwater, importing more water, or using recycled wastewater. These agencies may include these recharge sources as groundwater, rather than the specific water sources used for recharge. Similar issues happen with other categories.

[11] The 2016 IRP (MWD 2016a) estimated that the agency had developed over 5.5 maf of storage capacity since the mid-1980s, a 13-fold increase. This number has since increased to more than 6 maf, based on data we gathered from MWD.

stored in Lake Mead (nearly 1 maf) plus nearly 300,000 af in banking agreements with other Colorado River users; and nearly 1.2 maf in groundwater and surface reservoirs within the SWP system (MWD 2020).

FIGURE A7

MWD water storage capacity by program and region



SOURCE: Compiled by the authors using MWD's IRP (2016) and MWD's January 2020 Water Surplus and Drought Management Update (2020).

NOTE: taf is thousand acre-feet. The MWD Service Area category includes the surface storage owned by the MWD and the Department of Water Resources, and conjunctive use programs. The Central Valley/SWP Area category includes SWP contractors in Southern California outside MWD's service area, including Mojave Water Agency and San Bernardino Valley Municipal Water District, in addition to the Central Valley water banks and San Luis Reservoir. The Colorado River category includes groundwater banks with Colorado River users in Southern California beyond the MWD service area (Desert Water Agency and Coachella Valley Water District advanced delivery account).

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