Desalination (Brackish and Seawater) Resource Management Strategy

Draft Memorandum

CALIFORNIA WATER PLAN UPDATE 2023

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DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

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Contents

Tables

Figures

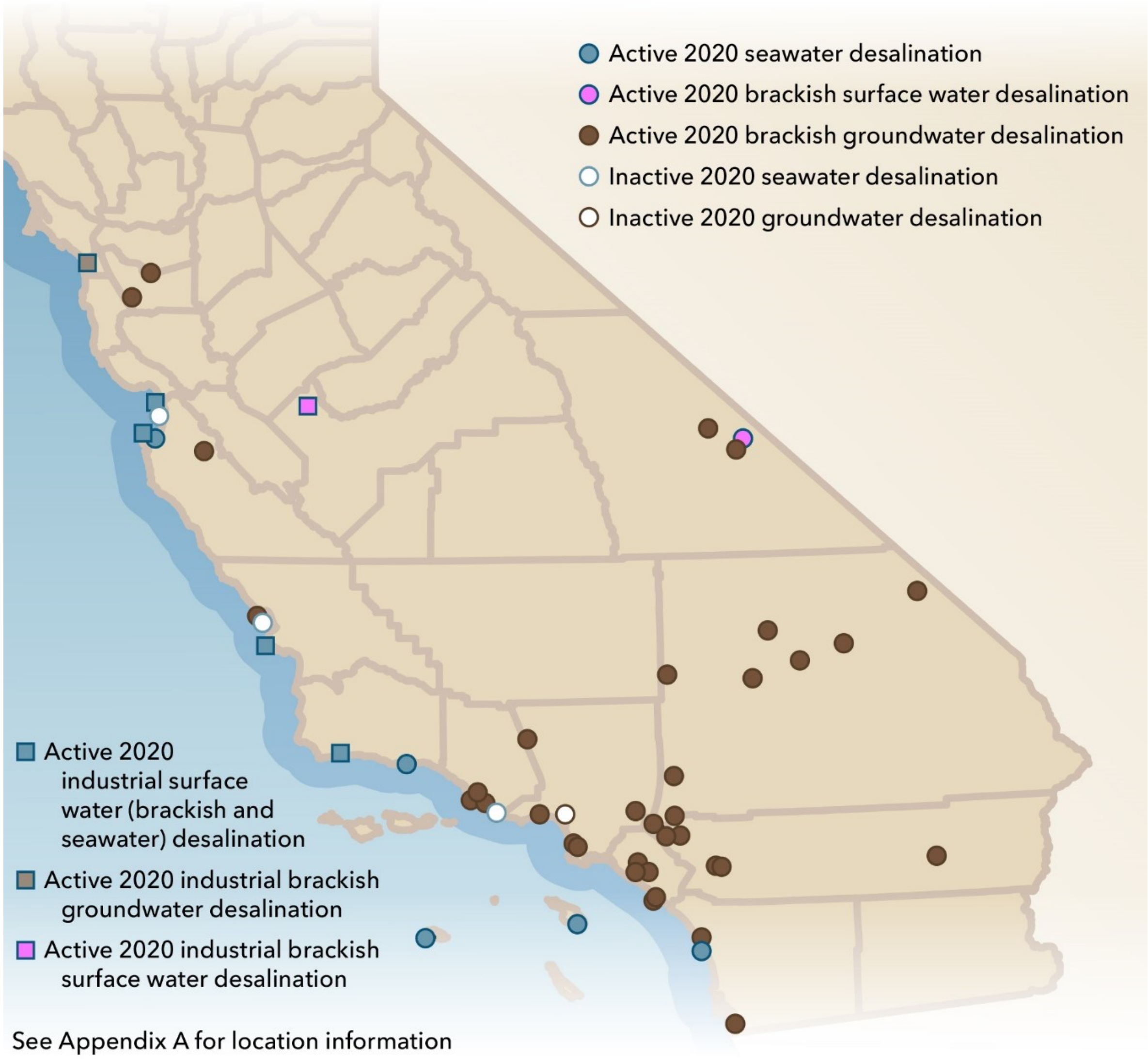
Acronyms and Abbreviations

af/yr	acre-feet per year
CEQA	California Environmental Quality Act
Desalination RMS	*Desalination (Brackish and Seawater) Resource Management Strategy*
DWR	California Department of Water Resources
GSP	groundwater sustainability plan
mg/L	milligrams per liter
RMS	resource management strategy
RWQCB	regional water quality control board
SGMA	Sustainable Groundwater Management Act
SMCL	secondary maximum contaminant level
State Water Board	State Water Resources Control Board
TDS	total dissolved solids
Water Supply Strategy	*California's Water Supply Strategy: Adapting to a Hotter, Drier Future*

1. Introduction

Desalination – the removal of naturally-occurring salt from water for beneficial use – occurred at 51 identified California facilities in 2020. The 51 facilities are shown in Figure 1 and are identified in Appendix A. These facilities desalinate groundwater or surface water to support potable and industrial needs of California communities ranging from small, remote locations to large, urban populations. In general, desalination of water occurs where available water supplies are limited or where local supplies are too high in total dissolved solids (TDS) (the amount of salts and other minerals present in the water) to be used without treatment.

Figure 1 Location of 2020 Desalination Facilities

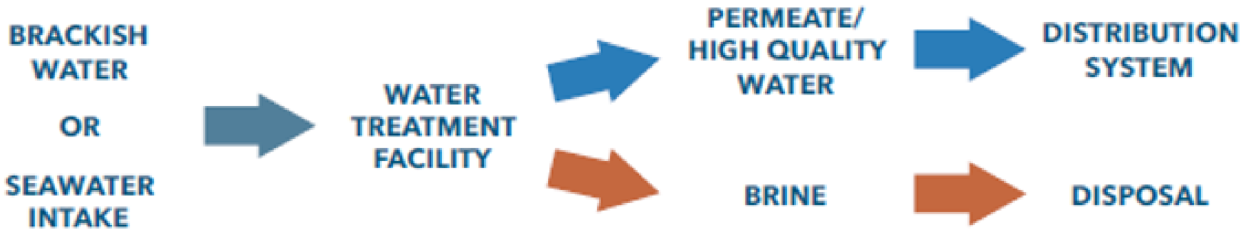


The objective of the *Desalination (Brackish and Seawater) Resource Management Strategy* (Desalination RMS) is to present the status of desalination in California, its projected future uses, and its benefits and challenges. The discussion herein does not take a position for or against desalination. Desalination is a methodology to be considered or implemented with other water supply and demand management approaches including conservation, potable and non-potable reuse, stormwater capture, and infrastructure improvements. This Desalination RMS does not rank other water supply approaches, nor does it prioritize them over desalination. The determination to implement desalination to support local or regional water supply resources is the decision of the local water suppliers, to be made after careful evaluation and consideration of alternatives, conformity to applicable State and local requirements, and thorough public process.

The Desalination RMS discusses issues associated with removing naturally-occurring salts for subsequent potable or industrial beneficial use of the water. Treating water that is saline because of anthropogenic activities, such as remediation and wastewater treatment for reuse, may use common technologies or have similar challenges and benefits as presented in the Desalination RMS. These other applications are discussed in other RMSs that are listed in Section 7, "Related Resource Management Strategies."

The process of desalinating water can be complex and expensive but can also produce a high-quality and reliable water supply. Figure 2 shows the general approach to desalinating water.

Figure 2 General Desalination Process



- **Intake**: How the water is extracted from its source. The intake can be a screened pump from a surface-water body, a groundwater well, a slant well extracting seawater through the seabed, or other method.
- **Treatment**: How salt is removed from the water extracted from its source. Treatment usually involves various processes including filtration and reverse

osmosis. The treatment process separates the intake water into permeate and brine.

- **Permeate**: The remaining water after salts have been removed. For potable facilities this is drinking water and will have additional treatment or blending before being introduced into the local distribution system.
- **Brine**: High TDS liquid waste product. It is disposed through various methods, including blending with discharged municipal wastewater, being distributed by ocean diffusers, and evaporation.

Factors and challenges influencing these steps in the desalination process will be addressed in later sections of this RMS.

A key factor in discussing desalination is the source water salinity. Seawater has more salt in it, by volume, than brackish water. Removing salt from seawater takes more energy than removing salt from brackish water and produces more brine. Salt that is removed during treatment remains in a concentrated brine at the end of the treatment process. Handling this brine is referred to as brine management. Both energy and brine management will be discussed further in Section 4, "Barriers to Implementing Desalination."

This RMS discusses the status of water desalination in California, its challenges, and what water suppliers and researchers are considering for the future. It focuses on desalination of water for potable supply, although desalinated water is also used for industrial processes throughout the state and is discussed briefly later in this RMS. The role desalination plays in future water supply strategies to address climate change issues – described in the August 2022 document *California's Water Supply Strategy: Adapting to a Hotter, Drier Future* (WSS) – will be discussed in Section 5, "Desalination and the Water Resilience Portfolio."

The previous version of this RMS, prepared in 2013, focuses on desalination methods and approaches. The 2023 version focuses more on current issues and future objectives. The reader is referred to the 2013 version for a thorough discussion of technologies and the history of desalination in California. The technologies are largely unchanged since 2013, but improvements in efficiencies are being widely implemented and new research is ongoing, as discussed later in this RMS.

Types of Desalinated Source Waters

Groundwater and surface water are desalinated in California for beneficial use. Source water characterization is irrespective of the method or methods used to collect the water to be treated.

- **Groundwater**: Groundwater desalination occurs when salts are removed from groundwater to meet State guidelines before it is delivered as potable water supply. The State Water Resources Control Board (State Water Board) has established the recommended secondary maximum contaminant level (SMCL) for TDS as 500 milligrams per liter (mg/L) with an upper SMCL of 1,000 mg/L. Most groundwater desalination in California occurs when TDS values are more than 1,000 mg/L, but some occurs when the TDS of the source water is between 500 and 1,000 mg/L.
- **Surface Water**: Surface water desalination in California has traditionally been seawater desalination, although a small facility in Death Valley desalinates surface water from springs. Additionally, two California communities are adding desalination treatment to address increasing salinity in inland surface water supplies. In 2021 the City of Fort Bragg began desalinating water from its Noyo River intake because of seawater intrusion during high tide. In 2025, the City of Antioch will begin desalinating water from its San Joaquin River intake because of increasing saline bay water intrusion.

Distinguishing the type of source water for a desalination facility is important not only because the salinity of the inflow water drives the treatment process. The siting process for new or expanded seawater facilities is significantly more involved and can take much longer as compared to brackish surface water or groundwater facilities. New or expanded coastal facilities require compliance for intake and brine disposal with the current *Water Quality Control Plan: Ocean Waters of California* (Ocean Plan) prepared by the State Water Board. Coastal facilities usually require a Coastal Development Permit from the California Coastal Commission, as well as involvement with the Department of Fish and Wildlife and the State Lands Commission. These processes for coastal facilities involve considerable agency and applicant coordination and development of supporting documentation, which can take years to complete and require significant financial investment. The State Water Board, in coordination with local, State, and federal agencies, completed the *Seawater Desalination Siting and Streamlining Report to Expedite Permitting* to identify approaches that facilitate permitting for coastal desalination facilities.

For coastal facilities, determining whether the source water is groundwater or surface water may not be immediately obvious. The Ocean Plan defines seawater as "salt water that is in or from the ocean." Source water intakes for coastal seawater facilities may be vertical, collector, or slant wells that may partially or fully collect saline groundwater affected by seawater intrusion. For this RMS, facilities with any type of well immediately adjacent to the coast that collect groundwater with a TDS comparable to seawater (more than 30,000 mg/L) are considered seawater desalination facilities. Those facilities identified in this RMS as seawater facilities are consistent with active seawater desalination facilities identified by the State Water Board on its website map.

Desalination in California

The volume of desalinated water produced for potable use in California during 2020 was 150,000 acre-feet at 46 active facilities (Table A-1), including 45 dedicated potable facilities and potable water produced for use at the Diablo Canyon Power Plant. An acre-foot is 325,851 gallons, which is approximately enough water to supply two to three households of four for a year. Information on 2020 desalinated water use was obtained from direct inquiries and the 2020 urban water management plans (UWMPs) submitted to DWR. This assessment of 2020 statewide desalinated water use only included centralized desalination facilities operated by a water supplier and did not include onsite treatment for individual residential or commercial buildings.

Desalination facilities in California are in a wide range of communities. These include areas that do not have reliable fresh water supplies but do have access to brackish or saline water supplies. This situation also applies to some island or isolated communities. Most of the urban areas using desalinated water are also using recycled water, indicating that desalination can effectively be a component of a diversified water supply portfolio.

Industrial desalination is not included in the 2020 volume of statewide desalination because some of the industrial suppliers did not provide production volumes. Because of this and because the 2010 quantified volume did not include industrial production either, the 2020 volume focuses on potable supply. The potable use estimate is also considered a reasonably accurate number because of the strong response provided by the potable suppliers to California Department of Water Resources' (DWR's) inquiries.

The 2013 RMS identified approximately 80,000 acre-feet of desalinated water for potable use in 2010, which was the last time potable water produced by desalination was quantified. Between 2010 and 2020, desalination production in California for potable use almost doubled. The rapid increase may be attributed to factors such as:

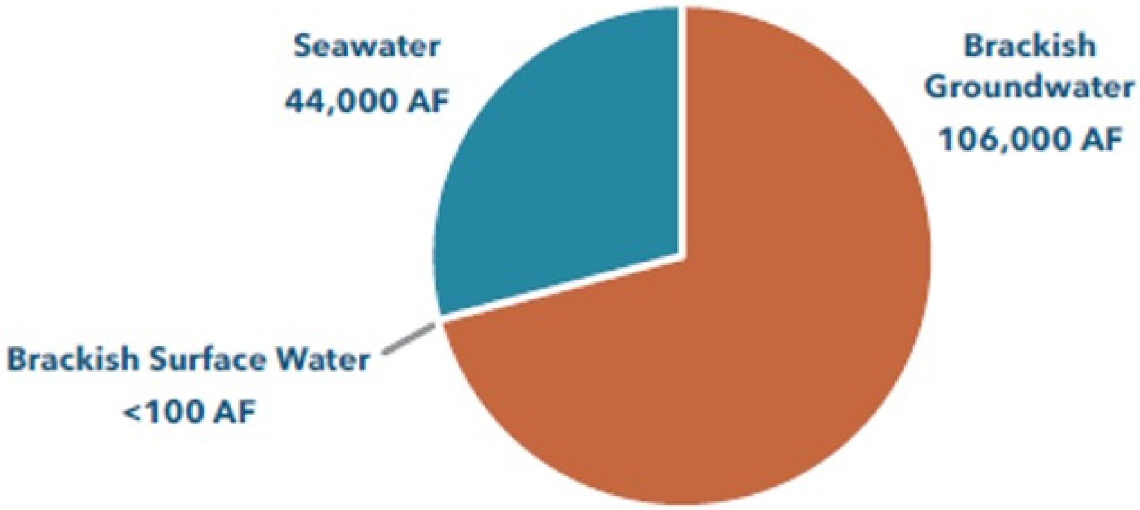
- Construction and start-up of the Claude “Bud” Lewis Carlsbad Desalination Plant, which delivers as much as 50 million gallons per day (56,000 acre-feet per year [af/yr]) of desalinated seawater to the San Diego County Water Authority, Vallecitos Water District, and Carlsbad Municipal Water District.
- Construction or expansion of multiple groundwater desalination facilities, particularly in Southern California.
- Improvement in efficiencies of desalination technologies, which has reduced the cost per unit of water.
- Increase in costs of traditional surface water supplies.
- Decrease in availability of inexpensive and reliable water supplies.
- Concern about reliability and availability of future water supplies.
- Severe drought and snowpack decline in recent years leading to a shortage of freshwater resources.

Considering the third and fourth factors, improvement in efficiencies of desalination technologies and increase in costs of traditional surface water supplies, the cost of desalination is becoming more comparable with other water supplies and is being considered by water suppliers throughout the state as a viable solution for addressing water scarcity. Transporting water supplies over long distances, such as moving Colorado River or Northern California water to Southern California, requires power to move the water while evaporation during transport in open canals degrades water quality. Including these factors in alternatives evaluation is an important component of assessing and comparing desalinated water to other water supply sources. These issues underscore the need for careful analyses and evaluation for desalination, and any water supply project, because treatment costs and comparisons can be very project specific.

Brackish Groundwater

Brackish groundwater is the source water for the majority of water desalinated in California in 2020 (Figure 3). Most brackish groundwater facilities are in the inland groundwater basins of Southern California, serving large urban areas and rural communities. Brackish groundwater facilities may provide the sole source of water for smaller communities in desert areas. For larger communities closer to the coast, brackish groundwater may be one component of a water supply portfolio.

Figure 3 **2020 California Potable Desalinated Supplies by Source Water Type**



Industrial Uses of Desalinated Water

There are six identified locations (Figure 1, Appendix A) where dedicated desalination facilities support a wide variety of non-potable uses in the state. These facilities are:

- **San Francisco**: A 92 af/yr facility in San Francisco that uses brackish groundwater collected from a dewatering facility at a BART station to support the City's heat production plant.
- **Santa Barbara County**: A 323 af/yr facility in Santa Barbara County that produces steam to warm oil from offshore oil rigs to improve its movement in pipelines.
- **Monterey**: The Monterey Aquarium desalinates approximately 11,000 gallons per day (about 12 af/yr) of its seawater intake for toilet flushing and life support equipment maintenance, which lessens the Aquarium's impact on local water supplies.
- **Moss Landing**: The Moss Landing power facility utilizes a seawater evaporator as a desalination plant to create ultra-high purity water for the steam turbines.
- **Diablo Canyon**: The desalination facility operating at the nuclear power plant produces potable and non-potable water.

Water is also desalinated on off-shore oil and gas platforms, probably for potable and non-potable uses. These platforms have not been specifically identified for this RMS.

Projected Future Growth of Desalinated Water

Table 1 identifies water suppliers reporting in their UWMPs that future water supplies will include desalinated water. This table includes three existing facilities (shown as inactive in Figures 1 and A-1) that were not operating in 2020 but that are restarted or are planned to restart. The locations of these suppliers are shown in Figure 4.

The projects listed in Table 1 that have not begun construction have a high, but not definite, probability of being constructed before 2040. These projects are either identified in UWMPs or communicated to DWR that they are planned. As a result, the water that these facilities are projected to produce is included in future UWMP water supply and demand calculations. There are other projects that are in earlier phases of planning but are not included in this RMS because there is less certainty of completion.

Figure 4 **Planned Desalination Projects Expected to be Online by 2040**

Table 1 California Desalination Facilities Expected to be Online by 2040

Agency	Facility	County	Planned Year	Source Water	Planned Capacity (acre-feet/year)	2023 Status
The Ranch at Live Oak	Desalination Facility	Ventura	2021	GW	Unknown	Operating. Restart of existing facility.
City of Camarillo	North Pleasant Valley Groundwater Desalter	Ventura	2022	GW	3,877	Operating
Ventura County Waterworks District No. 1	Moorpark Groundwater Desalter	Ventura	2030	GW	5,000	Project dependent on extension of existing brine line.
City of Thousand Oaks	Los Robles Desalter	Ventura	2025	GW	500	Planned
United Water Conservation District	Point Mugu	Ventura	2030	GW	5,000	Treatment will begin in Phase II of the project.
City of Beverly Hills	Beverly Hills Desalter	Los Angeles	2022	GW	2,952 to 3,327	Operating. Restart of existing facility. Expansion in 2030.
Water Replenishment District	Regional Brackish Water Reclamation Program	Los Angeles	2027	GW	10,000	Planned expansion of the existing Goldsworthy Desalter.
Eastern Municipal Water District	Perris II Desalter	Riverside	2022	GW	5,400	Operating
Naval Facilities Command	Twentynine Palms Treatment and Blending Facility	San Bernardino	2022	GW	3,363	Operating

Agency	**Facility**	**County**	**Planned Year**	**Source Water**	**Planned Capacity (acre-feet/year)**	**2023 Status**
Rainbow Municipal Water District	Rainbow MWD Desalination Facility	San Diego	2030	GW	2,000	Planned
Olivenhain Municipal Water District	San Dieguito Basin Desalter	San Diego	2028	GW	1,120	Planned
Otay Water District	Rancho Del Rey Groundwater Well Project (Desalination)	San Diego	2035	GW	500	Planned
City of Fort Bragg	Fort Bragg	Mendocino	2022	BSW	2	Operating
City of Antioch	Antioch	Contra Costa	2025	BSW	3,000	In construction
Marina Coast Water District	Marina Desalination Facility Expansion	Monterey	2030	Seawater	300	Restart of existing facility planned for 2024.
California American Water-Monterey	Coastal Water Desalination Project (Cal-AM)	Monterey	2030	Seawater	6,252	Planned
City of Santa Barbara	Charles Meyer Desalination Plant	Santa Barbara	2030	Seawater	5,000	Planned expansion from existing 3,125 to 5,000 af/yr.
South Coast Water District (et al.)	Doheny Ocean Desalination Project	Orange	2025	Seawater	5,600 to 16,802	Planned. Expansion in 2035.
Catalina Island	Plants 1 and 2	Los Angeles	2025	Seawater	145	Currently expanding total from 186 to 331 af/yr.

2. Benefits of Integrating Desalination into a Water Supply Portfolio

Desalination, at properly designed and sited facilities, has the benefit of providing a reliable supply to a local water supplier's water supply portfolio in locations where other water supply options are not readily available or where existing supplies are affected by elevated salinity (i.e., TDS) levels. The benefits of desalination in these situations are discussed below. If adequate and sustainable water supplies are reliably available that do not require desalination, in most cases water suppliers will opt for non-desalinated supplies because of cost and other issues discussed in Section 4, "Barriers to Implementing Desalination."

Diversified Water Supply Portfolio

Water suppliers are diversifying water supply resources and developing alternative water sources such as desalinated water, recycled water, stormwater, and gray water to augment traditional surface water and groundwater resources. They are also implementing demand management measures such as conservation and efficiency measures, as well as repairing or improving infrastructure. Having multiple sources of water provides water supply resilience to help meet an uncertain water supply future. Changing climatic conditions are making existing water supplies less reliable and drought conditions more common. Diversifying water supplies usually incurs additional costs with the construction of additional infrastructure or development of water-sharing agreements. The ability to manage resources, such as being able to reduce groundwater pumping when groundwater levels are declining, may outweigh the additional infrastructure costs. Being able to maintain a consistent water supply for customers during drought and other periods of uncertainty by developing desalinated supplies could be comparable to obtaining water from external sources during drought periods because obtaining additional water supplies during extended drought periods can be more difficult and expensive. These factors should be considered and evaluated during alternatives analysis.

A regional or watershed approach to water supply diversification can also be beneficial, especially when considering desalination. Two existing desalination facilities are regional providers of water. The Poseidon facility in Carlsbad and the City of Santa Barbara's facility support multiple water suppliers. It is expected that the soon-to-be-constructed South Coast Water District Doheny facility also will be a regional provider, as will the planned California American Water Company's

Monterey plant. This enables these desalination facilities to defray construction and operational costs and balance regional water needs. Conveyance costs also need to be considered when assessing regional supply opportunities.

Water supply diversification is being implemented as a tool to identify additional water supplies and to replace existing supplies to make sure that future supplies can support future needs. Future water supplies may be unreliable, over-allocated, or unavailable. Desalination, where appropriate, may be evaluated as a feasible option.

Water Supply Reliability

Properly designed and sited desalination water treatment facilities provide unique reliability because they are generally sourced from consistent surface or groundwater supplies. They may also be less affected by changing climatic conditions or droughts, especially if the source water is seawater. As climate change continues to affect weather patterns in California, there is potential for increased occurrence of extreme climatic conditions such as droughts or floods. Investment in cost-effective and consistent water supply approaches may provide options. Desalination is one type of reliable water supply, as are recycled water projects, gray water projects, and stormwater projects that capture recurring stormwater events. Costs and environmental impacts for these different supply options are generally considered during development of a supplier’s water supply plan.

In communities implementing groundwater or seawater desalination, desalination is usually an effective baseline component of a diversified water supply portfolio. For the city of Santa Barbara and the San Diego region, desalinated seawater provides a baseline supply of approximately 15 percent to 25 percent, and 10 percent, respectively, of their total water supplies. This enables both communities to use other diversified supply portfolios components to meet seasonal and annual water needs, as they are available. The South Coast Water District’s Doheny facility and the California American Water Company’s Monterey plant are expected to have similar approaches to operation of their planned facilities. Water suppliers desalinating groundwater also rely on these sources as a component of total supply. Most also have groundwater resources that are not desalinated, as well as recycled water and surface water supplies as part of their diversified water supply portfolios.

Operating desalinated resources as a baseline supply also provides water suppliers with a level of certainty for local or regional supplies. Local supplies can provide greater reliability when planning future water supply availability because they may be more reliable than water supplies conveyed over long distances, or imported supplies which may be subject to allocation reductions during drought periods.

Human Right to Water

In California, the Human Right to Water means that “every human being has the right to safe, clean, affordable, and accessible water." This includes having sufficient supplies for direct consumption, cooking, and sanitary purposes. This right extends to all Californians, regardless of location or socioeconomics.

The right to water inherently implies reliability. In some more arid parts of the state, where local water supplies contain naturally high levels of salt, desalinated water may provide the only reliable option for water supply. As the State evaluates future water supply options and changing climatic conditions, desalination could play a role in supporting the human right to water.

Two key components of the human right to water that directly apply to desalinated water are accessibility and affordability. Desalination has the potential to affect water rates. The accessibility of desalinated water to disadvantaged communities, and methods to shield disadvantaged households from the effects of potential rate increases, has been discussed at hearings for proposed desalination projects. As water suppliers evaluate water supply options, these issues should be included and documented in an alternatives analysis, particularly with respect to supporting water supply needs for disadvantaged households, to develop implementable and successful methods to address water affordability issues.

Variable Water Sources for Other Uses

The advantage of a baseline sustainable water source enables a water supplier to manage its supplies. The water supplier may be able to use less expensive sources, as they are available, or enable surface water supplies to recharge groundwater during wet periods so that groundwater is available during droughts. It may also enable suppliers to utilize supplies in different distribution system zones to reduce pumping costs or enable water transfers to other water suppliers or users.

Beneficial Use of Low-quality Water

Desalination enables brackish or saline water, unusable as water supply because of salinity, to be used for potable supply. Removal of salts in potable water can also support a community’s reuse program by lowering recycled water salinity. Other potential beneficial uses include agriculture or manufacturers operating in water-challenged areas of the state. Treatment approaches and water-quality objectives would be considered on a project-specific basis.

Using either brackish water or seawater requires ensuring that the source water use complies with existing requirements. Use of brackish groundwater should adhere to groundwater management plans that comply with the 2014 Sustainable Groundwater Management Act (SGMA) or basin adjudication allocations. Seawater desalination must comply the Ocean Plan and Coastal Act requirements. Brackish surface water, unless it is within the jurisdiction of the Ocean Plan would need to comply with existing surface water rights.

Projects are being evaluated to develop brackish groundwater projects that would provide dual benefits when desalinating low-quality water. If they move forward, these projects address water supply problems associated with seawater intrusion.

Historic Seawater Intrusion

The regional Brackish Groundwater Reclamation Program will remove brackish water to remediate the groundwater basin and desalinate the extracted water for water supply. The project, which expands current brackish groundwater extraction for potable supply, is being planned by the Water Replenishment District. Its regional partners plan to capture and treat saline groundwater from seawater intrusion into the Coastal Plain of Los Angeles groundwater basin that occurred in the 20th century. Brackish water was trapped in the West Coast subbasin when the seawater injection barriers were implemented to address seawater intrusion. The trapped saline water adversely affects the groundwater of several suppliers. By expanding extracting and desalinating this water, the regional partners will have an additional water supply and, in the future, be able to recharge the basin with high-quality recycled water. The regional partnership helps defray the desalination costs among multiple agencies and supports local disadvantaged communities.

Extraction Barriers

Two extraction barriers are planned where ongoing seawater intrusion is impacting local supplies. These projects will extract groundwater along the coast to prevent further inland migration of seawater and then desalinate the extracted water for local and potable use. This approach differs from existing seawater intrusion barriers in Los Angeles and Orange counties which inject highly treated recycled water to create a barrier. The Monterey County extraction barriers is discussed in two groundwater sustainability plans (Montgomery & Associates 2022; Montgomery & Associates 2020) and the Ventura County project is discussed on the United Water Conservation District website.

3. Investment Needs and the Cost of Inaction

As California looks to strengthen water supply reliability, developing water resources that can respond to changing conditions will be a key factor in meeting the state's future needs.

Changing Water Supplies

Groundwater and surface water were the water sources used by Californians in the 19th and 20th centuries to meet agricultural, industrial, and personal needs. With more frequent and prolonged drought conditions in the late 20th century and again early in the 21st century, coupled with larger population and aging infrastructure, water suppliers began to look at other potential sources of water to meet growing water demands. Options such as hauling icebergs and barging large "pillows" of fresh water filled from northern rivers (the Columbia River and Alaska were often cited) were seen as stop-gap measures. As water suppliers realized that climate change was a global phenomenon with widespread impacts, they began to look for locally available resources. Recycled water is now a key component of many water suppliers' portfolios, particularly in Southern California.

David Sedlack, a University of California, Berkeley engineering professor, recently noted, "The water supplies of 2050 will be different from those of 2020." (Sedlack pers. comm. Feb. 2023). Although 2050 water supplies cannot be predicted exactly, it is expected that groundwater and surface water will no longer be the only sources water suppliers utilize to meet future needs. For example, the 2023 *Municipal Recycled Water RMS* reports that municipal recycled water accounted for approximately 7 percent of the developed urban water supply statewide in 2020 and 13 percent in the greater Los Angeles/San Diego area, where recycled water use is highest. Local resources will become increasingly important to water suppliers as they seek to be able to meet customer needs with sources that they can rely on through their own efforts. This will also reduce the impact of evaporation and electrical consumption required to convey water over long distances. To support long-term sustainability, suppliers will seek ways to reduce using water once and discharging it to locations where it cannot be reused.

The Cost of Inaction

California requires a secure water supply to support its population as well as its agricultural, commercial, and industrial needs. The state faces the risk of potential water supply insecurity if it does not begin to plan comprehensively and cohesively to develop the water supply resources for 2040 and beyond. Desalination, as well as other alternate water supplies such as recycled and gray water, can play a key role in providing a reliable water supply.

Developing reliable and sustainable long-term water supplies will require extensive planning and design. Key drivers supporting sustainability will be how water solutions interact with other resources, are protective of the environment, identify multi-benefit approaches, and address climate change impacts. Implementation of long-term, sustainable solutions will require careful planning and consideration of impacts, which can take years or decades. These solutions will also require extensive local and regional coordination to support broad-scale connection and to avoid inter-regional divergence and must look at long-term changes versus annual variability.

Once appropriate plans are developed, design and construction of major infrastructure projects will also require time. This is true especially for desalination projects, which will be discussed further in Section 4, “Barriers to Implementing Desalination.” Because desalination, as well as other water projects, require longer lead times for implementation of a balanced project, this is the time for planning reasonable and sustainable projects. Crisis response runs the risk of developing inappropriate projects potentially with lasting negative impacts. This could result in wasting money, often at the expense of taxpayers and ratepayers.

Climate Change

Adaptation

Climate change has started affecting water resources in California and is expected to continue doing so. Observational records over the last 100 years indicate greater weather extremes, reduced snowpack, higher sea level, and changes in river flows. The warmer atmosphere the Earth is experiencing has brought increased temperatures and is affecting precipitation patterns. As a result, California is expected to fluctuate between extreme weather of droughts and floods more frequently.

California’s already inconsistent and varied water years are expected to become more erratic in the future and desalination could help provide more consistent, reliable water supply in a more extreme climate. The adaptation strategy that desalination can provide will also help diversify water portfolios by expanding the local water supply. Expanding local water supplies has the potential to reduce water importation and lessen water demands pressures in other regions of California, particularly in constrained ecosystems such as the Delta which is vulnerable to degradation caused by climate change and water supply demands. Additionally, water managers are encouraged to prepare an energy consumption and greenhouse gas (GHG) emissions assessment to inform their decisions on the most sustainable water sources.

Sea level rise is caused by warmer temperatures, melting ice sheets, and oceans absorbing heat creating thermal expansion. It will affect the physical coastline and coastal aquifers. As sea level rises, the coastline moves inland causing saltwater to intrude into existing groundwater basins adjacent to the coastline. Saltwater intrusion reduces the amount of fresh water in coastal groundwater basins and can affect water suppliers that use coastal aquifers for water supply. Desalination may be used to supplement the loss of capacity in coastal aquifers and restore coastal water supplies. Proposed project locations would need to comply with permitting requirements relative to sea level rise and address energy source impacts.

Mitigation

The “greenhouse effect” refers to certain gases in the Earth’s atmosphere that trap heat like a blanket and effectively warm the planet. Increasing emissions of these gases through human activities are thickening this blanket and causing climate change. The biggest contributor of human-caused emissions is the burning of fossil fuels for energy and transportation. Reducing these human activities is essential for halting climate change and avoiding the most severe global impacts.

The energy demand associated with desalination is quite high, as mentioned previously in this document. Energy is not only needed for water treatment, but also for brine management including conveyance. Producing energy from fossil fuels for the purposes of desalination will increase GHG emissions and further advance global warming. As a result, although desalination may provide a climate-resilient and robust water supply, the operation of desalination facilities has the potential to counteract GHG reduction goals if fossil-fuel-powered plants are used as the primary source of energy.

If energy for desalination facilities is produced wholly, or in part, through renewable sources, then GHG emissions could be avoided or reduced. Renewable energy sources are a potential mitigation opportunity for the future but is currently not the dominant energy source. In the near future, sources of renewable energy are expected to drastically increase as a result of California's recent carbon neutrality goals, including Governor Gavin Newsom's *California Climate Commitment* of building a 100 percent clean energy grid by 2045, including interim goals. The conversion of energy production to renewable sources would make operating a desalination facility from fossil-free energy a possibility in the future.

Competition for renewable energy may increase because there will be greater demand for this energy source which may make building desalination plants more difficult in the future. As a result, there is a need to explore new technologies that will lower the energy demands for desalination to better balance renewable energy production. Additionally, other mitigation measures that can be coupled with sustainable energy sources involve reducing energy consumption by increasing operation and process efficiencies within the facilities.

Investment Needs

Infrastructure

Diverse water supply portfolios will require additional infrastructure investment at the state and local levels. As indicated above, changing future climatic conditions are expected to result in more frequent fluctuations between droughts and extreme wet years. This could mean that additional infrastructure is needed to support multiple approaches to supporting water supply to account for both wet and dry periods. For example, infrastructure could be needed to increase groundwater recharge during wet years and desalination to support water supply reliability. Modifications may also be needed to existing infrastructure for coastal desalination facilities to move water from lower coastal areas higher into the distribution system or to address deficiencies identified in required annual water loss audit reports prepared by urban water suppliers.

Planning and creative solutions are needed to make appropriate infrastructure investment. Decisions as to what components are included in a diversified water portfolio – and if desalination is included – will be decided by local and regional water suppliers, their customers, and local interested parties.

Research

Inclusion of desalination into more California water supply portfolios will require advances in challenges such as reducing energy consumption, increasing longevity of system components, addressing environmental impact, and developing methodologies to optimize operational efficiency and brine management. Research is ongoing into each of these areas throughout the world. In addition, other research into characterizing environmental impacts resulting from desalination operations could support overall permitting, but project proponents have responsibility for evaluating potential site-specific impacts and subsequent monitoring based on permit requirements.

Currently, the State of California is partnering with the National Alliance for Water Innovation (NAWI), a five-year research program located at UC Berkeley and supported by the U.S. Department of Energy (DOE) in partnership with DWR, the State Water Board, and other partners to lead and foster the research in these areas. NAWI has an existing contract with the DOE to act as its Energy-Water Desalination Hub coordinator to conduct research to lower the cost and energy of desalination. DWR is providing $16 million beginning in 2021 to NAWI to coordinate and fund research projects in these key areas. These research projects will advance desalination technology and support evaluation of water supply alternatives.

NAWI is focusing research on technologies that enable desalination to be cost-competitive with other alternative water supplies, more easily implemented, more reliable, and more energy-efficient. Currently, work is focusing on improving treatment and brine management, because these are the two most energy-intensive aspects of removing salt from water. Several ongoing projects are evaluating approaches to harvesting minerals from brine and process improvement to reduce scaling, a common issue with reverse osmosis.

The NAWI research effort is already seeing benefits for California agencies with desalination and reverse osmosis facilities. Existing desalters currently are partnering with researchers to evaluate methods of improving technologies and addressing real-world challenges. These partnership opportunities occur for early-stage research and pilot stage applications and will increase as NAWI broadens its funding opportunities. Participation in these projects directly benefits California water suppliers by enabling early access to innovations and helping to lead in the identification and solutions to challenges, as well as supporting communities in need.

Emerging Technologies

Several innovative desalination approaches are being pilot tested or are emerging as noteworthy approaches. Testing of these technologies will help determine whether they can be developed at commercial scale to support California's water supply needs.

Two approaches to wave-energy desalination will be pilot-tested in California in 2024. These facilities are located offshore and generally use reverse osmosis technology. The energy generated by wave motion powers the treatment process. Brine can be immediately returned to the ocean and desalinated water is conveyed to shore.

Desalination at deeper ocean depths is another emerging technology. It proposes to use the higher pressure deeper in the water column to desalinate water more efficiently. Again, brine is returned immediately to the ocean and desalinated water is conveyed to shore.

In addition to these direct treatment technologies, there is also ongoing work into beneficial linkage of desalination to green hydrogen production and carbon sequestration.

- **Green Hydrogen Production**: Mechanisms for integrating desalination and green hydrogen production are being evaluated, with the potential to benefit both processes. This technology is in the early research phase.
- **Carbon Sequestration**: Some forms of carbon sequestration using direct air capture technology can utilize brine to create its carbon capture solvent. Co-locating with water treatment facilities, such as desalination, and repurposing existing industrial-scale technologies, direct air capture can reduce or eliminate any brine discharge from these facilities while capturing atmospheric carbon.

Other Contributing Issues

Environmental Justice

Investment is needed to support the process of locating desalination facilities. Desalination plants can be considered industrial facilities. Locations should not disproportionally affect underserved communities. For example, if a proposed facility is within, or adjacent to, legacy industrial sites, it may represent a continuing disproportionate burden to nearly communities of concern.

Facility operational impacts could include air quality or noise, how the desalinated water is dispersed within the distribution system, how brine is managed, local uses, or traffic increase associated with the facility. Involvement of community representatives during project planning and development is an important component to evaluating and addressing environmental justice issues.

As discussed earlier, it is also important to identify approaches to reduce the economic impact of higher treatment costs on disadvantaged communities. Approaches would be determined with discussions with impacted communities as part of early project outreach. Documentation of this outreach and approach may need to be included during subsequent permitting and environmental documentation.

The California Coastal Commission's Environmental Justice and Social Equity webpage, and the State Water Board's Racial Equity Resolution and Related Actions webpage may provide useful information for considering coastal desalination facilities.

Another consideration for environmental justice discussion is the potential for impacts associated with water shortage. Advanced planning is required so that supplies are available to support the water needs of California communities. Providing fair access to clean drinking water in the future will require evaluating multiple factors when considering a desalination facility: siting, environmental impacts, affordability and economic affect, and future water needs.

Tribal Considerations

Tribal considerations are key required components of desalination project planning and development to ensure that they are identified, responded to, and documented. Early and sustained involvement of Tribal leaders and communities will safeguard inclusion during project development and is required by the California Environmental Quality Act (CEQA) documentation.

4. Barriers to Implementing Desalination

Implementation of a desalination project, similar to most water supply projects, involves extensive evaluation, planning, and coordination. There are potential negative impacts that can be associated with desalination. Studies may be necessary to assess the potential for impacts.

The first two subsections of Section 4 (Demonstrated Need, Costs and Challenges) address the types of potential barriers that can affect desalination projects using any type of source water. Issues, barriers, and potential impacts that apply only to seawater desalination projects are presented in the third subsection (Seawater and Coastal Desalination Considerations), followed by the last subsection (Groundwater Desalination Considerations) which addresses issues specific to groundwater desalination.

The following discussions provide general statements of the issues and are not intended to be in-depth information. Most desalination projects have a unique set of issues and potential impacts, and it is well beyond the scope of this RMS to attempt to go into detail about any of them. Links to key topics and documents are included in Section 9, "Useful Web Links."

Demonstrated Need

The initial step for any desalination project, or any water supply project, is whether additional water supply is needed to meet present or expected future demands. California urban water suppliers that prepare an urban water management plan (UWMP) every five years are required to include supply and demand assessments considering a variety of scenarios. The required scenarios include normal conditions, short- and long-term droughts (defined as up to five years), and emergency outages. Future projects needed to meet water needs (often referred to as "demands") are to be included in the UWMP. A water supplier will use this as the basis for determining if a desalination facility or other water supply project is needed and would then begin the siting and permitting process. This effort enables water suppliers to document potential future shortage and identify water supply alternatives.

The Seawater Desalination Siting and Streamlining Report to Expedite Permitting identifies ways in which the seawater desalination permitting process can more efficiently achieve full compliance with regulatory requirements. One of the identified streamlining approaches is for the project proponent to identify, at the beginning of the permitting process, the water supply need for the project. This could include incorporating information from the UWMP.

Linking water supply planning in the UWMPs to desalination permitting could expedite the permitting process because UWMPs are public documents certified by the water supplier. It would also support early identification of prospective desalination projects in UWMPs, which would also facilitate public outreach and identification of potential environmental or environmental justice issues. It also supports development of well-integrated desalination projects and attempts to avoid emergency projects that may respond to unforeseen circumstances but could result in water that is more costly and less-efficient projects.

As part of the siting and permitting of any desalination facility in California, each of the issues identified below, applicable to the source water and location, will need to be addressed and documented for the appropriate regulatory agency.

Costs and Challenges

This subsection addresses the issues applying to any type of desalination project using both groundwater and surface water as source water.

Energy

The most common treatment method for desalinating water in California is reverse osmosis, a technology that also can be used to clean wastewater for subsequent beneficial reuse and to remove contaminants from water. Reverse osmosis forces water through a finely perforated membrane to capture most dissolved constituents and let the water pass through. This process is relatively energy-intensive because it occurs at high pressures. As a result, in general, the saltier or more contaminated the source water being treated, the higher the energy requirements of the desalination facility.

The higher energy use of reverse osmosis makes the operation of a desalination facility vulnerable to energy cost fluctuations which creates an uncertainty in planning long-term operational costs and comparing it to other water supply options. Depending on the source of energy used, desalination may result in the production of GHG emissions. These issues can have negative effects on the sustainability of desalination and on environmental considerations.

It should be noted that legislation passed in 2022 (Assembly Bill 1279) establishes 2045 goals of reducing GHG emissions by 85 percent and achieving carbon neutrality. As a result, with energy supplies increasingly originating from carbon neutral resources over the next two decades to reach the 2045 goal, the GHG emission issue associated with desalination may be reduced.

Between now and 2045, energy uncertainties can be offset by developing green energy sources that can support desalination energy demands. This may include solar or wind facilities in combination with energy storage facilities such as pumped hydro or other storage options facilitating renewable energy or zero-carbon resources. The City of Santa Barbara is implementing such a plan while working with the local energy supplier to lower energy use during peak energy-demand days. As discussed in Section 3, "The Cost of Inaction and Investment Needs," innovative technologies are being tested and research is ongoing to lower desalination energy demands.

An opportunity for additional work is comparing the energy demands and GHG production of desalination to other water supply issues. Previous assessments, such as Szinai et al. (2021), would be compiled, reviewed, and updated to provide additional discussion comparing local desalination to water conveyance over hundreds of miles, or desalination to direct potable reuse of wastewater. This information will help water suppliers make informed decisions regarding water supply portfolio options.

Brine Management

When salts, minerals, or contaminants are removed from water during desalination, the removed constituents are not destroyed. As shown in Figure 2, during desalination the salts removed from the water remain as brine, a highly saline liquid. The concentration of salt in seawater is approximately 35,000 mg/L (3.5 percent salt by weight of water or 35 grams per liter). Every 1,000 gallons of seawater contains almost 300 pounds of salt. Disposal of the salt or brine produced during desalination is a major component of desalination and the permitting and siting process.

Brine management requires energy to convey the brine for disposal or to beneficially use the brine for marshland or mineral recovery. Brine management or disposal is usually expensive and requires consideration of environmental impacts. For these reasons, it is a component of desalination which often requires careful planning and evaluation.

Brine disposal can be accomplished by various approaches.

- **Evaporation**: In arid regions, evaporation is an option, but this requires extensive land area, can have negative air quality impacts, and entails collection and disposal of the dried salts.
- **Brine Line**: Brine also can be collected by a separate wastewater system referred to as a brine line. A brine line conveys brine to a coastal discharge point.
- **Commingled with Treated Wastewater**: Brine can be commingled with wastewater to be discharged to an ocean outfall. Occasionally, brine can be discharged to a sanitary sewer where it mixes with domestic and industrial wastewater prior to wastewater treatment.
- **Diffusers**: Brine diffusers are usually associated with seawater desalination and will be discussed below in the "Seawater and Coastal Desalination Considerations" subsection.
- **Injection**: Brine can be disposed underground by deep-well injection.

Work is being done to determine if brine can be used to support development of coastal wetlands. Research is also being conducted to see if treatment wetland methods can support brine management and the effectiveness of lowering freshwater recovery rates to reduce brine concentration. As mentioned in Section 3, "The Cost of Inaction and Investment," research is being done to identify technologies that can remove materials from brine to provide economic benefit.

Treatment

Operation of a desalination facility as part of a water supply portfolio may include additional considerations such as whether desalinated water is chemically compatible with other water sources, if they are blended within the distribution system, or if plant operators require higher classification or different training. These considerations are in addition to the energy demand and environmental issues already discussed and are consistent with other projects implementing water supplies from multiple sources.

The desalination process is a complex issue. There are several methods and technologies that can be used to desalinate water, but as previously mentioned, reverse osmosis is the most common approach in California (Figure 5). Reverse osmosis can be implemented as a component of a treatment process operated by the water supplier or, for very small applications, it can be implemented as a self-contained package facility maintained by a commercial third party.

Figure 5 **Reverse Osmosis**

Seawater and Coastal Desalination Considerations

Locating seawater desalination projects involves multiple coastal issues that do not apply to other desalination projects, as discussed below.

Alignment with California Ocean Plan

The Ocean Plan identifies standards to be enacted to protect the water quality and beneficial uses of the Pacific Ocean along California's coastline. Requirements and preferred alternatives for ocean discharges and intakes are identified in the Ocean Plan. California Water Code and Ocean Plan desalination provisions require seawater desalination facilities to use the best available site, design, technology, and feasible mitigation measures to minimize intake mortality of all forms of marine life.

Adherence to the Ocean Plan is a fundamental requirement of siting or expanding seawater desalination facilities. As it pertains to coastal desalination facilities, the Ocean Plan indicates that:

- Subsurface intakes are the preferred intake method for coastal marine desalination facilities unless the regional water quality control board (RWQCB) determines them to be infeasible.
- Commingling brine with wastewater discharge is the preferred technology for brine discharge to minimize intake and mortality of marine life.

These key coastal seawater desalination requirements have been developed by the State Water Board to be protective of the marine environment and its beneficial uses. Potential marine impacts from intake and brine disposal operation at coastal seawater desalination facilities is a key concern and the primary reason the State Water Board has developed these requirements.

The Ocean Plan is periodically updated to address changing issues. The next update will be in 2024. Changes to be considered may include recommendations identified in the *Seawater Desalination Siting and Streamlining Report to Expedite Permitting*, as well as other issues identified since the Ocean Plan was last updated in 2018.

Permitting and Regulatory Considerations

Multiple permits are required to site most coastal infrastructure projects, including desalination treatment facilities, intakes, and discharge infrastructure on the coast. These permits require extensive coordination with regulatory agencies and may entail conducting studies and assessments to quantify potential project impacts. These permits involve coordination and applications to the applicable RWQCB, the California Coastal Commission, State Lands Commission, Department of Fish and Wildlife, and various federal agencies. Each project is different, so there is no definitive list of project permits that are required. Approved CEQA documentation is also required.

Permitting addresses issues such as environmental and habitat impacts during construction and operation, future sea level rise, climate-related coastal hazard considerations, methodology and impacts related to brine discharge, and intake technology and siting. Permitting often takes years and involves complex timing because some permits have a limited term and if other aspects of the permitting process are delayed, approved permits may expire. Sequencing permits correctly may also be an issue if obtaining one permit requires another permit to already have been obtained. State agencies involved in permitting coastal desalination facilities have signed a 2020 memorandum of agreement to facilitate timely and effective coordination during the permitting process.

As previously indicated, the *Seawater Desalination Siting and Streamlining Report to Expedite Permitting* identifies ways in which the seawater desalination permitting process can more efficiently achieve full compliance with regulatory requirements (State Water Resources Control Board 2023). It is anticipated that implementation of the approaches identified in the document will support future permitting efficiency.

Mitigation

Coastal seawater desalination facilities are to avoid environmental impacts where feasible. If avoidance is not possible, environmental impacts are required to be minimized. Mitigation measures are then required to offset environmental impacts that may occur as the result of the construction or operation of the desalination facility. Mitigation of adverse impacts is required as part of environmental documentation preparation or being granted a permit. Mitigation may involve developing an offsetting or compensatory action to compensate for minimized, yet unavoidable, impact. The agency issuing a permit or land lease will determine the mitigation required for a facility. Specific mitigations are negotiated between the permitting agency and applicant and may involve input or coordination with affected or interested parties.

Siting Criteria

Each proposed facility and location involve different considerations and raise unique sets of issues or permitting requirements. There are specific considerations that must occur, such as the Coastal Commission’s requirement that sea level rise be considered when siting any component associated with a desalination facility occurring within its jurisdiction. Assessment and documentation of impacts to environments and habitat may vary throughout the state. It is the responsibility of the water supplier seeking to site a seawater desalination facility to coordinate with the relevant State and federal agencies to begin the permitting and environmental review process. Interagency coordination for reviewing environmental documents and permit applications through the implementation of the memorandum of agreement is intended to reduce permitting uncertainties and delays.

Brine Discharge

The Ocean Plan identifies two technologies for brine disposal to the ocean, as well as enabling consideration of alternative technologies that provide equivalent environmental protection. The "preferred technology for minimizing intake and mortality of all forms of marine life resulting from brine discharge is to commingle brine with wastewater (e.g., agricultural, municipal, industrial, power plant cooling water, etc.) that would otherwise be discharged to the ocean" to minimize "intake and mortality of all forms of marine life." The Ocean Plan also indicates that multiport diffusers are "the next best method for disposing of brine" when it can't be diluted with wastewater. Multiport diffusers are submerged mechanisms that disperse brine to mix it with the receiving water to rapidly dilute brine to background receiving water salinity. The Ocean Plan also allows a project proponent to identify other brine methodologies if it can be demonstrated that the method provides a "comparable level of intake and mortality of all forms of marine life."

Hazards

Permitting agencies are responsible for identifying practices or structures that could cause physical or environmental hazards and to then require changes or mitigations as a coastal desalination facility is planned and permitted. The Coastal Commission, State Lands Commission, and RWQCBs each require consideration of various hazards when issuing their respective permits. Hazards could include adverse water or air quality associated with brine disposal, obstructions from coastal well sites; or coastal hazards associated with sea level rise, erosion, or tsunamis. Additionally, CEQA requires applicants to identify geologic and hydrologic hazards within proposed projects. The hazards analyses required by CEQA and each State agency are slightly different.

Public Access Limitations

A key issue for coastal desalination facilities is the potential for these facilities to obstruct, limit, or restrict coastal access. This is an issue that the Coastal Commission considers when it reviews applications for the coastal development permits it issues.

Algae

Algae can be an operational issue for seawater facilities with open intakes. Occasionally, algal blooms will clog intake systems. This may lead to unplanned or unintended plant shut-downs or require installation of screen cleaning mechanisms.

Groundwater Desalination Considerations

The primary issues unique to groundwater desalination projects relate to the groundwater basin. If a basin is adjudicated, the inflow to the basin may have to align with the groundwater allotment to the water supplier. This is not the case in all adjudicated basins, which may consider saline water extraction not applicable to allocations. If a groundwater basin has a groundwater sustainability plan (GSP), whether approved or not, groundwater extracted for a desalination facility should be compliant with the GSP or coordinated with the groundwater sustainability agency. If a groundwater basin is neither adjudicated nor has a GSP, the desalination project still needs to be protective of the safe yield or existing users in the groundwater basin and avoid adverse groundwater impacts.

Groundwater desalination often occurs within inland groundwater basins. Brine disposal is often challenging for these projects. Brine lines can be expensive and discharge to conventional wastewater treatment facilities can adversely affect wastewater treatment or effluent quality relative to reuse opportunities.

5. Desalination and the Water Resilience Portfolio

California's Water Supply Strategy: Adapting to a Hotter, Drier Future (Water Supply Strategy) was issued in August 2022. The Water Supply Strategy provides specific actions and goals to support developing new water supplies and managing existing ones to prepare for changing climatic conditions. The Water Supply Strategy updates priorities and accelerates actions in the2020 *Water Resilience Portfolio* , which is considered to be the State's plan for water supply resilience to prepare for climate change challenges.

The *Water Resilience Portfolio* identified the following actions related to desalination:

6. Consider use of desalination technology where it is cost effective and environmentally appropriate.

> 6.1 Consider new desalination projects according to existing State criteria including the Water Board's Ocean Plan and the Coastal Act.
>
> 6.2 Team with federal and academic partners to develop desalination technologies that treat a variety of water types for various uses, with a goal of enabling manufacturing of energy efficient desalination technologies in the U.S. at a lower cost, same or better quality, and reduced environmental impact than non-traditional water sources.

The Water Supply Strategy then quantified goals for increasing desalination in the state, as well as specific implementation steps:

> 1.2 Expand brackish groundwater desalination production by 28,000 acre-feet per year by 2030 and 84,000 acre-feet per year by 2040 and help guide location of seawater desalination projects where they are cost effective and environmentally appropriate.

Implementation Steps

- By January 1, 2024, the DWR and the State Water Board, in coordination with local agencies, will identify the brackish desalination projects that have the potential to be operational by 2030 and by no later than 2040. The State will consider investing in grants to local agencies for planning and building desalination projects.
- By January 1, 2024, the State Water Board will review groundwater basins impaired by salts and nutrients and determine the volume of water available for brackish groundwater desalination.
- As the State's representative on the U.S. Department of Energy's five-year, $100 million desalination innovation hub, DWR will continue to guide research investments towards technological breakthroughs that solve California desalination challenges.
- The State will help streamline and expedite permitting to provide better clarity and certainty to further desalination projects. To this end, by June 30, 2023, the State Water Board, Coastal Commission, DWR and other State entities (e.g. State Lands Commission) will develop criteria for siting of desalination facilities along the coast and recommend new standards to facilitate approval.
- Within the following year, these agencies will identify potential available mitigation sites to facilitate the expedited approval of desalination facilities. The State Water Board will consider amendments to the Desalination Policy in its Ocean Plan to streamline permits that meet the recommended siting and design standards for projects located in the identified priority areas.

Projected Desalination Production

Looking to the future, many water suppliers are planning to include desalinated water as part of their water supply portfolio and others are planning to expand existing production. Numerous other water suppliers are evaluating including desalination as part of future supplies, as discussed in Section 1, "Introduction." The Water Supply Strategy identifies goals to increase annual desalinated brackish water supplies by 28,000 acre-feet by 2030 and 84,000 acre-feet by 2040.

Reviewing the 2020 UWMPs, as well as conversations with suppliers conducted during the 2020 survey of suppliers with existing desalination facilities, an additional 42,600 acre-feet of desalinated brackish water supplies, over 2020 use, are planned by 2030. If these projects are constructed as planned, the 2030 WSS goal for additional brackish desalinated water will be met (Table 2).

Table 2 Estimate of Annual Increase in Brackish Water Desalination Capacity Compared to Water Supply Strategy Goals

Category	Water Supply Strategy: Goal for Annual Brackish Water Production Increase	Brackish Groundwater	Brackish Surface Water	Saline Surface Water (Seawater)
Actual 2020 Production (acre-feet)	-	106,000	Less than 100	44,000
Planned Capacity Increase by 2030 (acre-feet per year)	28,000	39,600	3,000	17,300
Planned Capacity Increase by 2040 (acre-feet per year)	84,000	500	-	11,200

Current estimates for desalination projects proposed to be implemented by 2040 do not achieve the Water Supply Strategy goal of an additional 84,000 acre-feet. In general, water agencies are still in preliminary planning for projects to be developed between 2030 and 2040 and may not be committed enough to desalination projects to be included in Table 2. DWR is aware of multiple agencies that are not currently desalinating water but are evaluating project feasibility. Climate conditions during the mid-portion of the 2020's are expected to strongly influence future water supply projects and the 2025 UWMPs will be closely reviewed to update projections for meeting the Water Supply Strategy goals. Finally, given that the amount of water desalinated in California increased from approximately 80,000 acre-feet in 2010 to 150,000 acre-feet in 2020, almost doubling in just 10 years, it is expected that the 2040 brackish water goal in the Water Supply Strategy will also be met.

DWR released the projections for projected brackish water desalination projects expected to be implemented by 2040 in a separate document in February 2024 (California Department of Water Resources 2024), which are consistent with the information presented in this RMS excluding the seawater projections. The separate document was prepared to comply with the first desalination implementation step.

Water Available for Brackish Groundwater Desalination

The State Water Board completed its review of the groundwater basins impaired by salts and nutrients to estimate the volume of water available for brackish groundwater desalination (State Water Resources Control Board 2024). This completed the second Implementation identified in the Water Supply Strategy. The State Water considered basins with more than 10 percent of extraction wells measuring more than 10,000 mg/L TDS to be basins with potential for brackish groundwater desalination. Volumetric assessment of brackish groundwater desalination potential was not estimated because of the lack of available data and only extraction wells were considered.

The State Water Board concluded that the highest potential for brackish groundwater desalination exists in coastal groundwater basins with access to existing infrastructure for brine disposal and where the extraction is consistent with the local groundwater sustainability plan. Projects would need to protect water quality and not mobilize contaminants or exacerbate seawater intrusion or subsidence. They also must be appropriately sized for each basin’s safe yield. Eighty-four groundwater basins were identified as having potential for brackish groundwater desalination, although for 34 of these basins this assessment was made with data from 10 wells or fewer.

Implementing the Water Supply Strategy

The Water Supply Strategy identified multiple steps to be implemented by various State agencies regarding desalination. Each of these steps is underway and expected to be completed by their required deadlines.

6. Recommendations

The following recommendations are made to support desalination in California and implement the steps identified in the Water Supply Strategy:

1. DWR proposes to increase interaction with regional leaders, water agencies, environmental justice organizations, Tribal communities, and community groups to support better education of desalination, implementation of the Water Supply Strategy, and integration of alternative water supply strategies into California's water supplies.
2. DWR proposes to assess methods to optimize continued integration of desalination. This assessment would include evaluating efficiencies of large regional facilities or smaller dispersed facilities; optimal approaches for desalination to support rural communities; assessing how energy demands impact water options, including conveyance; and how energy efficiency, brine management, and treatment support can be maintained. This assessment would include reviewing how existing agencies are implementing desalination and provide guidance for other agencies considering implementing desalination and reviewing the costs and environmental effects for water movement and comparing them to desalination. Opportunities for federal collaboration would also be explored.
3. DWR and the State Water Board will continue to work closely with the National Alliance for Water Innovation to improve energy efficiency, brine management and valorization, and cost-effective desalination technologies through technical interaction and funding to support and improve implementation of desalination in California.
4. In coordination with *Municipal Recycled Water RMS* Recommendation #5 (Assess what the potential costs are for advanced treated water for direct potable reuse. Identify GHG emissions for comparison to SWP and Colorado River conveyance and desalination), collect information from existing desalination facilities of various sizes and types and compare desalination costs and GHG emissions and compare them to projected direct potable reuse. parameters.
5. Identify if there are issues to be included in future Ocean Plan amendments that may be needed to address possible offshore desalination facilities.

7. Related Resource Management Strategies

The following resource management strategies have connections to desalinated water. These strategies may not directly mention desalination, but there are common issues.

- **Agricultural Water Use Efficiency**: Desalination technologies are being considered for supporting agricultural water demands and treatment of agricultural water.
- **Groundwater and Aquifer Remediation**: Desalination is linked to this RMS in two ways. First, methodologies used to desalinate water may be similar to those used to remove chemical and biological contaminants in water. Second, saltwater intrusion may affect groundwater conditions, requiring treatment prior to potable or industrial use.
- **Municipal Recycled Water**: Municipal recycled water and desalinated water are considered alternate water supplies. Both water types can incorporate similar treatment methods. Some opponents of desalinated water believe recycled water opportunities should be fully implemented before a water supplier implements desalination. Direct potable reuse is also proposed for implementation in California. Comparison of costs and environmental impacts for direct potable reuse and desalination will be important to understand and compare to enable water suppliers to make informed water supply decisions.
- **Outreach and Engagement**: Introduction of desalinated water as a local water supply resource requires extensive public outreach and education regarding its uses, as well as addressing environmental issues and potential rate impacts.
- **Salt and Salinity Management**: Desalination is closely linked to the occurrence of saline water in groundwater basins, as well as the potential effect of brine management on salinity of the underlying groundwater basin.
- **Urban Water Use Efficiency**: Improvements in urban water use efficiency may delay or offset the need for desalination facilities.

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9. Useful Web Links

Brackish Groundwater Reclamation Program
https://www.wrd.org/brackish-groundwater-reclamation-program

California Climate Commitment
https://www.gov.ca.gov/wp-content/uploads/2022/09/Fact-Sheet-California-Climate-Commitment.pdf

California Coastal Commission Environmental Justice Policy
https://www.coastal.ca.gov/env-justice/

California Ocean Plan
https://www.waterboards.ca.gov/water_issues/programs/ocean/docs/oceanplan2019.pdf

California State Water Resources Control Board Racial Equity Resolution and Related Actions
https://www.waterboards.ca.gov/racial_equity/resolution-and-actions.html

California Water Plan Update 2018
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2018/Final/California-Water-Plan-Update-2018.pdf

California's Water Supply Strategy: Adapting to a Hotter, Drier Future (2022)
https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Water-Resilience/CA-Water-Supply-Strategy.pdf

Desalination RMS 2013, California Water Plan, Volume 3 - Resource Management Strategies, Desalination (Brackish and Sea Water)
https://resources.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/RMS/2016/09_Desalination_July2016.pdf
Note: The year shown in the link is 2016 because the document was updated for accessibility.

Memorandum of Agreement for Interagency Coordination of Seawater Desalination Project Review. July 2020.
https://www.waterboards.ca.gov/water_issues/programs/ocean/desalination/docs/desalination-memorandum-of-agreement.pdf

National Alliance for Water Innovation.
https://www.nawihub.org/

Pacific Institute. The Future of California’s Water-Energy-Climate Nexus
https://pacinst.org/wp-content/uploads/2021/09/Water-Energy-Report_Sept-2021.pdf

Seawater Desalination Facilities Interactive Map
https://waterboards.ca.gov/water_issues/programs/ocean/desalination/

Seawater Desalination Siting and Streamlining Report to Expedite Permitting
https://www.waterboards.ca.gov/water_issues/programs/ocean/desalination/docs/desal-siting-streamlining-report-dec2023.pdf

Sustainable Groundwater Management Act
https://www.waterboards.ca.gov/water_issues/programs/gmp/

Sustainable Groundwater Management Act Program
https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management

Sustainable Groundwater Management Act legislation:

- Assembly Bill 1739 (Dickinson): https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1739
- Senate Bill 1168 (Pavley): https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1168
- Senate Bill 1319 (Pavley): https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1319

United Water Conservation District
https://www.unitedwater.org/coastal-brackish-water-treatment-project/

Water Resilience Portfolio
https://resources.ca.gov/Initiatives/Building-Water-Resilience/portfolio

Water Resilience Portfolio
https://resources.ca.gov/Initiatives/Building-Water-Resilience/portfolio

Water Quality Control Plan: Ocean Waters of California
https://www.waterboards.ca.gov/water_issues/programs/ocean/docs/oceanplan2019.pdf

Appendix A. 2020 Desalination Facilities

The locations where desalination occurred in 2020 are shown in Figure A-1 and summarized in Tables A-1 and A-2.

Figure A-1 **Locations Where Desalination is Occurring in 2020**

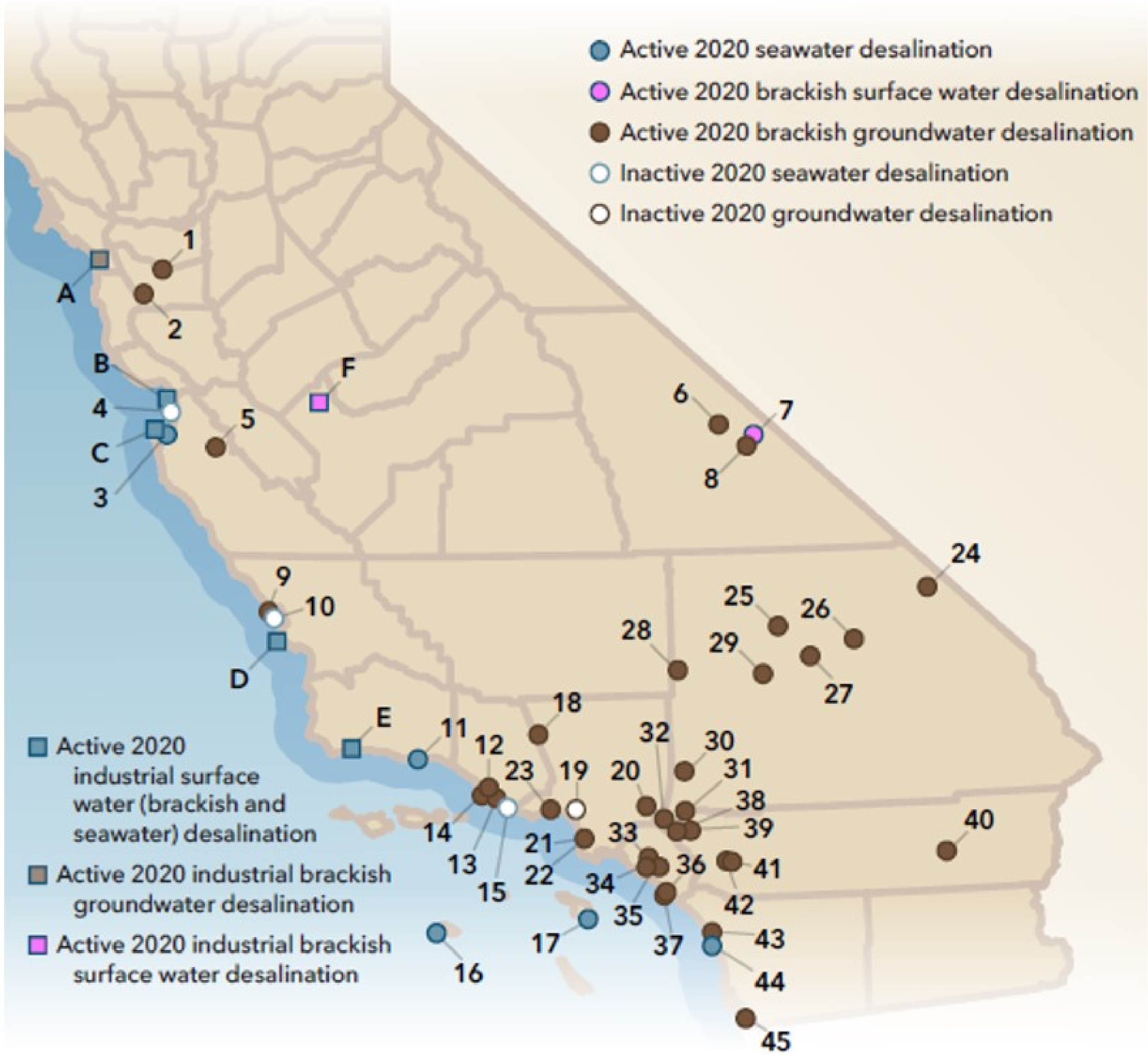

Table A-1 **California Potable Desalination Facilities (2020)**

Figure A-1 Reference Number	Agency	Facility	County	Capacity (acre-feet)	2020 Production Groundwater (acre-feet)	2020 Production Surface Water (acre-feet)
1	Zone 7 Water Agency	Mocho Groundwater Demineralization Plant	Alameda	6.1 mgd	1,850	
2	Alameda County Water District	Newark Desalination Facility	Alameda	13,451	8,680	
3	California American Water-Monterey	Sand City Desalination Project	Monterey	300		213
4	Marina Coast Water District	Marina Desalination Facility Expansion	Monterey	1		inactive
5	California Department of Corrections and Rehabilitation	Salinas Valley State Prison Reverse Osmosis Water Treatment Plant	Monterey	-	319	
6	National Park Service	Stovepipe Wells	Inyo	-	17	
7	National Park Service	Cow Creek/Nevares Wells	Inyo	-	78	
8	National Park Service	Furnace Creek	Inyo			
9	Morro Bay, City of	Morro Bay Desalination Facility (Groundwater Unit)	San Luis Obispo	581	61	

Figure A-1 Reference Number	Agency	Facility	County	Capacity (acre-feet)	2020 Production Groundwater (acre-feet)	2020 Production Surface Water (acre-feet)
10	Morro Bay, City of	Morro Bay Desalination Facility (Seawater Unit)	San Luis Obispo	-		inactive
11	Santa Barbara, City of	Charles Meyer Desalination Plant	Santa Barbara	3,125		2,763
12	Oxnard, City of	GREAT Program Groundwater Desalination Facility (Blending Station No. 1)	Ventura	8,400	3,093	
13	Camrosa Water District	Round Mountain Water Treatment Plant	Ventura	1,121	566	
14	Port Hueneme, City of	Port Hueneme Water Agency Desalter/Brackish Water Reclamation Demonstration Facility	Ventura	4,484	2,128	
15	The Ranch at Live Oak	Desalination Facility	Ventura	-	inactive	
16	U.S. Navy/ Port Hueneme	San Nicolas Island Desalination Facility	Ventura	45		19
17	Southern California Edison	Santa Catalina Island Desalination Facility	Los Angeles	-		200

Figure A-1 Reference Number	Agency	Facility	County	Capacity (acre-feet)	2020 Production Groundwater (acre-feet)	2020 Production Surface Water (acre-feet)
18	Paradise Ranch Mobile Home Park	Paradise Ranch Mobile Home Park (MHP) RO Unit	Los Angeles	-	10	
19	Beverly Hills, City of	Beverly Hills Desalter	Los Angeles	2,600	inactive	
20	Cal Pomona Dept of Water Ops	Cal Pomona WTP	Los Angeles	549	86	
21	West Basin Municipal Water District (CWS Dominguez)	C. Marvin Brewer Desalter	Los Angeles	-	438	
22	Torrance/WRD	Robert W. Goldsworthy Desalter Facility	Los Angeles	4,000	2,710	
23	Santa Monica, City of	Arcadia Water Treatment Plant	Los Angeles	11,300	366*	
24	Caltrans	Caltrans/CHP Nipton Headquarters	San Bernardino	-	<1	
25	U.S. Army	Fort Irwin	San Bernardino	2,190	1,531	
26	National Park Service	Zzyzyx	San Bernardino	-	<1	
27	Caltrans	C.V. Kane Reverse Osmosis Unit	San Bernardino	-	1	
28	Caltrans	Beechers Corner Maintenance Station	San Bernardino	-	<1	

Figure A-1 Reference Number	Agency	Facility	County	Capacity (acre-feet)	2020 Production Groundwater (acre-feet)	2020 Production Surface Water (acre-feet)
29	San Bernardino County	Calico Ghost Town	San Bernardino	-	29	
30	Caltrans	Cajon Maintenance Station	San Bernardino	-	<1	
31	Chino Desalter Authority/Inland Empire Utilities Agency	Chino Desalter II	San Bernardino	36,989	23,669	
32	Chino Desalter Authority/Inland Empire Utilities Agency	Chino Desalter I	San Bernardino	15,917	15,493	
33	Tustin, City of	Tustin 17th Street Desalter Treatment Plant	Orange	3,363	2,843	
34	Irvine Ranch Water District	Wells 21 and 22 Desalter	Orange	6,400	2,295	
35	Irvine Ranch Water District	Irvine Potable Treatment Plant	Orange	5,600	2,861	
36	San Juan Capistrano, City of	San Juan Capistrano Groundwater Recovery Plant (Desalter)	Orange	5,761	1,701	

Figure A-1 Reference Number	Agency	Facility	County	Capacity (acre-feet)	2020 Production Groundwater (acre-feet)	2020 Production Surface Water (acre-feet)
37	South Coast Water District	South Coast Water District Groundwater Recovery System (GRF - Groundwater Recovery Facility)	Orange	1,121	844	
38	Western Municipal Water District of Riverside	Arlington Basin Groundwater Desalter Project	Riverside	-	4,814	
39	Corona, City of	Temescal Basin Desalter	Riverside	11,209	10,835	
40	Caltrans	Desert Center Maintenance Station	Riverside	-	<1	
41	Eastern Municipal Water District	Menifee Basin Desalter	Riverside	3,360	9,565	
42	Eastern Municipal Water District	Perris I Desalter	Riverside	7,500	-	
43	Oceanside, City of	Oceanside Mission Basin Brackish Groundwater Desalter	San Diego	7,130	2,302	
44	San Diego County Water Authority	Carlsbad Seawater Desalination Facility	San Diego	-		40,780
45	Sweetwater Authority	Richard A. Reynolds (Lower Sweetwater) Groundwater Desalination Facility	San Diego	8,800	7,161	
				Total	**105,982**	**43,975**

Table A-2 **California Non-potable Desalination Facilities (2020)**

Figure A-1 Reference Number	Agency	Facility	County	Estimated Capacity (acre-feet)	Source Water	Comments
A	San Francisco Public Utilities	Energy Center San Francisco	San Francisco	92	Groundwater	Water from Powell Street BART Station
B	DYNERGY	Moss Landing	Monterey		Seawater	Evaporative system
C	Monterey Bay Aquarium	Monterey Bay Aquarium Desalination Facility	Monterey		Seawater	
D	PGE	Diablo Canyon	San Luis Obispo	708	Seawater	
E	Chevron	Gaviota	Santa Barbara	323	Seawater	
F	USBR	Demonstration Project	Fresno		Surface	Produced water is commingled with brine and returned to source so no net water production
----	Various	Off-Shore Oil and Gas Drilling Platforms	Various		Seawater	Produced water is used for both potable supply and machinery operation


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