

# PROCEED WITH CAUTION II: *California's Droughts and Desalination in Context*

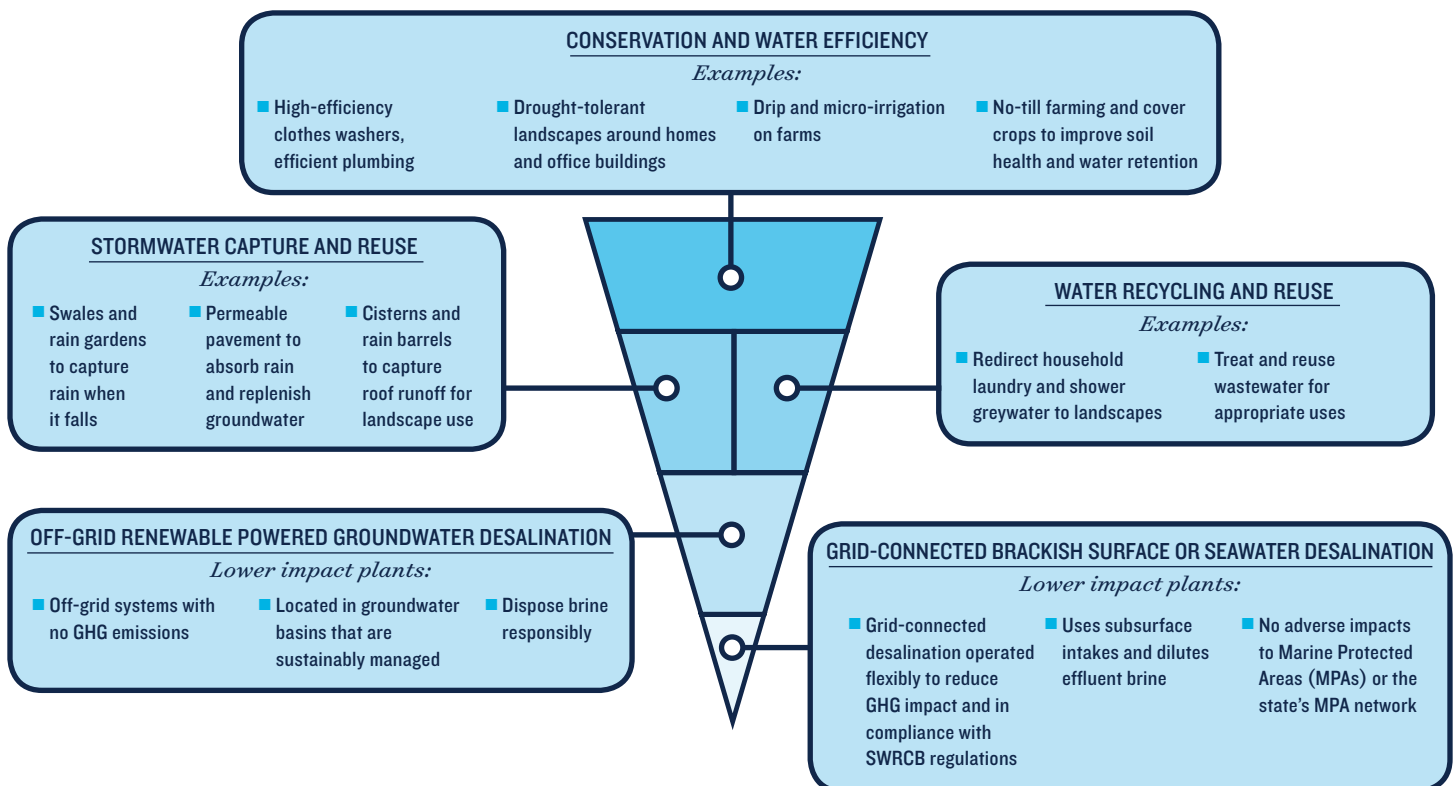
## I. INTRODUCTION

Over the last four years, California has experienced some of the driest and hottest periods on record,<sup>1</sup> resulting in extreme drought conditions across virtually the entire state.<sup>2</sup> As scientists predict a hotter and drier future for California, some observers question whether California's water shortage can be solved through seawater desalination. The question has become even more pertinent after California passed the Proposition 1 relief package (Water Bond, Assembly Bill 1471), which provides \$7.545 billion for new water projects and allocates \$100 million for desalination. The funds have not been distributed yet but could finance brackish groundwater, brackish surface water, and/or seawater desalination plants as pilot or full-scale projects.<sup>3</sup> As California considers desalination plants, we recommend the state proceed with caution.

NRDC, California Coastkeeper Alliance, California Coast Protection Network, Orange County Coastkeeper, Heal the Bay, the Nature Conservancy, and Surfrider co-authored this paper as an overview of the science related to desalination, and as a policy guidance tool. Here, we demonstrate why conventional seawater desalination should be reserved as the last option to address long-term droughts, while offering more sustainable alternatives. With careful application of our information and recommendations, California can meet the state's water needs without compromising valuable natural resources or slowing the state's leadership on climate policy.

**CHART I: PREFERRED PRIORITIZATION OF CALIFORNIA WATER RESOURCES**

*(Based on application of cost, energy, efficiency, and environmental considerations. Note this prioritization can change based on local resource needs and conditions.)*



In general, seawater desalination is far more expensive and energy-intensive than alternative water supply and demand reduction options and poses serious threats to marine and coastal resources.<sup>4</sup> Desalination of brackish<sup>5</sup> surface water,<sup>6</sup> likewise, presents many of the same cost, energy, and environmental disadvantages. Desalination facilities often take many years to build and operationalize. Furthermore, they may not be cost-effective to operate once built, resulting in stranded assets that increase ratepayer costs for little or no return. Thus, both seawater and brackish surface water desalination should only be pursued after we have exhausted other alternatives, including water conservation, water-use efficiency, stormwater capture, water recycling, onsite reuse and brackish groundwater desalination. We recommend that water utilities adopt or update water management plans that prioritize these preferred water resources first. Should desalination be deemed appropriate, projects should be scaled to meet demonstrated water supply needs, utilizing best management practices (BMPs) and best available technology (BAT), as described in the Evaluative Matrix in the Recommendations section.

## II. WHAT IS DESALINATION?

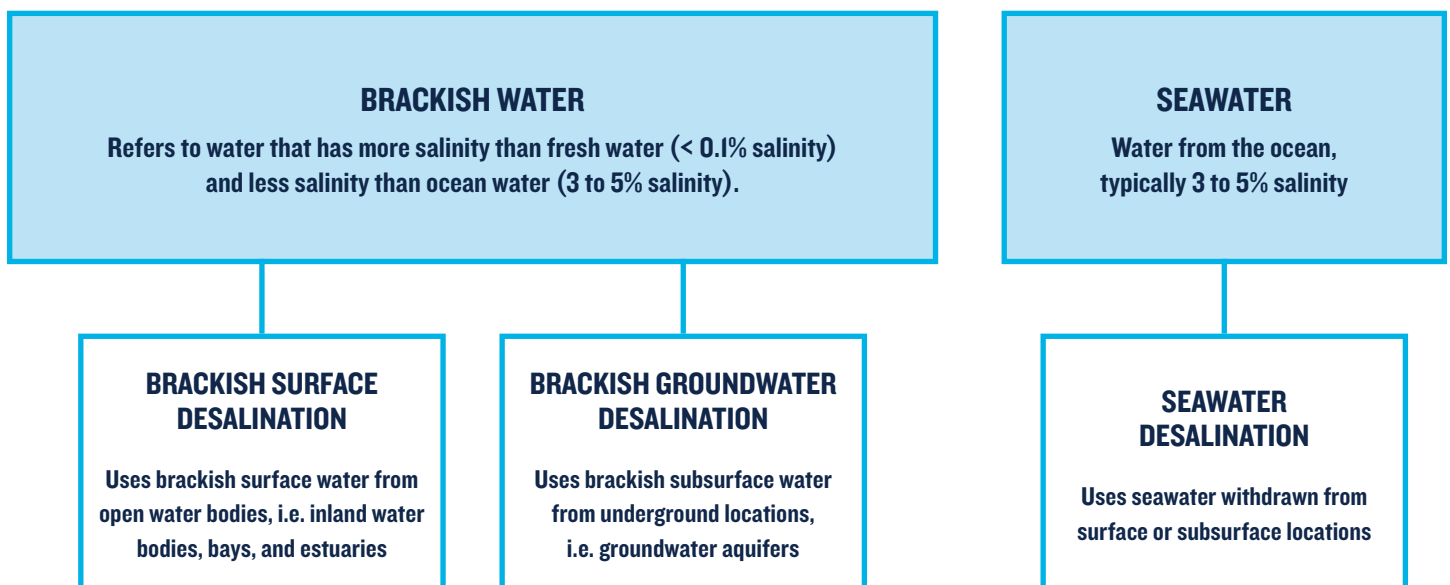
Desalination is the process of removing salt and other minerals from seawater, brackish water, wastewater, or contaminated groundwater to create pure water for drinking and other purposes.<sup>7</sup> While desalination technologies vary, most modern plants use reverse osmosis, in which high volumes of saline water pass through membranes under high pressure to remove salts.<sup>8</sup>

Much of the recent discussion of desalination as a water supply alternative focuses on seawater desalination. Desalination can, however, be applied to brackish surface water, found in the tidal mixing zone of California’s estuaries and bays, as well as brackish groundwater or contaminated water from underground aquifers. These other types of desalination—particularly brackish groundwater desalination can play a role in meeting California’s water demand.

California’s 2013 Water Plan Update indicated that brackish groundwater desalination plants significantly outnumber seawater desalination plants, both in number of facilities and in water produced. The Plan identified 23 brackish groundwater desalination plants in operation—with a combined annual capacity of 139,627 acre-feet per year.<sup>10</sup> Of those, 22 are located in Southern California, and one is in the San Francisco Bay Area.<sup>11</sup> The majority are located in adjudicated groundwater basins. The update also noted three such plants in the design and construction phase, along with 17 more proposed plants.<sup>12</sup>

By comparison, as of 2016, there are 12 existing seawater desalination plants with a combined annual capacity of 62,840 acre-feet per year for all active facilities, which is—less than half the capacity of all groundwater desalination plants.<sup>13</sup> One brackish surface water plant in the San Francisco Bay Area has completed pilot testing and is currently under study for full-scale design.<sup>14</sup> There are currently no such plants in operation.

CHART 2: TYPES OF DESALINATION<sup>9</sup>



### III. DESALINATION IS EXPENSIVE

The average price per acre-foot of water produced by seawater desalination is four to eight times higher than alternative sources. Estimates for proposed seawater desalination plants in California range from \$1,900 to more than \$3,000 per acre-foot.<sup>15</sup> A plant that produces 50 million gallons per day (MGD<sup>16</sup>), such as the one recently constructed in Carlsbad, is projected to cost between \$2,042 to \$2,290 per acre foot.<sup>17</sup> The estimated cost of water from brackish desalination plants ranges from \$600 to \$3,000 per acre-foot.<sup>18</sup> Alternative water resources, including imported water, efficiency and recycled water, are all generally significantly cheaper.

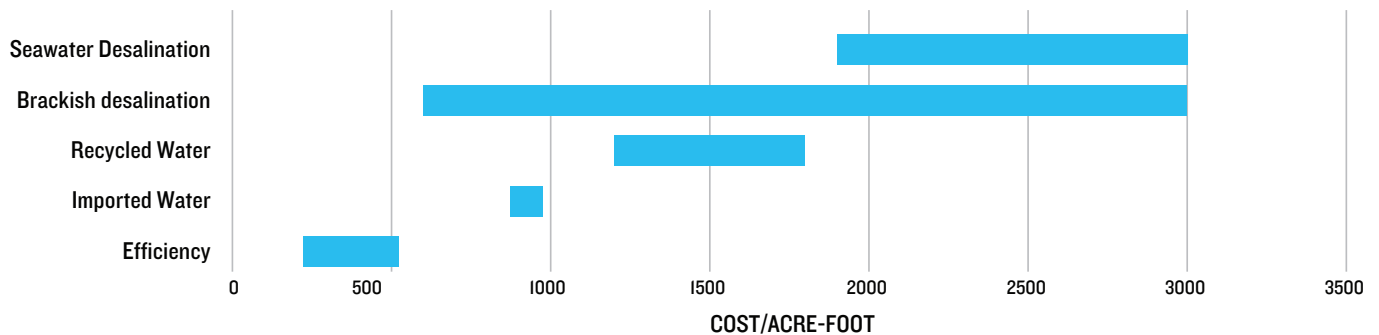
While the cost of seawater desalination has declined over the past 20 years, it remains very expensive and is generally not competitive with the lower-impact water resources described in our Recommendations.<sup>20</sup> Additionally, alternatives such as water conservation, water efficiency, stormwater capture, and water recycling often provide multiple benefits, including lower energy costs, pollution abatement, reduced demand on sensitive aquatic ecosystems, and flood control. While economic value of these benefits is often not included in per-acre-foot cost estimates, they should be included in project cost-benefit analyses.

### IV. DESALINATION IS ENERGY INTENSIVE

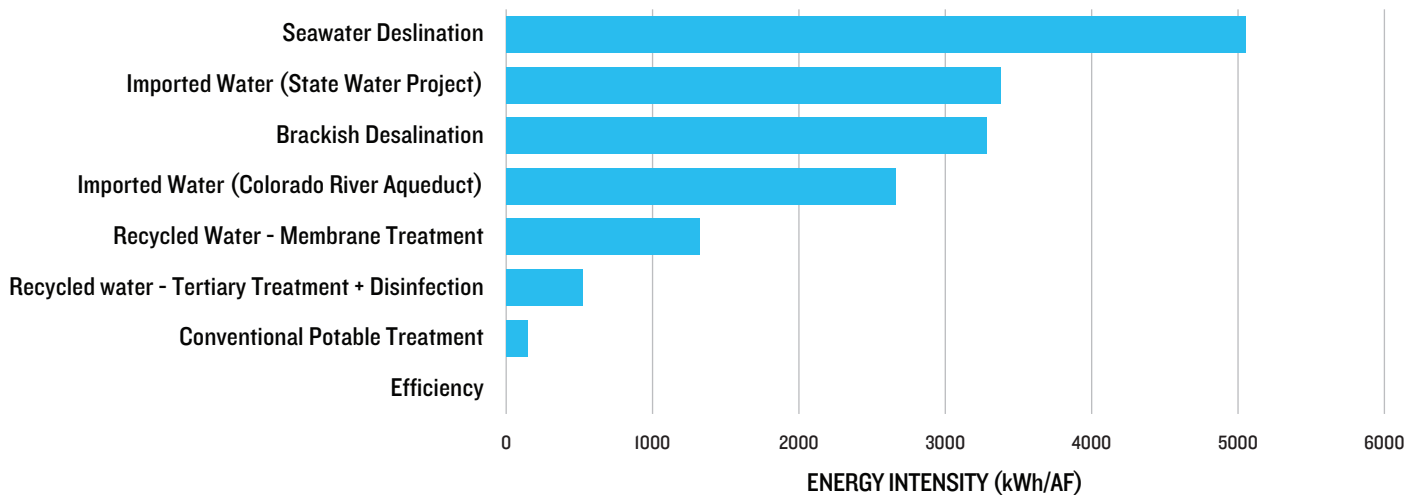
Desalinating water uses more energy, per unit of water, than any other source. In fact, energy accounts for 37 percent of the operating cost to run a reverse osmosis seawater desalination plant.<sup>21</sup> For example, the Carlsbad seawater desalination plant is currently the most energy-intensive water source in the region’s water supply portfolio and requires 52 percent more energy per acre-foot than water delivered to San Diego from the State Water Project.<sup>22</sup> The energy intensity of various water supply options can differ based on technology, size, and location. For example, seawater desalination energy intensity can range from 3,300 kilowatt hour per acre-foot (kWh/af) to 5,900 kWh/af.<sup>23</sup> In Figure 2, we focus on the relative energy intensities of average water supply options in Southern California.<sup>24</sup>

California’s current water management system is already extremely energy-intensive. According to Navigant Consulting, “water-related energy use consumes 19 percent of the state’s electricity, 30 percent of its natural gas, and 88 billion gallons of diesel fuel every year.”<sup>26</sup> This system level total includes energy used to heat water for various end uses as well as downstream energy used to treat wastewater. “Embedded energy” refers to the total energy used to move a unit of water from its source, to its end user, and finally to disposal. Not all water contains the same

**FIGURE 1: COST OF CALIFORNIA'S WATER RESOURCES<sup>19</sup>**



**FIGURE 2: AVERAGE ENERGY INTENSITY OF CALIFORNIA'S WATER RESOURCES<sup>25</sup>**



amount of embedded energy: embedded energy in water depends on the various energy intensities at each stage of the process. As noted in Figure 2, different water sources have different energy intensities, greatly impacting the amount of energy embedded in our total water system.

California is a global leader in expanding energy efficiency and reducing greenhouse gas (GHG) emissions. In fact, the state plans to reduce GHG emissions by 40 percent below 1990 levels by 2030.<sup>27</sup> Expanding energy-intensive water treatment technology will make it more challenging and expensive to achieve the state's climate goals. Conventional desalination plants connected to the electric grid increase electricity consumption from fossil fuel plants, which increase GHG emissions in the power sector. California should, instead, prioritize water supply and treatment options that are more energy efficient, such as water efficiency, stormwater capture and recycled water. If desalination is pursued, we recommend reducing the energy consumed at the plant, the corresponding GHG emissions, and grid reliability impacts.

## V. STRATEGIES FOR REDUCING DESALINATION PLANTS' GHG EMISSIONS AND GRID RELIABILITY IMPACTS

In its 2013 Climate Change Scoping Plan, the California Air Resources Board (CARB) stated that one way for the state to achieve GHG emissions reductions is to replace existing water supply and treatment processes with more energy efficient options.<sup>28</sup> Most desalination plants would take the state in the opposite direction, as conventionally desalinated water is more GHG-intensive than preferred water resources.

Desalination plants produce most of their GHG emissions indirectly, through electricity consumption during facility operations (though a small fraction are emitted during plant construction). The emissions levels vary depending on the GHG intensity of the electricity source (for example, solar energy versus fossil fuels) and how the plant is operated. The bulk of California's desalination fleet simply draws electricity from the grid when needed and increases GHG emissions. To avoid these impacts, and only after preferred water supply options have been implemented, we need strategies to reduce the emissions from desalination plants.

### RELATED CONCEPTS

Energy intensity = how much energy it takes to bring each gallon of water to your house

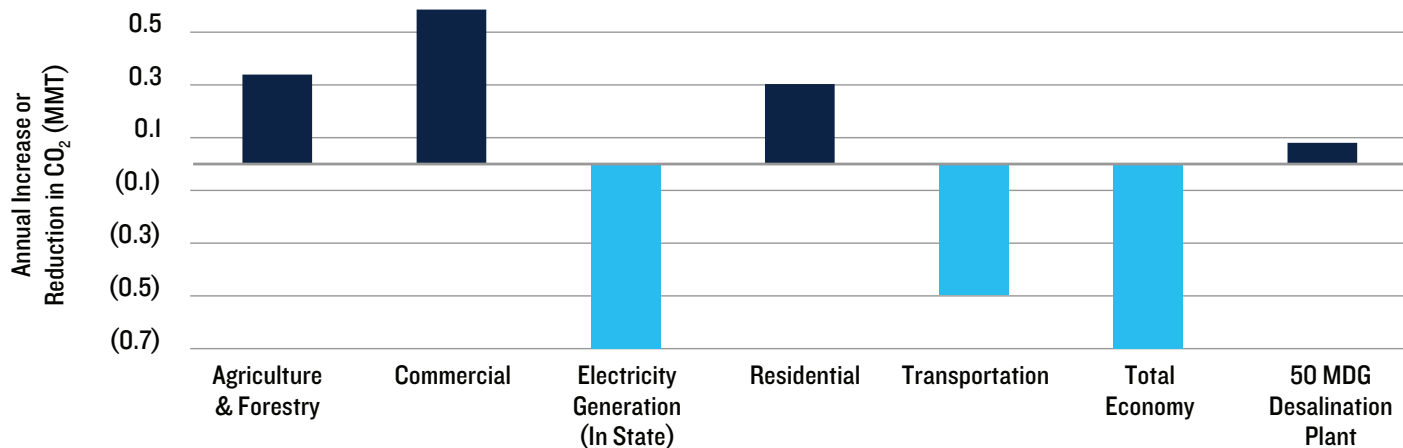
GHG intensity = how much carbon dioxide is emitted to make the energy to bring each gallon of water to your house

Example: a renewably-powered brackish desal plant has a relatively high energy intensity, but because the GHG intensity of making the energy is zero, its water production results in no carbon emissions

### Conventional Desalination Plants Should Be Deprioritized And Should Mitigate Their Indirect GHG Emissions With Compliance-Grade Instruments

Conventional desalination plants are connected to the electric grid, operate continuously and create new GHG emissions from the electricity they use. While California has a relatively clean electric grid, the bulk of the electricity used to power conventional desalination plants still comes from fossil fuel power plants. For example, one seawater desalination plant the size of the Poseidon Resources facility in Carlsbad, if unmitigated, would create GHG emissions that register on a statewide level. That's equivalent to approximately one-tenth of the statewide average annual reductions in carbon emissions over the last five years.

FIGURE 3: INCREASES AND REDUCTIONS IN GHGS FOR SELECT SECTORS OF CALIFORNIA ECONOMY, ON AVERAGE ANNUAL BASIS SINCE 2009,<sup>29</sup> AND ANNUAL INCREASE FROM A 50 MGD DESALINATION PLANT.<sup>30</sup>



Considering California’s ambitious GHG emissions reduction goal, conventional desalination plants should use credible, compliance-grade, GHG-reduction instruments to mitigate their sizeable impacts. While numerous instruments are available to reduce GHG impacts, it is critical that they meet the state’s standards under Assembly Bill 32, the California Global Warming Solutions Act of 2006. Simply put, they must be real, permanent, quantifiable, verifiable, enforceable and additional.<sup>31</sup>

### Conventional Desalination Plants Impact Local Electric Grids and Should Reduce Their Energy Consumption Through Energy Efficiency Improvements

Connecting desalination plants to the electric grid places an additional and unplanned load on the electric system. Several of the proposed locations for new desalination plants, including virtually all coastal locations in southern California, are in electrically constrained local areas—locations where new resources are being built just to meet the existing and future electricity demand. For example, after accounting for significant retirements of old power plants, the California Public Utilities Commission (CPUC) authorized Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) to add more than 5,000 MW of new generation resources in coastal areas of southern California to meet projected energy needs. But the CPUC made these decisions based on status quo levels of growth in Southern California, not accounting for new desalination plants.<sup>32</sup> The increase of large seawater desalination plants—like the Carlsbad plant that draws 38 MW of electricity from SDG&E’s fossil-fuel dominated grid—creates an additional and unaccounted for load on the electric system that, all else being equal, will require new resources. The annual energy consumption of a desalination plant like Carlsbad, of 274 GWh, would surpass the amount saved by a year’s worth of SDG&E’s energy efficiency programs,<sup>33</sup> and place a peak capacity demand on the system greater than all the reductions from all of SDG&E’s

residential demand response programs at peak need.<sup>34</sup>

To reduce their burden on the grid, we recommend that conventional desalination plants reduce their energy consumption through energy efficiency improvements to plant equipment and processes.

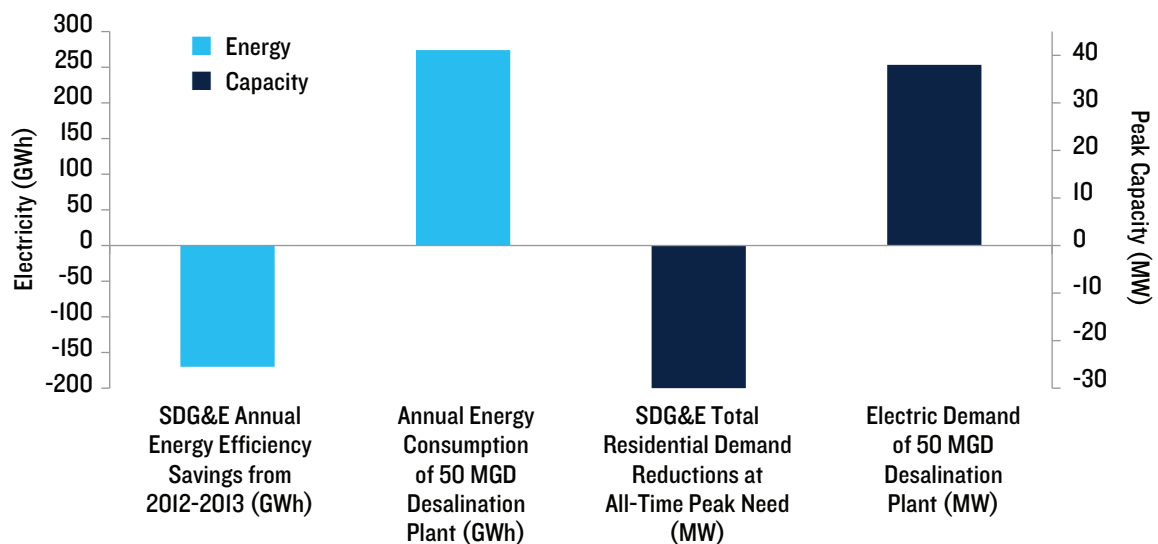
### Conventional Desalination Plants Have Not Yet—But Should—Reduce Their GHG Emissions by Operating Flexibly

Desalination plants that primarily operate when there is excess generation on the grid has emerged as a theoretical option to meet both electric grid and water needs. However, such a desalination plant has not yet been deployed commercially or operated in the United States.

Flexible operating hours at commercial scale have not been demonstrated—only small desalination plants in research and development stages, not large-scale commercial plants,<sup>36</sup> have been able to ramp up and down. This is mostly because of the inevitable wear and tear on filters, pumps, and parts and because financial incentives encourage continuous operation. Operating a desalination plant for only those hours of the day when needed generates less revenue and amortizes total costs over fewer units produced. Some seawater desalination plants have take-or-pay contracts, including the Poseidon plant in Carlsbad, California,<sup>37</sup> which means that the utility and its billpayers pay for water whether or not it is produced. This provides a strong incentive to operate the plant around the clock, as the Carlsbad plant does, and as Huntington Beach plant is proposed to do. All in all, large-scale desalination plants should change their designs to operate flexibly to integrate more renewable energy and contracting parties should not structure payments that create additional economic barriers to flexible operations.

Additionally, energy-storage can enable grid-connected flexible operations. For example, on November 9, 2015, Inland Empire Utility Agency (IEUA) announced its intention to install 3.5 MW of energy storage systems for

**FIGURE 4: ENERGY AND CAPACITY EQUIVALENTS FOR SAN DIEGO’S DEMAND SIDE RESOURCES AND DESALINATION PLANT<sup>35</sup>**





six of its water recycling and desalination plants.<sup>38</sup> Energy storage allows desalination plants to wean itself off the electric grid when fossil fuels are producing the plant's electricity, and to draw from the grid when renewable sources are producing the plant's electricity. However, because the exact times of renewable electricity generation vary, monitoring the daily and seasonal energy consumption patterns of these desalination projects will be critical to verify whether energy storage reduces their carbon emissions.

### **Powering desalination plants on stand-alone renewable resources is a more costly option, but guarantees no additional GHG emissions, no adverse grid impacts and should be prioritized before conventional plants**

Desalination plants that are powered entirely by stand-alone renewable energy guarantee that a desalination plant will result in no additional GHG emissions. These facilities do not connect to the electric grid; rather they are solely powered by renewable energy, like solar, wind, or potentially geothermal resources. Such plants reduce GHG emissions for the water sector. California's scale of off-grid, renewable-powered desalination plants, however, is presently insignificant.

Cost and reliability are two main barriers to stand-alone renewable energy. On-site renewable energy costs are generally higher, compared to the grid (given that on-site systems do not receive any benefits of the larger network). Renewable energy varies by day and season, so in order to operate a plant in the absence of renewable energy; a plant needs to be able to draw energy from storage<sup>39</sup> or ramp down its production—and account for these flexible operations in financial and engineering plans.<sup>40</sup> Both of these options increase costs, but the environmental benefits should be prioritized.

For example, the Panoche Water District operates a pilot stand-alone solar-powered brackish water desalination plant in Fresno, California. The District is planning a commercial version in 2016,<sup>41</sup> where it will use stand-alone thermal solar energy, and use thermal energy storage to increase reliability. There are also several small international plants (and one field test in Nevada) powered by stand-alone solar energy.<sup>42</sup>

## **VI. SEAWATER DESALINATION CAN CAUSE SIGNIFICANT HARM TO THE ENVIRONMENT**

Seawater desalination takes in large volumes of seawater that contain aquatic life and discharges highly concentrated saline water, or “brine,” posing significant threats to the marine environment. These impacts may be particularly severe on the network of marine protected areas (MPAs) recently established in 16 percent of the state's coastal waters.<sup>43</sup> California must ensure seawater desalination does not undermine its investment in maintaining vibrant, economically valuable marine ecosystems.

### **Outdated open ocean intake technology can kill billions of fish and other marine life each year**

Of the seawater extracted for desalination, typically 45 to 55 percent is converted to freshwater, which means these plants must take in twice as much seawater to produce an equal amount of freshwater.<sup>44</sup> A number of large-scale desalination projects in California have proposed to use open ocean intakes or large outdated pipes above the seafloor that kill marine life in the process of taking in source water. Marine animals are frequently injured or killed when they become trapped or “impinged” on the screens that are put across the front of these intake pipes. Smaller organisms, such as fish eggs and larvae, can pass through the screens but suffer a nearly 100 percent fatality rate as they become “entrained” in the plant's interior workings.<sup>45</sup>

### **Discharge of concentrated brine can be toxic to marine organisms**

The brine produced by desalination can have serious impacts, including acute and chronic salinity toxicity, when discharged into the marine environment.<sup>46</sup> Brine is composed of highly concentrated constituents normally found in seawater (e.g. magnesium, boron, and sulfate). It is often combined with a suite of chemicals, used throughout the desalination process, including aluminum chloride, polyphosphates and biocides. These chemicals can be toxic to marine organisms, even at low concentrations.<sup>47</sup> Brine may also contain heavy metals from corroding equipment, and it may cause thermal pollution, because it is warmer than receiving waters.<sup>48</sup>

Since most seawater desalination plants discharge their brine into estuaries or the ocean, the use of brine diffusers—discharging the brine into sub-tidal offshore areas with persistent turbulent flows—can help minimize negative impacts.<sup>49</sup> Another brine discharge mitigation strategy is flow-augmentation, which involves in-plant dilution by mixing brine with additional seawater prior to discharge. However, this method requires additional seawater intake, and can significantly increase impingement and entrainment, threatening marine life.<sup>50</sup>

### **Desalination may threaten California's newly created Marine Protected Area (MPA) network**

In 2012, California finalized the nation's first science-based network of MPAs, under its landmark Marine Life Protection Act.<sup>51</sup> Along the entire state's coastline, this network of 124 protected areas was created to safeguard marine life and habitats for future generations. Although no desalination surface intakes or discharge structures will be permitted in these areas, plants with infrastructure sited near MPAs could cause significant impacts from intakes and brine discharge. They may also reduce connectivity between MPAs through entrainment and impingement, thereby compromising the network's effectiveness.

## CAUTIONARY TALES OF DEMAND RISK

When evaluating expensive desalination projects in response to the pressing drought, California should learn from past mistakes. These examples illustrate the danger of demand risk—“the risk that water demand will be insufficient to justify continued operation of the desalination plant due to the availability of less expensive water supply and demand management resources.”<sup>52</sup>

In response to the 1987 to 1992 drought, the city of Santa Barbara spent \$34 million to build a desalination plant that was promptly placed on long-term shutdown because of the plant’s very high operational costs.<sup>53</sup> Now, the city is considering a two-year process to reactivate the plant, at an additional cost of \$55 million.<sup>54</sup>

Similarly, in Australia, severe drought from the mid-1990s until 2012 prompted the construction of six large-scale seawater desalination plants at a cost of \$10 billion Australian Dollars (AUD).<sup>55</sup> The plants took years to build. Meanwhile, the National Water Initiative implemented water policy reforms and improved efficiency measures that led to cheaper water supply alternatives.<sup>56</sup> By the time the plants were operational, the abatement of the drought and proliferation of cost-effective alternatives made desalinated water prohibitively expensive.<sup>57</sup> As of 2015, most of these facilities stood idle, or operated at a significantly reduced capacity:

NAME	LOCATION	CAPACITY (MILLION GALLONS PER DAY)	COST (AUD)	STATUS
Gold Coast Desalination Plant	Queensland	33	\$1.2 billion	Suspended to reduce residential water bills. <sup>58</sup>
Victorian Desalination Plant	Wonthaggi	108	\$3.6 billion	No production since December 2012, and the government has placed a zero-water order for the supply period ending June 2016. <sup>59</sup> Meanwhile, water consumers continue to pay \$670 million AUD annually for the plant’s construction through water bill surcharges during this time. <sup>60</sup>
Sydney Desalination Plant	Kurnell	66	\$2 billion	No water produced since 2012. In 2015, it was reported that water consumers have paid around \$534.7 million AUD for the facility due to a 50-year guaranteed water contract. <sup>61</sup>
Adelaide Desalination plant	Lonsdale	71	\$2.2 billion	When the drought ended, the plant was scheduled to be shut down. <sup>62</sup> As of December 2014, however, it has been operating at minimum capacity, producing freshwater at only 10 percent of its potential. <sup>63</sup>
Southern Seawater Desal Plant	Binningup	71	\$955 million	Active <sup>64</sup>
Perth Seawater Desal Plant	Kwinana	34	\$387 million	Active <sup>65</sup>

In response to the current drought, California should carefully evaluate these past, expensive experiences with seawater desalination and instead prioritize water resources that are less expensive, less risky and have fewer environmental impacts.

## VII. BRACKISH WATER DESALINATION CAN CAUSE SIGNIFICANT HARM TO THE ENVIRONMENT

Brackish surface water desalination and brackish groundwater desalination can also harm the environment, if facilities are not sited, constructed, and operated responsibly. Brackish surface water facilities can damage freshwater ecosystems, while brackish groundwater facilities can cause subsidence issues for California’s natural aquifers.

### Surface brackish water desalination plants raise environmental risks for California’s estuaries and deltas

Brackish surface water desalination raises environmental concerns for California’s estuaries in the same way that seawater desalination threatens marine environments. These desalination plants can kill aquatic life through open intake structures and brine disposal. They also threaten habitats and protected areas and impair ecosystem

productivity. California’s estuaries contain many imperiled aquatic species that are critical for a functioning ecosystem and ecological balance and diversity, including commercially valuable species such as chinook salmon.<sup>66</sup> Thus, brackish surface water desalination plants should include subsurface intake structures, responsibly dispose of brine, and avoid building facilities near sensitive habitats.

### Groundwater desalination plants have fewer environmental risks than brackish surface water and seawater desalination plants

Brackish groundwater does not pose the same threats to marine or estuarine environments as seawater and brackish surface water desalination. This is particularly true if it includes environmentally safe brine disposal strategies. Brackish groundwater desalination can also improve the availability of local water supplies by making poor quality water sources available for use.

Still, there is the risk of groundwater overdraft, which is associated with land subsidence, increased energy use to pump water at lower depths, and water quality problems. It may also impact neighboring wells.<sup>67</sup> Thus, it is important to site these plants in sustainably managed groundwater basins. For example, Orange County actively recharges its aquifer with recycled water.<sup>68</sup> Desalination is not the only—nor the predominant—cause of these problems, but each of these impacts damage aquifers’ potential as a reliable source of water.

## IX. HOW DOES CALIFORNIA REGULATE DESALINATION?

Multiple state agencies have authority to create policy or administer regulations regarding seawater desalination, including the State Water Resources Control Board (SWRCB), California State Lands Commission, and California Coastal Commission. The SWRCB is California’s designated water pollution control agency under the Federal Water Pollution Control Act. In conjunction with the Regional Water Boards, it is authorized to issue Waste Discharge Requirements and National Pollutant Discharge Elimination System permits.<sup>69</sup>

### State Water Resources Control Board

On January 28, 2016, the SWRCB approved an amendment to the state’s Water Quality Control Plan for the Ocean Waters of California (Ocean Plan Amendment or OPA) to address impacts associated with the construction and operation of new or expanded seawater desalination plants.<sup>70</sup> The OPA requires such facilities to use BAT and BMPs to minimize intake and mortality of marine life, as described below:

#### ■ Intake technology:

The OPA establishes several requirements for seawater intakes at all new or expanded seawater desalination plants. First, plants must have subsurface intakes (which draw water from the undersea substrate, such as sand sediment, rather than above the seafloor), unless the Regional Water Board responsible for permitting a plant determines that subsurface intakes are not feasible. This determination must be based on an analysis of geotechnical data, oceanographic conditions, design constraints, energy use, and project life cycle costs. It must also account for the presence of sensitive habitats or species. The Board may not determine that subsurface intakes are infeasible merely because they are more costly than open-ocean intakes.<sup>71</sup> When subsurface intakes are deemed infeasible, facilities must install Imm slot screens on open ocean intakes (or an alternative method that provides equivalent protection), and ensure that water velocity through the screen does not exceed 0.15 meters per second to protect marine life. Second, the owner or operator must evaluate a reasonable range of project sites, including those that would support the use of subsurface intakes, before choosing a location. Lastly, if subsurface intakes are not feasible, the owner or operator must evaluate alternative design capacities.<sup>72</sup>

#### ■ Brine Disposal Methods:

The OPA establishes preferences and standards for brine disposal, prioritizing disposal by comingling brine with treated wastewater to dilute harmful pollutants. When treated wastewater is not an option, pressurized, spray brine diffusers are recommended. Moreover, the OPA prohibits flow augmentation<sup>73</sup> (in-plant dilution of brine with additional seawater prior to discharge) for any plants with open ocean intakes, with an exemption for the recently constructed Carlsbad desalination plant. Regardless of the technology used to discharge brine, the OPA regulates receiving water salinity to a maximum of 2.0 parts per thousand above background salinity no further than 100 meters horizontally from each discharge point.<sup>74</sup>

#### ■ Siting:

The OPA requires desalination plants avoid impacts to sensitive habitats and MPAs. It also prohibits intake and discharge structures within MPAs—except subsurface intakes that cause no sea life mortality.

### Regulation of Intakes from Once-Through Cooling Technology

The authoring organizations have spent decades working with state and federal agencies to develop regulations to minimize the intake and mortality of marine life from open ocean intakes and antiquated once-through cooling technology for coastal power plants.<sup>75</sup> The SWRCB’s 2010 regulations required power plants on the coast and estuaries to employ “best technology available” to reduce the entrainment and impingement of marine life.<sup>76</sup>

### California State Lands Commission

The California State Lands Commission (SLC) has regulatory authority over public trust lands, including tidal lands and those under navigable waters. It also has authority to “exclusively administer and control all [public trust lands]” to “lease or otherwise dispose of such lands, as provided by law.”<sup>77</sup> The SLC must grant permission for any private company or public entity must to use sovereign lands for any public trust use. Applications “must include an outline of the proposed project, supporting environmental data, and payment of appropriate fees.”<sup>78</sup>

### The California Coastal Commission

The California Coastal Commission (CCC) regulates use of the shoreline and coastal waters, in partnership with coastal cities and counties. The CCC issues coastal development permits (CDP), certifies local governments’ Local Coastal Programs, reviews appeals of locally issued CDPs, and conducts federal consistency review pursuant to the Coastal Zone Management Act (CZMA). When considering desalination projects, the CCC must evaluate whether plant design and siting is consistent with the California Coastal Act, which protects environmentally sensitive habitats, marine resources, biological productivity of coastal waters, and public access.<sup>79</sup> The CCC must also determine whether seawater desalination facilities qualify as coastal-dependent



developments, as the California Coastal Act prioritizes such uses over other development on or near the shoreline.<sup>80</sup>

### **Ocean Protection Council**

The Ocean Protection Council (OPC) is responsible for improving the effectiveness of ocean management in California by coordinating state agencies and enhancing scientific understanding through data collection and sharing. OPC's 2012–2017 Strategic Plan identifies desalination as a priority issue and acknowledges its own key role in promoting interagency collaboration for siting, design, mitigating, and permitting desalination facilities.<sup>81</sup> Given this strategic priority, OPC is well positioned to support the SWRCB's coordination of agency evaluation of desalination projects through the development of Memorandum of Agreement between the CCC, SLC, and California Department of Fish and Wildlife.<sup>82</sup>

### **Other Agencies and Local Governments**

The Department of Water Resources does not have a regulatory role regarding desalination, but it does prepare the California Water Plan with stakeholder input. This plan is updated every five years to assess trends, challenges, and opportunities in water management.<sup>83</sup> The 2013 Water Plan Update contains a Desalination Resource Management Strategy that surveys issues to consider when developing a desalination project. The Strategy, however, is non-binding.<sup>84</sup>

Local governments, local water districts, the California State Parks Department, and the Department of Public Health, may also participate in siting and overseeing seawater desalination projects. These entities are tasked with certifying environmental impact documents, negotiating water purchase agreements, granting easements for proposed pipelines that would carry desalinated water or for other infrastructure, and issuing Wholesale Drinking Water permits.<sup>85</sup>

## **X. RECOMMENDATIONS**

Given the significant energy, climate, and financial costs of desalination, California should prioritize water conservation, water use efficiency, stormwater capture, wastewater recycling, and renewably-powered groundwater desalination. Brackish surface and seawater desalination should only be pursued once these cheaper, safer alternatives have been implemented. If and when it is considered, decision makers should be careful to minimize adverse effects on sensitive marine and estuarine environments and minimize GHG emissions.

Our recommendations outline policies and planning processes that should inform any decisions related to desalination plants. These recommendations can help decision makers achieve water supply goals while minimizing costs and environmental impacts associated with desalination.

### **I. Less costly and lower impact water supply options should be prioritized over grid-connected seawater and surface water desalination.**

Water conservation, water use efficiency, stormwater capture, rainwater harvesting, wastewater recycling, and brackish groundwater desalination are generally less expensive and have fewer environmental impacts than grid-connected seawater or brackish surface water desalination. They should be pursued before seawater or brackish surface water desalination is considered.

#### ***A. Conservation and water efficiency***

Conservation and water efficiency should be California's top priority. In response to an emergency directive from Governor Brown, the state's urban residents used water conservation and efficiency measures to save more than 1.087 million acre-feet of water between June and December 2015, compared to the same months in 2013.<sup>86</sup> That's more water than would be generated annually by 19 new seawater desalination plants the size of the Poseidon plant in Carlsbad.<sup>87</sup> Throughout the drought, California has taken many steps to promote urban water conservation and efficiency, many of which will have lasting impacts on reducing water demand. For example, in 2015, the California Energy Commission adopted the nation's strongest water efficiency standards for faucets, toilets, urinals, and showerheads.<sup>88</sup> But significant water efficiency savings potential remains in California: California's urban water consumption ranks higher than other countries that use desalination at 201 gallons per capita per day (GPCD). That is in comparison to Australia's urban water use of 80 to 130 GPCD in the early 2000's, Israel's 84 GPCD, and Spain's 76 GPCD.<sup>89</sup> NRDC and Pacific Institute's 2014 report, "The Untapped Potential of California's Water Supply: Efficiency, Reuse, and Stormwater," found that agricultural water conservation and efficiency could reduce demand by 5.6 to 6.6 million acre-feet per year, while urban water conservation and efficiency has the potential to yield an additional savings of 2.9 to 5.2 million acre-feet per year.<sup>90</sup>

#### ***B. Water recycling and reuse***

Increased wastewater recycling, especially the vast quantities of treated wastewater California currently dumps into the ocean, is another important drought-proof alternative that has far fewer adverse environmental impacts than desalination. "The Untapped Potential of California's Water Supply" estimated that California's water reuse potential at 1.2 to 1.8 million acre-feet per year, even after significant improvements to urban water use efficiency.<sup>91</sup> Orange County's Sanitation District built a world-renowned water reuse facility that produces enough purified water to serve 500,000 people.<sup>92</sup> According to the Report Card for America's Infrastructure, this facility is 35 to 75 percent cheaper than saltwater desalination and will consume half the energy.<sup>93</sup>

By prohibiting ocean discharges from wastewater treatment plants by a date certain, where feasible and cost-effective, the state could dramatically accelerate the adoption of water recycling and improve the drought resistance of urban communities. This shift could significantly expand the state’s water supply for all water users. It would have at least two additional benefits. First, it would improve coastal water quality by reducing ocean discharges, particularly of treated wastewater. Second, it could potentially reduce GHG emissions, since recycled water consumes less electricity than many alternative water supply sources, including water imported from the Bay-Delta to Southern California and ocean or brackish water desalination.

**C. Low-impact development techniques, including green infrastructure and stormwater capture**

By treating stormwater as a waste product that needs to be disposed, California’s cities and urban areas turn a valuable water supply resource into a water quality problem. For example, a one-inch storm in Los Angeles County generates up to 10 billion gallons of runoff that flows through storm drains and is discharged into the ocean.<sup>94</sup> Stormwater runoff is also California’s leading source of surface water pollution. Left untreated, it carries bacteria, metals, and other pollutants to our waterways, harming the environment and causing hundreds of millions of dollars in public health costs per year.<sup>95</sup> “The Untapped Potential of California’s Water Supply” estimated that capturing stormwater in urban southern California and the San Francisco Bay could increase average water supplied by 420,000 to 630,000 acre-feet each year, while reducing flooding and surface water pollution.<sup>96</sup>

Low impact development (LID) is a land-use planning and engineering approach that emphasizes rainwater harvesting. This method uses water infiltration into the

ground through parks, open spaces, and swales, as well as rainwater capture in rain barrels or cisterns for later use onsite in urban areas.<sup>97</sup> Expanding LID could allow California to increase its water supply, improve water quality, and expand green space in urban environments. Improved stormwater management increases safe and reliable water sources while consuming less energy and generating fewer GHGs.<sup>98</sup>

**D. Brackish groundwater desalination plants**

Small-scale, brackish groundwater desalination plants that rely on stand-alone renewable energy pose fewer environmental risks than large-scale, grid-connected seawater desalination plants that harm California’s marine ecosystem. There are currently 23 groundwater desalination plants in California. There is significant potential to support brackish groundwater plants in the agricultural Central Valley, where irrigation drainage tainted by minerals, including salt and selenium, can be treated for agricultural use or potentially potable water. To minimize impacts, these plants should sustainably manage their effluent brine and use zero-discharge processes, which reclaim salts and other byproducts. Moreover, the least impactful plants would be powered by stand-alone renewable energy that result in no additional GHG emissions and supporting groundwater management through pumped basins.

**2. If California determines that all other water supply strategies have been implemented and seawater desalination and brackish surface water desalination are necessary, desalination plants should be guided by comprehensive statewide policy that utilizes BMPs and BAT and be situated to minimize environmental impacts.**

The following matrix summarizes the impacts of various methods and technologies, identifying the least impactful options.

**CHART 3: EVALUATIVE FRAMEWORK**

CRITERIA	LOWEST IMPACT (BEST)	MODERATE IMPACT	HIGH IMPACT (WORST)
Intake technology	Subsurface Intakes		Open ocean intakes
Brine disposal methods	Commingling brine with wastewater*	Multiport diffusers	Flow augmentation from surface intakes
Siting intake and discharge structures (alternative sites must be considered per SWRCB desalination policy)	Outside MPA boundaries; sited to avoid impacts to sensitive ecological areas, marine wildlife and organisms and MPAs.		Adverse impacts to MPAs, interferes with connectivity of MPAs, and/or affects areas with sensitive marine, habitats, wildlife and organisms.
Design Capacity	Capacity designed to accommodate subsurface intakes and meet demonstrated community water needs.		Capacity designed to maximize water production, regardless of need.
Energy and GHG Emissions	Standalone plant powered by renewables with no GHG emissions	Grid connected plant operating primarily during times of excess renewable generation	Grid connected plant operating continuously with high GHG emissions

\* Note: SWRCB’s requirement per the OPA. This does not preclude any future wastewater recycling.

### ■ Intake Structures

We strongly agree with the SWRCB's analysis, which identifies sub-seafloor intake systems as the preferred technology to minimize environmental impacts. This technology significantly improves raw water quality, while reducing financial and environmental impacts, decreasing the carbon footprint, and reducing the cost of treated water to consumers. Subsurface intakes also provide filtration and active biological treatment of raw seawater. Contaminants like algae and bacteria are removed by natural filtration through layers of rock or sand, reducing the need for treatment in the desalination process.<sup>99</sup> We recommend conducting lifecycle cost analyses that include all environmental, energy, and siting impacts over the entire operating period, rather than only considering initial capital costs, to determine whether subsurface intakes are feasible.

### ■ Discharges

Following SWRCB policy, we recommend commingling brine with wastewater before discharge to reduce harmful effluent pollutants and minimize marine impacts. However, we strongly argue that water recycling options should be maximized before desalination options are pursued, and if diluting brine waste from desalination using wastewater impedes water recycling options, it should not be used. In that case, brine dilution through multipoint diffusers will be the preferred BMP.

### ■ Siting Intake and Discharges Structures

We recommend siting new brackish surface water and seawater desalination plants based on the application of the best geospatial data to choose a site that will minimize impacts to marine and estuarine life. As detailed in the OPA, the best locations pose no adverse impacts to MPAs or other sensitive ecological areas. We recommend a thorough alternative site analysis to evaluate a range of project sites where subsurface intakes can be utilized.

### ■ Design Capacity

We recommend that desalination plants be designed to meet demonstrated community water needs, accounting for county general plans and urban water management plans, rather than design capacity to maximize water production and sales. Moreover, Regional Water Boards must follow SWRCB policy and cannot deem subsurface intakes infeasible if the design capacity is in excess of local water needs.

### ■ Energy and Carbon

We recommend prioritizing plant designs that avoid or reduce GHG emissions. To achieve the highest degree of certainty, desalination plants should rely on stand-alone renewable energy to reduce GHG emissions. Stand-alone renewable energy (and likely storage), instead of connecting to the electricity grid, can increase operating costs. However, it eliminates the plant's GHG emissions as well as adverse impacts on the electricity grid.

We recommend that grid-connected plants primarily draw electricity from the grid at times when facilitates integrate more renewable energy onto the electric grid, which requires overcoming financial and engineering barriers to flexible operation. For both flexibly operated desalination plants and conventional plants connected to the grid with continuous operations, we recommend making the plant's processes more energy efficient and mitigating GHG impacts through CARB compliance-grade offsets or allowances and monitoring consumption patterns on a daily and seasonal basis in order to verify GHG impacts.

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