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Column notes	All additional information required in the margins will be specified in the next draft after 11/13/2012.
Annotations:	Annotations are used to provide notes to the readers, conduct specific outreach for information or other purposes, and to give general comments on issues not appropriate for the chapter text. The format for annotations is using italic font within square brackets. Example: *[DWR seeks expert opinion and additional perspectives to improve this particular issue.]*

Foreword

This is the first draft of the Desalination—Brackish and Sea Water Resources Management Strategy (Desal-RMS) for the California Water Plan Update 2013 (CWP-2013). This chapter is a substantive change from previous water plans. As a component of the California Water Plan, this chapter is a part of the integrated water resources management from a state perspective. The review of this draft is an opportunity for stakeholders to participate in shaping the issues presented in the chapter. The draft contains many gaps, missing data, or data that need to be updated. Because the draft is incomplete, there has been little effort to edit the content to eliminate repetition, or improve clarity and readability. While any comments or suggestions are welcome, DWR is most interested in identifying issues that need to be added, receiving perspectives that may help shape the issues, and obtaining data to have current and accurate information. DWR encourages readers to submit additional and current information for our review and possible inclusion into the chapter.

Chapter 9. Desalination (Brackish and Sea Water)

Desalination of the various types of saline waters throughout California is an important resources management strategy that deserves unique considerations by many communities in the state to safeguard, sustainably develop, and use existing and future water sources.

Desalination of brackish and sea water as a resource management strategy (Desal-RMS) is one of 27 strategies recommended to be evaluated when a community sets out to meet local or regional water management objectives. Desal-RMS does not dwell outside the confines of regional and local water management objectives. These objectives and associated constraints must be well defined with or prior to evaluating desalination as a resource management strategy.

Because of the energy intensity of removing salt and other impurities, energy generation and desalination have historically been coupled. In the 1960s, desalination was coupled with the promise of energy production from nuclear and conventional power plants using once-through cooling processes. Today, that promise has been replaced by coupling desalination with renewable energy production consistent with the mandate in Senate Bill X1-2 (2011) to obtain a 33 percent of statewide energy production from renewable sources by 2020.

As we look to the future, emerging advancements in technologies used for generating renewable power that may be suitably coupled with desalination facilities are ocean wave-power, solar, wind, hydraulic, and geothermal. Coupling renewable power generation with desalination to reduce cost and greenhouse gas emissions may be important for implementation of desalination projects.

The objective of this chapter is to provide a framework for desalination as a statewide resource management strategy (Desal-RMS) for meeting water supply objectives. The goals as reflected in the content of this chapter are to:

This chapter focuses on Desal-RMS for the purpose of meeting municipal water demands primarily associated with municipal drinking water supply.

- familiarize and define desalination to the reader in context of the resources management strategies (RMS).
- qualify distinctions between the function of desalination as a RMS and the function of water treatment technologies and processes required to desalinate various types of source waters.
- provide information and perspectives on key issues surrounding brackish and sea water desalination
- provide information pertinent to legislation and funding, including loans and grant availability.
- present the potential benefits, costs of desalination in California.
- furnish recommendations to facilitate Desal-RMS throughout the State, and
- guide interested readers to related sections of the California Water Plan for a full-spectrum view of why desalination is but one of many resource management strategies necessary to better our future.

This chapter's context for desalination as an RMS (Desal-RMS) is based on employing treatment technologies and processes through integrated planning primarily for urban potable water supply purposes and for removal of salt, not other impurities, in the source water. Programs or projects employing desalination water treatment technologies and processes primarily for purposes *other than* municipal drinking water supply or from sources other than brackish (ground or surface) or sea water are *not* the focus of this chapter.

[Levels for hierarchy of chapter sections/subsections headings are given by L2, L3,and L4.; L1 being the main chapter title.]

Salt and Salinity (L2)

The presence of certain impurities (e.g., minerals, elements, and chemical compounds) in water, especially at higher concentrations, affects the aesthetics or use of water. For example:

- halite, the mineral (NaCl) commonly known as table salt or sodium chloride, readily dissolves in water into ionic forms and is found objectionable to human taste even at low levels,
- sodium, the element (Na), can affect soil properties damaging crops, and
- calcium carbonate (chemical compound, $CaCO_3$) deposits on household fixtures and industrial equipment causing damage or increasing maintenance.

When solid substances mix with water or other liquids, they may separate (dissolve) into two parts, one with a positive charge (such as sodium or calcium) and one with a negative charge (such as chloride or bicarbonate). This form of a dissolved solid is termed an ionic substance. The majority of dissolved solids in municipal water supply sources, fresh or saline, are ionic inorganic substances such as calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, bromide, and nitrate. These dissolved ionic elements or compounds are known collectively as "salt".

The principle source of salt in the oceans and brackish waters comes from the land, leached out as each hydrological cycle completes. Over the millenniums, the oceans, seas, and other saline bodies of water have become salty through the action of fresh water interacting with rocks

containing minerals like sodium chloride (NaCl) to make them salty. And after water evaporates from the surface of a saline water body (salt sink), the salt is left behind increasing the salinity. After millions of years, the oceans have developed a noticeably salty taste.

The saltiness of water is referred to as its salinity. "Salinity" is generally defined as the amount of salt dissolved in a given unit volume of water. It is variously measured in units of electrical conductivity (EC), total dissolved solids (TDS), practical salinity units (psu), or other units depending on the scientific discipline of the person doing the measuring and the purpose of the study or monitoring program.

Salinity is often considered equivalent to total dissolved solids." [REF-43] However, TDS includes other dissolved chemicals besides salts.

There are a number of ways to measure saltiness in water with each having its role in various sciences (e.g., oceanography, hydrology, and geology). The most used metrics are shown in Table -9-1:

Table 9-1 Measurements of salinity

Salinity metric	Common Units	Comment
Electrical conductivity (EC)	µS/cm	Unit name is Siemens the measure of electrical conductance in a solution (electrolyte).
Total dissolved solids (TDS)	mg/l or ppm	TDS is the dry weight (mass) in milligrams per volume in liters of solution, pure water (H_2O).
Practical salinity units (PSU)	Unit-less	

Salts are naturally occurring in the environment, but human activity often increases salinity in water and soil. Because of the negative impacts of salinity on human use or the water environment (fresh and saline), salinity management is a critical resource management strategy (see Chapter 18, Salt and Salinity Management—Improve Water Quality).

Many details about water chemistry and drinking water regulations are beyond the scope of this chapter but play a significant role in setting state, regional and local water quality and supply objectives.

Desalination as Technology or as Resource Management Strategy (L2)

Desalination, that is, the process or technology for removal of salts from water to provide a water of lesser salinity than the source water, is an important component of salinity management. Desalination allows us to use a water that otherwise is unusable for most municipal purposes (e.g., drinking water). It also allows us to improve the quality of a wastewater so that it can be discharged safely into the fresh or saline natural water environment.

Publications use the terms "desalting", "desalination", "demineralization", "saline conversion", "sea water conversion", "water demineralization" and "brackish water conversion" when

referring to or reporting on the subject of removing salt from saline waters to increase fresh water supplies. These various terms are generally considered synonymous to "desalination". "Desalination" is the term used in this Chapter for consistency.

Desalination technologies can be applied to many sources of water for different purposes. For example: desalination technologies may be applied to:

- remove pollutants before discharge (e.g., groundwater remediation and municipal wastewater),
- remove chemicals harmful to human health to produce a suitable water drinking, and
- allow industry to obtain a high purity water for certain manufacturing purposes.

Desalination as a resource management strategy (Desal-RMS) in the California Water Plan is the application desalination technologies or processes to convert brackish (ground or surface) or sea water to a drinking water source. The resource management strategy incorporates sound planning practices within the context of integrated water management and sound engineering and science to ensure desalination appropriately serves the social objectives of a safe and reliable water supply in a manner protective of the environment.

The proper implementation of Desal-RMS requires the understanding of societal and environmental aspects of water supply economics, quality-of-life issues, sustainability, renewability, and reliability as applied to local and regional water supply objectives. These and additional aspects are interweaved into a complex fabric of laws, policies, norms, and, expectations at many levels and sub levels. At the forefront, may well be, the growth inducing aspects of Desal-RMS coupled with a responsible Earth's stewardship for life, terrestrial and aquatic. Desal-RMS is unique in that it affords us the means by which to free ourselves from the old constraints, problems, and reliance of the limited fresh water supply delivered through the natural hydrologic cycle while creating new challenges and issues surrounding safeguarding the environment and meeting our water supply objectives in a sustainable fashion.

Key Aspects Concerning This RMS (L2)

A key aspect to consider when understanding Desal-RMS is the way water is classified by source and typed by quality. All water bodies as source waters in California are generally typed as either a surface or ground water with some further distinctions to improve delineations. For purposes of desalination planning and description, examples of distinctions are:

- groundwater under the direct and natural influence of surface water
- confined groundwater with limited natural reoccurring recharge, and
- semi-enclosed brackish surface water such as an estuary which may be fresh or saline dominant.

[improve this list and focus on desalination]

The general terms "brackish" and "seawater" are used to characterize the degree of salinity of source waters and are often measured or compared with their known concentrations of total dissolved solids (TDS). The units-of-measure most often used for TDS in water science are milligrams per liter, mg/l. These units are basically equivalent to "parts per million" since one liter of pure water weighs one million milligrams. Parts per million (ppm) and mg/l are used interchangeably in water sciences. A TDS of 35,000 mg/l or ppm (the generally accepted value for salinity of open sea water) is also expressed as 35 parts per thousand (ppt) TDS or 3.5 percent salinity (salt).

The term "brackish", in general, refers to water that has more salinity than fresh water but less than sea water. There is not a rigid standard for the border between fresh and brackish water, but for the purposes of this chapter, a TDS of 500 mg/l is the upper limit of fresh water. There is also not a rigid delineation between brackish surface and sea water, however, 30,000 mg/l or 3 percent salinity will be used for the purposes of this chapter.

For defining the term "brackish" in this chapter, a concentration value of 500 mg/l is used for the lower range as shown in the table below, Table 9-3 General water salinity levels based on total dissolved solids (TDS).

The term "brine" is a general term and may refer to effluent from a desalination facility or naturally occurring water with a high salinity. In many food preserving processes, brines are used of varying salinity to achieve a specific purpose. For the Desal-RMS, the term "brine" refers to the high salinity reject water normally associated with the treatment processes used to remove salts. And while the reject water from a desalination facility may be referred to as "brine" it may only reach concentrations of 4,000 mg/l TDS such as in the case of desalting some brackish ground waters.

Table 9-3 "General water salinity levels based on total dissolved solids (TDS)

General water term	Relative salinity, mg/l (ppm) TDS
Fresh	Less than 500[1]
Brackish	500 to 30,000
Sea	30,000 to 50,000
Hypersaline	Greater than 50,000 or that found in the sea.
Brine	50,000 to slurries [2]

1. based on preferred drinking water quality standards but could be set at less than 1,000 ppm TDS.

2. Also, natural brines or "salines" from groundwater are 100,000 ppm or greater TDS, NaCl saturated solutions are approx. 260,000 ppm in concentration, and the concentration of reject water from a desalination facility may be referred to as "brine" but may only be 4,000 mg/l TDS in concentration.

Source waters are often associated with certain ranges of salinity, as shown in Table 9-4

Table 9-4 "General source water for Desal-RMS".

General Classification Desal-RMS	Relative salinity, mg/l TDS
Brackish groundwater (confined or unconfined)	1,000 to X,000
Enclosed brackish surface water (salt sinks as in the Salton sea)	1,000 to brine
Open/semi-enclosed brackish surface water (estuaries, marches—fresh water dominate)	1,000 to 20,000 (open sea)
Semi-enclosed/enclose sea water (bays, estuaries, marshes—salt water dominated)	20,000 to brine
Coastal and open sea water	30,000 to 50,000

Draft table-range values not finalized

It is convenient to classify water on the earth as either saline or fresh and qualitatively grade

saline waters for our fresh water needs. In most instances, the less salt there is in water the more versatile or recyclable the water is. With saline water constituting approximately 94% of the water on the earth and the remaining 6 percent as fresh water distributed at any one time among clouds, glaciers, snowpack, surface and ground waters, only a portion of this 6 percent is available to meet our fresh water demands. The remaining percentage falls back into the ocean as precipitation. Supplementing this naturally but limited fresh water supply through brackish and sea water desalination technologies is one way to help meet water quality and supply objectives.

Major water source types in California, including those requiring desalting to provide a fresh drinking water, together with a typical treatment facility are shown in Figure 9-1 "Desalination Facility Basic Components and Source Waters"
[proposed graphic of the state depicting likely major desal sources with approx. volumes or yields].

For our fresh water and in particular our drinking water, it is convenient to understand how salinity is currently regulated under drinking water regulations by the California Department of Public Health (CDPH). This enables us to share common water quality objectives and how we judge and control the amount of salt in our public water supply. The CDPH regulates water purveyors of certain sizes and sets the levels of salinity through secondary maximum contaminant levels for drinking water systems.

Technologies Related to Desalination (L2)

Significant effort has been devoted to desalination and related water treatment technology research, development, and implementation over the past 50 years. Those efforts have led to significant improvements in the reduction in cost and the improved performance of desalination and related technologies. Unfortunately, there are still only two major desalination processes in common application today, thermal distillation and membrane separation. Though there are several major commercially available technologies in these categories, reverse osmosis (RO) and multistage flash distillation (MFD) continue to be the most prominent, accounting for XX% (90%) of the number of plants and XX% (80%) of the capacity in the world. The desalination industry estimates that in the next 20 years over $XXB ($70B) will be invested world-wide in designing and building new desalination plants and facilities. *[source to be provided]*

Worldwide growth in the development of membrane technologies has led to an ever increasing availability of improved membrane materials with higher efficiencies and reliabilities to overall desalination treatment systems. This continuous advancement is coupled with reduced capital and operational costs and environmentally sustainable practice.

Table 9-5 Desalination Technologies and their general application

Desalination technology	Brief definition/description (reference for additional info.)	Chemicals removed	General Application
Multi-Stage Flash evaporation (MSF)			Large scale sea water desalination facilities oil is used for energy at less than market prices.
Multi Effect Distillation (MED)			
Vapor Compression (VC)			
Electrodialysis (ED)			
Nanofiltration (NF)			
Reverse Osmosis (RO)			
Forward Osmosis (FO)			
Microfiltration membranes (MFM)			*Related*
Ultrafiltration Membranes (UFM)			*Related*
Capacitive Deionization Technology ™			*Pilot stage, experimental—an alternative to RO and other desalination technologies.*

[table under development]

Desalination in California (L2)

General (L3)

Without desalination, water supply in many California communities is likely not sustainable. Over extraction of surface and ground water supplies is causing adverse impacts such as saline-water intrusion into the existing fresh water supplies, irreversible land subsidence causing diminished groundwater storage capacity, and insufficient environmental water during sensitive biologic periods through wetlands, the Delta, and streams. Desalination is one of the options that must be considered to address regional and local water quality and supply objectives including climate change preparedness, sustainability, and reliability of our municipal water supplies.

Several regional plans contemplate desalination as an integral component of the water resources portfolio along with water recycling and increased water use efficiency. Moreover, as a resource management strategy, desalination must be evaluated by the integrated regional water management (IRWM) planning region as a method to meet their water resource management goals and objectives of the region.

It is estimated that there are more than X persons in California (XX% of all Californians) who rely on raw (untreated) water sources containing more than 500 mg/l of TDS, the recommended secondary drinking water standard, and XX person relying on raw water sources with over 1,000 mg/l TDS.

Nearly continuous incremental technological advances in the technologies used for desalination

and other water treatment technologies as narrowed the gap between what is considered feasible and infeasible regarding brackish and sea water desalination for municipal uses. Utilizing saline water bodies more effectively throughout California is a vision which is becoming clearer and more vivid. Similarly, advancements in the technologies for renewable energy production are occurring.

Past (L3)

As stated in our previous version of this RMS in 2009, "desalination began in California in 1965. The past ten years has seen a rapid rise in installed capacity. This is primarily due to dramatic improvements in membrane technology and the increasing cost of conventional water supply delivery."

It is worthy to note that in 1960, in the transmittal letter for DWR Bulletin 93 entitled "Saline Water Demineralization and Nuclear Energy in The California Water Plan", DWR wrote then Governor Edmund G. Brown and members of the Legislature of the State of California these words:

"Although no saline water demineralization technique yet developed can compete with the costs of large scale development of natural sources of water in California, it is probable that saline water conversion plants will have a definite place in the water program. The Department of Water Resources will continue to take a definite and continuing interest in those areas of research and development that may have promise of eventually producing low cost converted water."

While the use of nuclear power is presently decoupled from desalination in California, DWR is still dedicated to promoting desalination, technological advancements, and the coupling of renewable power sources for sustainable freshwater supplies from saline water sources.

[Historical data on actual desalination facilities is being complied for presentation in this section, send any, especially 1960 era or earlier data, for quality assurance of DWR records]

Present (L3)

As of 2012, there were XX water treatment facilities using desalination technologies operating in California providing municipal drinking water for urban uses. The total capacity of these plants is approximately XX,XXX acre-feet per year (AFY) or XX million gallons per day. These include XX brackish and XX sea water desalination facilities. Table 9-6 shows these facilities with source water and capacity.

Table 9-6 (Draft) Existing Calif. municipal water desalination facilities.			
Facility	**Capacity, MGD (AF/Y)**	**Source Water (examples)**	**Status**
Facility 1	Cap 1	Brackish groundwater	
Facility 2	Cap 2	Brackish open surface water (fresh)	
Facility 3	Cap 3	Brackish open surface water (sea)	
Facility 4	Cap 4	Seawater, open surface intakes	
Facility 5	Cap 5	Seawater, groundwater intakes (direct surface influence)	
Totals, Count =XX	XXX (XXX)		

[source provided for table]

Future (L3)

Future municipal water desalination facilities are considered proposed projects and categorized as shown in Table 9-7. The desalination plants in operation, design, or construction, and planned or projected for construction as of 20XX are given. While not all of these are likely to be constructed due to various reasons, it is assumed that they, or an equivalent number, will be operational by 20XX.

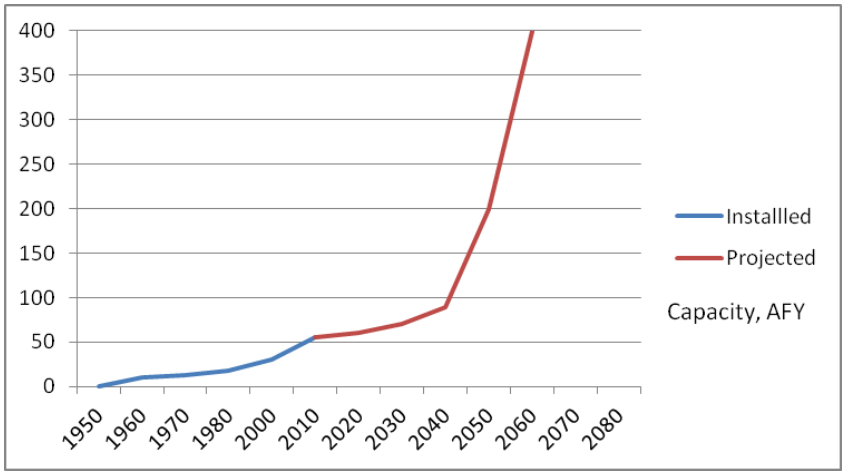
Table 9-7 (Draft) Planned (potential) municipal water desalination facilities in Ca.			
Facility	**Capacity, MGD (AF/Y)**	**Source Water (examples)**	**Category**
Facility 1	Cap 1	Brackish groundwater	Feasibility
Facility 2	Cap 2	Brackish open surface water (fresh)	Design
Facility 3	Cap 3	Brackish open surface water (sea)	Planned
Facility 4	Cap 4	Seawater, open surface intakes	Proposed
Facility 5	Cap 5	Seawater, groundwater intakes (direct surface influence)	
Totals, Count =XX	XXX (XXX)		

[source provided for table]

Figure 9-3 gives installed with projected capacities of brackish and sea water desalination facilities in California.

[Figure 9-3 "Existing and projected California Brackish and sea water desalination plant capacity" is a mock-up. If sufficient data are available, this figure could be developed.]

Figure 9-3 Existing and projected California brackish and sea water desalination plant capacity



Brackish Water (L2)

General (L3)

In general and for purposes of this RMS, both surface and ground brackish water is taken to have a salinity level measured with total dissolved solids (TDS) concentrations ranging from 1,000 (or 500?) to salinity levels approaching sea water taken as 30,000 milligrams per liter (mg/l).

Desalination of brackish waters, as defined above, may be required for potable use. Approximately xx,000 AFY of additional capacity is under construction or planned. Groundwater desalination may provide water from a source that is not currently being used or designated for municipal beneficial purposes. Whether brackish groundwater recovery is a sustainable water strategy depends on whether the groundwater source is being naturally or artificially replenished. Mining a brackish aquifer, extracting without natural or artificial replenishment, has a finite life. Insofar as seawater intrusion in overdrafted groundwater basins is increasing the salinity of groundwater and the geographic extent of the contamination, seawater desalination may be a strategy to reduce dependency on groundwater or a source of water to recharge groundwater. Thus, seawater desalination may mitigate a worsening brackish groundwater situation.

Groundwater desalting plants are generally designed to reclaim groundwater of impaired use and are located in urban areas from the San Francisco Bay Area to San Diego. While the capacity of these plants are generally less than 5 million gallons per day (mgd) (5,600 AFY), several plants are projected to increase in capacity size to 15-20 mgd (16,800-22,400 AFY). Currently there are seven new groundwater desalting plants and nine plant expansions in the design and construction phase or the planned and projected phase, for a total of about 88,000 AFY in new capacity.

Sea Water (L2)

[This section under development]

Legal and Regulatory Framework of Desalination in California (L2)

Statutes and Legislation (L3)

[A "current affairs—what's going on?" subsection is likely to be developed to report proposed legislation and point out recent or key statutes.]

General (L4)

The statutes and legislation concerning desalination are listed with a brief description when warranted, especially in concert with identified issues or benefits.

[The following are legislative related elements and their resulting statutes which are being reviewed for applicable inclusion into the chapter. A past and current context maybe provided.]

- SB 1319, Burton - 2004: The California Ocean Protection Act
- AB 2918, Laird - 2004: Desalination Facilities
- SB 318, Alpert - 2004: Urban Water Suppliers: Desalinated Water
- The Urban Water Management Planning Act
- Proposition 204, 2001-2004, Salt Separation & Utilization Projects
- AB 314, Kehoe - 2003: Desalination
- AB 1747, 2003, Water Code Section 79547.2(c)),
- Proposition 50, 2002, Water Security, Clean Drinking Water, Coastal and Beach Protection Act
- AB 2717, Hertzberg - 2002: Water Desalination Task Force
- SB 1062, Poochigian - 1999: The California Water Plan
- Proposition 204 Drainage Sub-account. The Safe, Clean, and Reliable Water Supply Act of 1996, section 78645,

Regulatory Framework (L3)

General (L4)

[A "current affairs—what's going on?" subsection is likely to be developed to focus aspects of the regulatory framework.]

Many laws, including the California Environmental Quality Act (CEQA) and the Permit Streamlining Act (PSA) influence and regulate planning and land use in California. While the permit process remains independent, it nonetheless interfaces with the CEQA process. To understand this interface, it is necessary to understand the role of various agencies that regulate development activities in California.

Brackish groundwater desalination projects have fairly routine environmental and permitting requirements with the exception of the problematic issue of concentrate disposal in inland locations.

Brackish surface or sea water desalination projects face a greater challenge. With a location within the coastal zone, and with the need for water intakes and outfalls, there are many reviewing agencies, organizations, and permitting requirements.

Most of the primary agencies that exercise regulatory and permitting authority with regard to water supply facility planning, construction, and operation, and that could exercise authority for construction and operation of desalination facilities, are listed below.

Table 9-x. Regulatory Agencies for municipal desalination projects	
Federal agencies	**Primary Role**
U.S. Army Corps of Engineers	
U.S. Coast Guard	
U.S. Environmental Protection Agency	
U.S. Fish and Wildlife Service	
National Marine Fisheries Service	
National Oceanic and Atmospheric Administration	
Tribal entities	
State agencies	
San Francisco Bay Conservation and Development Commission	
California Coastal Commission	
State Lands Commission	
California Department of Boating and Waterways	
California Department of Fish and Game	
California Department of Parks and Recreation	
California Department of Public Health	
California Department of Transportation	
California Department of Water Resources	
California Public Utilities Commission	
State Water Resources Control Board	
Regional Water Quality Control Boards	
Delta Stewardship Council or other Delta agencies	
California Public Utilities Commission	
Local agencies	
Air Pollution Control Agencies	
County Agencies	
County Health Departments	
Local Planning Commissions	
Water Management Districts	

[This table is under development]

Basin plans (L4)

A perspective for consideration in Desal-RMS is that provided in the basin plans regarding suitable or potentially suitable drinking water of the State as given below:

"THEREFORE BE IT RESOLVED:

All surface and ground waters of the State are considered to be suitable, or potentially suitable, for municipal or domestic water supply and should be so designated by the Regional Boards with the exception of: 1. Surface and ground waters where: a. The total dissolved solids (TDS) exceed 3,000 mg/L (5,000 uS/cm, electrical conductivity) and it is not reasonably expected by Regional Boards to supply a public water system,…" [(2) Notes on Region 1, North Coast, May 2011 dated Basin Plan.]

The question may be asked that given desalination and other water treatment technologies available today, should the salinity be a controlling factor or criteria for designating viable municipal water sources?

Another perspective is centered around the words "reasonably expected"; should the task of defining the term "reasonably expected" be assigned to through community planning or the regulatory bodies? This issue allows for discussion and possible improvements to the regulatory framework.

The San Francisco Bay has only recently been identified as a potential drinking water source by the Regional Water Board. It is worthy to note that the following is included in the most recent Basin Plan for the area "If water supply agencies implement desalination to augment supplies along with waste management practices that protect beneficial uses, the Water Board will consider amending the Basin Plan to designate the municipal and domestic supply (MUN) beneficial use for applicable marine or estuarine areas of the Region." (Region 2, San Francisco, December 31, 2010 dated Basin Plan. 4.26.2 Desalination, Page 4-92). Waiting for municipal desalination projects utilizing saline water prior to MUN designations could be acting as a barrier in our regulatory framework.

Potential Benefits of Desalination (L2)

General (L3)

Desalination is becoming increasingly important in certain locations and circumstances throughout California. Coastal and inland communities are piloting and implementing full-scale brackish and sea water desalination facilities to meet water demands for:

- existing and anticipated population growth,
- replacing imported water deliveries (State Water Project and Colorado River),
- increasing reliability for periods of local drought,
- safeguarding against disaster scenarios (risk reduction) which could affect imported or natural fresh water deliveries (e.g., Delta levee failure, out-of-region and statewide droughts, and earthquake damage to conveyance systems),
- fulfilling restoration and sustainability commitments for the natural environment,
- implementing strategic planning initiatives for climate change adaptation,
- protecting all water sources (fresh and saline) from degradation, and
- practicing environmental justice.

The list above is not intended to be exhaustive, but it highlights the multiple benefits which may be achieved by building a desalination facility. First and foremost, benefits and drawbacks for any action or inaction to increase, replace, or do nothing concerning municipal water supply must be well understood and accepted at the local and regional levels.

1. *[Brief discussion on--existing and anticipated population growth]*
2. *[Brief discussion on--replacing imported water deliveries (State Water Project and Colorado River)]*
3. *[Brief discussion on--increasing reliability for periods of local drought]*
4. *[Brief discussion on--safeguarding against disaster scenarios (risk reduction) which could affect imported or natural fresh water deliveries (e.g., Delta levee failure, out-of-region and statewide droughts, and earthquake damage to conveyance systems)]*
5. *[Brief discussion on --fulfilling restoration and sustainability commitments for the natural environment]*
6. *[Brief discussion on--implementing strategic planning initiatives for climate change adaptation,*
7. *[[Brief discussion on--protecting all water sources (fresh and saline) from degradation]*

8. [Brief discussion on--practicing environmental justice.]

[The paragraphs below will be merged into these topics]

Desal-RMS provides the necessary mechanisms helping to meet the diverse needs of the community or region by safeguarding environmental protection and municipal water supply development through providing a key check-and-balance approach to achieving an open and participatory role by all stakeholders to establish specific desalination facility planning and design criteria when saline water sources are warranted to be developed.

Seawater desalting creates a new water supply by tapping the significant supply of potential feedwater from the Pacific Ocean. In addition to seawater desalting, desalination technologies can be used to produce potable water from brackish waters and impaired waters. Many surface and groundwater sources are brackish which can be naturally occurring due to the soil type and aquifer lithology or induced by man-made activities such as farming and overdraft of coastal aquifers causing seawater intrusion. Desalination was also proven to treat to very high levels of purity other water that may have low salinity but is impaired by high levels of specific contaminants such as nitrate. Accordingly, desalination in water resources planning is a unique tool serving both water supply augmentation and water quality improvement strategies.

Desalination of states saline waters through well planned and environmentally sustainable facilities will increase our emergency preparedness and the ability to respond in the water sector to meet essential fresh water supply objectives during natural disasters and prolong droughts. The use of saline waters through desalination techniques offers potentials when other more traditional resource management strategies are maximized or not applicable in a region or specific case. Desalination potentials should be well understood and mapped out in appropriate regions and sites throughout the State and should always be placed in context with among the other resources management strategies as shown below. The synergy which may be developed when including saline water bodies as a potential drinking water source or other water use type through desalination techniques must be understood especially in regards to preparedness and response to drought and disaster.

Desalination provides a means to protect and preserve current drinking water supplies (ground water and surface water) by relieving groundwater over-drafting, stemming seawater intrusion, and maintaining surface flows for the environment. This may require consideration for updating source water protection areas and protection plans of drinking water to include ocean and other brackish water not identified in the current basin plans. Updating drinking source water delineations, assessments and protection plans to address anticipated climate change impacts and inclusion of saline water bodies as drinking water sources is likely essential.

In times of water scarcity and an ever-growing demand for fresh water due to population growth, and given current climate trends, water resources will become even more unevenly distributed as water-scarce regions experience more frequent and prolonged droughts. Desalination can be a reliable water supply alternative and a part of the solution for meeting current and future water needs. Conventional water sources are often limited by overdraft, depletion, pollution, and environmental requirements. Furthermore, traditional water supply management methods such as

surface water storage, groundwater extraction, and inter-basin water transfer may not be sufficient to meet increasing water demand.

Through Desal-RMS, even small scale desalination facilities can serve to meet sustainability and reliability objectives for municipal water supply by providing an emergency water supply. Such facilities as, mobile water treatment units including those that can desalt sea or other saline waters can provide emergency potable water supply for towns and communities during droughts, emergencies, or unplanned disruption of their water supplies (e.g., contaminated supply, loss of water transfer). Mobile water desalination units are, generally reverse osmosis technology, mobile desalination units—that can be truck-mounted or air-lifted, enabling the provision of short-term emergency water supply as well as supplemental supply for drought-stricken, disaster, or other emergency stricken areas. These units can provide a flexible solution to water shortages as they can be quickly and easily deployed. Unlike permanent desalination plants, temporary mobile units can be commissioned, installed and put into production in a short period of time provided environmental and other concerns are addressed. They can also be quickly and easily decommissioned or moved to other locations should emergency or drought conditions ease. Please see the Mobile Desalination Units article in the Volume X Reference Guide under the Drought topic. *[coordination of contingency plans involving desalination?]*

Potential Costs of Desalination (L2)

General (L3)

The cost of desalination depends on numerous factors that are often project-specific. A cost breakdown for a typical seawater RO desalination plant is shown in Figure 9-1[need to update costs]. When planning desalination projects, it is important that cost estimates take into account the costs of concentrate management and intake systems, including environmental and permitting costs in addition to process costs (i.e., costs of pre-treatment, post-treatment, and main desalting process).

The cost and affordability of desalination is influence by the type of feedwater, the available concentrate disposal options, the proximity to distribution systems, and the availability and cost of power. The higher costs of desalting may, in some cases, be offset by the benefits of increased water supply reliability and/or the environmental benefits from substituting desalination for a water supply with higher environmental costs (e.g. Carmel River, Monterey Bay area). When comparing the cost and impacts of desalination as a water supply option, it is important to compare it to the development of other new water supply options.

Technological advances in desalination have in the last 20+ years significantly reduced the cost of desalinated water to levels that are comparable, and in some instances competitive, with other alternatives for acquiring new water supplies. Prop. 50 grant funding cycles in 2005 and again in 2006 are funding a number of research and development programs directly related to desalting in California. Membrane technologies in the form of reverse osmosis (RO) have the most significant improvement. Continuing improvements in system design, membrane technology and energy efficiency and recovery have helped increase efficiency and reduce costs and energy demand. The RO process has been proven to produce high quality drinking water throughout the

world for decades.

Table 9-8		
2013 Cost breakdown for seawater reverse osmosis desalination		
Item	Cost,%	
Annualized capital costs	25%	
Parts/Maintenance	5%	
Chemicals	11%	
Labor	16%	
Membranes	5%	
Electrical energy ($0.05/kWh)	38%	
Total	100%	

[could be presented in pie chart form as a figure as was done in 2009]

Table 9-9		
2013 Cost breakdown for Brackish water reverse osmosis desalination		
Item	Cost,%	
Annualized capital costs	25%	
Parts/Maintenance	5%	
Chemicals	11%	
Labor	16%	
Membranes	5%	
Electrical energy ($0.05/kWh)	38%	
Total	100%	

[mock-up data in table, DWR requests data from all source at this time.]

The estimated capital cost to achieve about X00,000 AFY in increased seawater desalting capacity is about $x.x-$x.x billion. Table 9-X shows the range in total unit water cost that can be expected from plants desalting brackish and sea water. These costs are based on the expected lifetime of the plant (20-30 years).

Table 9-X. Total unit water costs of desalination.	
Type of desalination Plant	Total water cost ($ per acre-foot)
Brackish (groundwater)	$X00-X00
Seawater	$X,000-X,000

[mock-up data in table, DWR requests data from all source at this time.]

Major Issues Facing Desalination (L2)

A following is a list of major factors influencing desalination as a viable resource management strategy:

- Funding (L3)
- Reject Water (Brine) Disposal (L3)
- Planning and Growth (L3)

- Climate Change (L3)
- Seawater Environment (L3)
- Energy Use and Sources (L3)

A brief but specific description of these major factors is provided in the next sections.

Funding (L3)

The financial aid and other funding are critical to the progression of desalination at the national, state, regional, and local levels. The recent successful progression of desalination from a cost prohibited alternative to the alternative of choice is attributed, in part, to funding.

The funding mechanisms available for the progression of desalination in California are grants, loans, and rebates. The California legislature emphasized the importance of water desalination in 2003 with the passages of Assembly Bill 314 which declared that it is the policy of the State that desalination projects developed by or for public water entities be given the same opportunities for State assistance and funding as other water supply and reliability projects.

Grants: (L4)

In November 2002, California voters passed Prop. 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002. Chapter 6(a) of that proposition authorized $50 million in grants for brackish water and ocean water related funding. The grant program aimed to assist local public agencies with the development of new local potable water supplies through the construction of feasible brackish water and ocean water desalination projects and advancement of water desalination technology and its use by means of feasibility studies, research and development, and pilot and demonstration projects. Two cycles of funding under this grant program were conducted during 2005 and 2006, competitively awarding the available desalination grants to 48 projects including 7 construction projects, 14 research and development projects, 15 pilots and demonstrations, and 12 feasibility studies. A third round of funding is underway and slotted for the 2013-2014 fiscal years. Areas of particular interest were identified as: 1)Better feedwater pretreatment processes and strategies. 2) Value and limitations of beach wells for feedwater intake. 3) Technologies to reduce entrainment and impingement impacts. 4) Strategies for brine/concentrate management. 5) Opportunities for energy efficiencies and application of alternative energy sources and combined energy and desalination technologies. 6) Improved membranes with high salt rejection and less susceptible to scaling and fouling. 7) Improved desalination process design, to include but not limited to: membrane processes and thermal processes.

Related to the $50 Million of grant funding specifically mandated in CWC § 79545(a) for desalination, is the $500 million grant funding program for Integrated Regional Water Management (IRWM) efforts throughout the state. The DWR and State Water Resources Control Board (SWRCB) jointly administer the Proposition 50 IRWM Grant Program. The Proposition 50 IRWM Grant Program included two separate grant types, planning and implementation. DWR and the SWRCB awarded funds for both types of grants in two grant funding cycles. In an IRWM region where desalination has been determined to be an active strategy within its water resource management portfolio (to further the goals of the plan),

opportunities for funding for desalination projects may be available through IRWM grants.

Loans (L4)

[General information concerning grant loans for desalination will be provided in this section.]

Rebates (L4)

[General information concerning rebates for desalination projects will be provided followed. As an example, there are rebate programs offered by the Metropolitan Water Districts (MWD) for desalination.]

Other (L4)

[General information concerning "other" as required rebates for desalination projects in this section. This subheading may not be needed. Readers should provide information to DWR if they are aware of funding not fitting into the previous subsections for inclusion here.]

Reject Water (Brine) Disposal (L3)

Desalination plants of any type produce a salt concentrate that must be discharged. The quantity and salinity of that discharge varies with the type of desalting plant and its operation. Brackish water plants in California discharge their concentrate to municipal wastewater treatment systems where they are treated and blended with effluent prior to discharge. For brackish water plants, this type of discharge is likely to continue. Inland desalting plants without a discharge to the ocean may be limited by the type of discharge options available. Seawater desalination produces a concentrate approximately twice as salty as seawater. In addition, residuals of other treatment chemicals may also be in the concentrate. Some plants currently being planned will use existing power plant or wastewater plant outfall systems to take advantage of dilution and mixing prior to discharge. The availability of power plant cooling systems to dilute the concentrate prior to discharge to the ocean will also be affected by the future of coastal power plants as discussed in the prior section. On the other hand, co-locating concentrate discharge with wastewater effluent outfall might have some environmental benefits to the extent that the concentrate from the desalination plant would increase the salinity of the wastewater effluent to levels that are comparable or closer to that of seawater.

Planning and Growth (L3)

The planning necessary to establish water quality and supply objectives for specific community goals concerning population growth and natural resources development must be resolved and supported prior to identifying desalination projects. Doing otherwise may invite litigation at the project specific stage. General and specific plans with robust programmatic environmental documentation which specifically addresses use of sustainable saline waters through desalination is essential in this regard.

The availability of water has been a substantial limitation on development in a number of locations, primarily coastal communities. Since seawater desalination on the coast is now a more affordable option in comparison to the past, the lack of water may no longer be as strong a constraint on coastal development. However, such a concern is not restricted to desalination and would also be associated with any other new water supply option.

Drawing on the work of the California Water Desalination Task Force, and within the framework

of providing assistance to California agencies pursuing desalination, DWR developed a California Desalination Planning Handbook in 2008, in collaboration with the California State University, Sacramento Center for Collaborative Policy (DWR, 2008). This handbook is an important resource for project proponents and communities. It provides a planning framework for developing, where appropriate, economically and environmentally acceptable desalination facilities in California. The planning process outlined in the handbook is intended to identify and address citing, regulatory, technical, environmental and other issues, which should be considered in determining whether and how to proceed with a desalination project.

The major issues facing desalination as a resource management strategy (Desal-RMS) and those facing a specific desalination project need to be discussed in context with state, regional, and local democratic planning decisions meeting the intent and extent of all applicable laws. The labeling or categorizing Desal-RMS or desalination projects as "*growth-inducing*" is likely the single most troublesome issue facing the community and the water resources planner/manager because planning-population issues (reducing, maintaining, or increasing population growth of any kind at the local, regional, or state level) should be dealt with independently of Desal-RMS. This distinction points to the fact that Desal-RMS is a service orientated strategy. And like many other strategies, one which is only viable when serving the greater and much more important planning goals and objectives of the community, whether that the community be local, regional, state, or national. This is not to say that community residents, planners, policy makers, or other stakeholders need not understand or use what is known within Desal-RMS or the specifics concerning likely technologies suitable to develop natural resources within their jurisdiction for they definitely do.

Court decisions related to the development of water sources are shaping the manner and extent to which land use, growth and water projections are interrelated. Court decisions are difficult to apply to specific projects and different decisions may take pro or con position as applied to specific developments. Because many of the court decisions involve the California Environmental Quality Act (CEQA), CEQA regulatory requirement or guideline relating to growth inducement is a crucial issue.

- The CEQA Guidelines (15126.2(d)): Growth-Inducing Impact of the Proposed Project. Discuss the ways in which the proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are projects which would remove obstacles to population growth (a major expansion of a waste water treatment plant might, for example, allow for more construction in service areas). Increases in the population may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects. Also discuss the characteristic of some projects which may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It must not be assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.

Climate Change (L3)

Flooding from increasingly frequent and intense precipitation, runoff events, and storm surges (Delta) will stress aging fresh water collection, storage, and conveyance infrastructure currently

relied upon making desalination more applicable to more communities (adapted REF#35).

Coastal community development by non-desalination freshwater source management including shoreline armoring, channelization of streams, and groundwater mining prevents wetland replenishment and leads to loss of wetlands under sea level rising scenarios (Draft-Ref#35).

Sea level rise may increase saltwater intrusion to coastal freshwater aquifers, resulting in water resources unusable without desalination. Increased evaporation or reduced recharge into coastal aquifers exacerbates saltwater intrusion (Draft-Ref#35).

Sea level rise will lead to direct and indirect losses for the region's energy infrastructure (e.g., power plants and oil refineries located along the coast, facilities that receive oil and gas deliveries), including equipment damage from flooding or erosion. Damaged energy facilities also may be a source of pollution (Draft-Ref#35).

Sea level rise, increased water temperatures, salinity distribution and circulation, changes in precipitation and fresh water runoff, and acidification will change aquatic ecosystem species composition and distribution. This will also result in potential for new or increased prevalence of invasive species (Draft-Ref#35).

Whether an overall increase or decrease in precipitation, runoff, or capture occurs due to climate change predictions, initial estimates of watershed models are that increases in temperature and consequent increases in evapotranspiration cause a _____; concern is warranted for securing safe and adequate drinking water supplies under climate change scenarios throughout the state (Draft-Ref#35).

Desalination Effects/Impacts (L4)

Green-house-gas (GHG) emissions and related effects and impacts associated with desalination.

The carbon footprint of a desalination plant is mainly a translation of its energy consumption. The associated GHG emissions will be measured by the indirect CO2 emissions from the electricity used by the plant. In instances where desalinated water is displacing other water supplies currently in use with their own GHG emissions (e.g., imported water), the net carbon footprint of desalination should be counted as the incremental GHG emissions beyond the current emissions baseline.

The average energy consumption of currently operational RO desalination facilities is estimated at about X,XXX kilowatt hours per acre-foot (kWh/AF) for brackish water and about X,XXX kWh/AF for seawater desalination. Using a conservative estimate of GHG emissions of 400 grams of carbon dioxide equivalents (CO2 eq) per kWh (assuming electricity is generated from natural gas, this number climbs up to 900 grams of CO2 eq /kWh for electricity generated from coal), the GHG emissions associated with an RO desalination plant operations are estimated to be XXX kilograms of CO2 eq /AF of desalinated brackish water and X,XXX kilograms of CO2 eq /AF of desalinated seawater. *[to be updated]*

Adaptation (L4)

Climate change projections include warmer air temperatures, diminishing snowpack, precipitation uncertainty, increased evaporation, prolonged droughts, and sea level rise. These anticipated changes could negatively affect water supply in many regions including those that are already experiencing difficulty meeting current water demands. A portion of the water supply in these challenged regions is currently being supplied by the desalting process. Within the framework of climate change scenarios, desalination may be a preferred regional and local strategy to meet current and future water demand. In addition, the "no imported water" and the strong urge to increase rreliability may compel water resources planners and managers to seriously consider desalination as a viable water resource management strategy in areas once thought to be immune to water supply shortages.

[under further development, call for additional information from experts]

Mitigation (L4)

[under further development, call for additional information from experts]

Identify potential opportunities for climate change mitigation by the California Water Desalination Task Force with economically and environmentally acceptable desalination as part of a balanced water portfolio to help meet California's existing and future water supply and environmental needs.

Seawater Environment (L3)

[This section is under development, DWR seeks additional technical information and perspectives for impacts of desalination in seawater environments including open sea, near coast, enclosed bays, and estuaries. There is likely new and relevant information DWR needs to update this section. DWR urges readers to contribute and specify what they believe the level four (L4) sub-headings should be in this section to present the perspectives/issues.]

A primary concern associated with coastal desalination plants is the impact of feed water intake on aquatic life. Surface intakes of seawater result in impingement and entrainment of marine organisms. This impact can be avoided by adopting subterranean intakes (e.g., beach wells and under ocean bed intakes) wherever feasible.

Once-through cooling (OTC) power plants (L4)

The issues surrounding entrainment and impingement of marine aquatic life OTC power plants and effects they may have co-located desalination facilities have been

It worth noting here that the On May 4, 2010 the State Water Board adopted a Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (Policy). This policy establishes technology-based standards to implement federal Clean Water Act section 316(b) and reduce the harmful effects associated with cooling water intake structures on marine and estuarine life. The Policy applies to the 19 existing power plants (including two nuclear plants) that currently have the ability to withdraw over 15 billion gallons per day from the State's coastal and estuarine waters using a single-pass system, also known as once-through cooling (OTC). Dependence upon or design with OTC is not consistent for best available technology for existing or future desalination projects.

A stand-alone desalination facility will be required to apply for an NPDES permit to discharge waste brine [2009 MIFD].

Energy Use and Sources (L3)

Energy is a major issue facing Desal-RMS and most all desalination projects concerns energy consumption or intensity-of-use. Most water treatment technologies, desalination included, rely on energy produced from other natural resources which we are either mining (coal, gas, and oil) or which may be considered renewable (solar, wave, geothermal, and hydraulic). As a society in general, we go to great lengths to define what is beneficial or reasonable versus what is unreasonable or nonbeneficial uses of water staring with the our highest form of state law, the California constitution. The labeling or categorization of desalination techniques, projects, or the Desal-RMS as "*energy intensive*", "*bad*", or "*of the last resort*" is an issue to be resolved, again, prior to identifying alternatives for our planned or unplanned water supply or quality objectives. And should be examined and placed to realistic context with regard to not water treatment technology but how we consume energy as a resource much like we measure or qualify our reasonable or unreasonable use of water.

Generally, the variance in energy requirements of RO desalination is a direct function of the salinity of the feedwater source (total dissolved solids (TDS)). As a result, given similar operating conditions and plant parameters, brackish water desalination is usually less energy intensive, and hence less costly, than seawater desalination. Strategies for energy use efficiency which include:

- Improved operation efficiency with energy efficiency technology and standards,
- Reduce power consumption, and improve and upgrade facilities,
- Develop the policy and regulation on when and where to use desalination by comparing energy intensity with other water supply options, and
- Update energy plan with efficiency standards and promote green, renewable and clean energy programs coupled with water supply infrastructure.

These strategies also help mitigate the negative impacts of climate change related to GHG.

Given the energy intensity of advanced water treatment processes used to separate salts from water, energy consumption represents a major portion of the direct operation and maintenance expenses of a desalination plant. Energy efficiency will therefore be a key factor in assessing the viability of using desalination as a water supply option in California. Furthermore, efforts to reduce desalination energy use will contribute toward the reduction of greenhouse gas (GHG) emissions from the many proposed desalination projects in California.

Measures to help reduce the carbon footprint of desalination plants include efficiencies through energy recovery devices, high efficiency pumps, variable frequency drives, low-energy with improved salt rejection membranes, the use of renewable energy sources, and carbon offset plans. A recent demonstration led by the non-profit Affordable Desalination Collaboration (a consortium of industry-leading companies, municipal and government agencies) showed that by using state-of-the-art energy recovery technology and high efficiency pumps and membranes, the energy required for seawater desalination can be substantially reduced to the range of X,XXX—

X,XXX kWh/AF.

Desalination's primary operation cost is for power. A new XX mgd seawater plant (approximately 50,000 AFY, assuming operating 90% of the time) would require about XX megawatts (MW) of power based on best available technology in 2012. Forecasted seawater desalination of about XXX,XXX AFY would require about XXX MW of power. The reduction in unit energy use has been among the most dramatic improvements in recent years due to improvement in energy recovery systems. Additional improvements in energy use are (are not) expected. *[update needed]*

Desalination has historically been prohibitively expensive. Improvements in technology and the rising cost of conventional water supplies have made desalination competitive with imported water and recycled municipal wastewater in a number of cases. As a result of the improved economics of desalination, other issues have increased in relative importance to cost, namely, environmental impacts and associated permitting (particularly for coastal plants).

Even though desalination is energy intensive, other conventional water supply options might in some instances be as energy intensive. At a given point-of-use, energy intensity of a water supply is the total amount of energy required for its extraction, treatment and conveyance. Energy required for pumping and transporting water over long distances may be higher than that needed to desalinate local saline waters. Delivering State Water Project (SWP) water to Southern California requires a significant amount of energy to convey and to pump over the Tehachapi Mountains. Due to continuing reductions in energy use, the energy needed at the end of the SWP pipe reaches levels that in some instances become, comparable to the amount of energy needed to desalinate seawater.

The increasing requirements to use the best available technology (BAT) to mitigate environmental impacts for newly proposed water works projects like the Poseidon Desalination Facility leads use to continually specify different sets of weights for the justification scale used to balance the benefits and disadvantages of major water works. It is hard to believe that such projects as the Hetch Hetchy and the State Water Project would be built today with the current justification scale. A new framework for sustainable water which allows allocating or coupling renewable power generation to desalinate water throughout the state may prove to may make more sense. It may be easier to rationalize dedicating renewable energy sources and prioritizing electric power demand to water and other basic needs first. The transmission of electrical power over large distances is likely more sustainable than moving water. Dedicating the power generated by the Hetch Hetchy to desalination facilities in Southern California may be more sustainable than other options.

The next-generation of renewable electrical power generation technologies coupled with desalination could provide a sustainable path to meet our water supply and energy objectives.

Existing research leading to future advancements in energy related to seawater desalination:

<u>Microbial Desalination Fuel Cell as a Sustainable Technology for Renewable Water and Power</u>, EPA Grant Number: SU836030. Objective: The proposal objective is to design a microbial

desalination fuel cell (MDFC) as a pretreatment to the current seawater desalination plant that will provide sustainable freshwater supply for human consumption at minimal energy cost. This will be achieved through the MDFC's innovative abilities to desalinate seawater and generate energy to sustain the long-term prosperity of people and environment. http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractdetail/abstract/9582

Desalination and Demineralization with Solar Evaporation Array (SEA), EPA Grant Number: SU833945. Objective: We plan to extend our research on the Solar Evaporation Array (SEA) panel, which is a self-contained desalination and water-purification apparatus powered by the sun. Our objective is to bring ready, inexpensive access to pure water. Existing water purification methods either cannot remove dissolved minerals and salts, or else are too expensive to be used for small applications. We aim to develop SEA panels as a way of making potable, irrigable water for a much lower cost per liter than existing methods. We also aim to reduce and possibly eliminate brine pollution from the desalination process. http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractdetail/abstract/8845/report/0

Recommendations to Facilitate Desalination in California (L2)

Desalination of brackish and sea water is a proven technique to augment water supplies. Treatment of brackish groundwater for beneficial use is a common practice in California. Small scale sea water desalination facilities have been built but have yet to become an established practice to meet municipal water demands except in a few drought situations. Nevertheless, sea water is a vital water source in some parts of the world, and water supply planners in California are continuing to include sea water desalination in the future portfolio of water sources.

Desalination, particularly of sea water, has been a challenge to plan for and implement. If desalination is to be an appropriate and successfully implemented component of California's water supply, certain constraints need to be agreed upon and certain actions need to take place in the planning, regulatory, and scientific arenas. The following recommendations are offered.

1. Desalination should be evaluated as a potential option wherever brackish groundwater or surface water or sea water is present as a potential water source.
2. Desalination should be evaluated within the context of integrated water management reflecting community and regional needs and priorities with respect to water quality protection, water supply, growth management, and economic development. Water management planning has to occur within a wider context of community values and visions for the future. Key stakeholders, the general public, and permitting agencies need to be engaged in the planning process.
3. Desalination needs to be evaluated using the same well-established planning criteria applied to all water management options, using feasibility criteria such as: water supply need within the context of community and regional planning, technical feasibility, economic feasibility, financial feasibility, environmental feasibility, institutional feasibility, social impacts, and climate change. The California Desalination Planning Handbook published by DWR should be one of the resources used by water supply planners.

4. Desalination should be implemented only with adequate environmental safeguards. A strong regulatory framework should be supported with the resources to establish technically sound criteria.
5. Because of the many regulatory agencies involved in desalination of ocean, bay or estuarine waters, a coordinated framework to streamline permitting approvals without weakening environmental and other protections should be explored. Establishing an appropriate sequencing of approval by the various agencies may be appropriate. The Ocean Protection Council may be appropriate for the role of coordinating regulatory reviews and guiding project sponsors through the regulatory process.
6. Climate change impacts, primarily due to greenhouse gas generation from energy consumption, should be evaluated for proposed desalination projects within the context of alternative water supplies available. Desalination should not be precluded solely on the basis of energy consumption, because the allocation of energy to meet water supply needs and reliability may be considered of higher social value to a community than other uses of energy.
7. To mitigate the energy needs for a desalination project, consideration should be given to coupling the energy from sustainable sources to desalination projects.
8. Desalination projects developed by public agencies or utilities regulated by the California Public Utilities Commission should have the same opportunities for State assistance and funding as other water supply and reliability projects.
9. Research and investigations should continue to develop emerging technologies to advance and refine desalination processes, feedwater intake and concentrate management technologies, energy efficiencies, and the use of alternative and renewable energy sources.
10. DWR should maintain technical expertise and current data on the status of brackish and seawater desalination in California to support the planning and policy roles of state government and to be an information resource to the public.

Desalination in the Water Plan (L2)

There are several key connections to be made for Desal-RMS throughout the Water Plan Update 2013 including but not limited to:

- the resources management strategies,
- regional reports, and
- sustainability indicators.

These connections are given below followed by a general discussion.

Desalination in the RMS (L3)

The following resource management strategies included in this volume have been identified and closely linked to the Desal-RMS and should be investigated accordingly to understand their relationship to meeting regional and local water supply objectives:

- Precipitation Enhancement, Chapter 10
- Recycled Municipal Water, Chapter 11.
- Salinity plays a basic role throughout the State in the complex relationship between water quality objectives, water for the environment, and water supply—See Chapter 18. Salt and Salinity Management.

[this section to be expanded to include the RMS connectedness as needed]

Desalination in regional reports (L3)

[Statements providing correlations to various regional plans such as those developed or planned under the Proposition 84 Integrated Regional Water Management Program.]

Desalination in the sustainability indicators (L3)

[Statements providing correlations to identified relative sustainability factors pertaining to desalination will be presented in this section.]

General discussion of RMSs, Regional Reports and Sustainability Indicators. (L3)

[A general discussion and conclusions of the information provided in the preceding subsections is proposed to be provided here.]

References (L2)

[A list of references is being prepared in conjunction with the writing of the chapter and will be made available during the first draft of the chapter.]

References Cited

[For now, the references provided for Update 2009 have been placed under the "References Cited" subhead. If they are no longer cited in the text after the text has been updated for 2013, they will placedunder the "Additional References" subheading instead or delete them altogether. Additional guidance on references and citations is contained within California Water Plan Update 2013: Publications Process and Style Guide, available from volume leads.]

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