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ATTACHMENT

WORKSHOP REPORT
ON WATER ENERGY NEXUS

WORKSHOP REPORT ON WATER ENERGY NEXUS

Water-Energy Cost Effectiveness Analysis

Public Workshop Presentation of Future Water Supply Selection

Report Prepared by Energy Division

June 16, 2014

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Background

CPUC decision 12-05-01 stated it is "*not prudent to spend significant amounts of [energy] ratepayer funds on expanded water-energy nexus programs until the cost-effectiveness of these programs, and particularly the net benefits that accrue to energy utility ratepayers, are better understood.*"

The goal of our research effort is to develop a method of valuing the monetary benefits of water savings via CPUC cost effectiveness tests.

Our core objective is to recommend modifications to existing Cost Effectiveness (CE) frameworks to include consideration of water.

Navigant/ GEI Presentation

Defining Marginal Water Supply

We are applying the industry standard practice of energy avoided cost development to water avoided cost development.

The CPUC assumes that water efficiency reduces reliance of water supply "on the margin"

"Marginal Water Supply" refers to the future water supply we would otherwise need to develop in the absence of water conservation.

The team researched the short term (< 10 years) and long term (> 10 years) marginal water supply.

The marginal supply directly informs two major aspects of the cost effectiveness test.

- Marginal Energy Intensity
- Avoided Water Capacity Cost

Our analysis is conducted at the California Department of Water Resources Hydrologic Region level.

The types of water supplies available to each region differ.

Many water supply planning activities and data are available at this level (see Attachment C for supporting documentation); water supply options are relatively consistent within a hydrologic region.

How we determined Marginal Supplies:

We gathered information from readily available public information sources such as DWR reports, IRWMPs and UWMPs;

Identified the supply options available in each of the hydrologic regions for the short term (0-10 year) and long term (11-20+ year) time frames;

Evaluated the economic and physical characteristics of each supply as well as legal and institutional issues;

Using the supply characteristics, we determined *draft* short and long term marginal supplies for each region;

Vetted marginal supply selections with the CPUC, PCG, and other experts such as DWR staff and regional water planners.

The table on the following page summarizes the marginal supplies in each region. The **bold** item is the marginal supply.

Supplies by Hydrologic Regions Supply Development Options		
Region	Short Term (0-10 years)	Long Term (10+ Years)
North Coast	Surface Water Groundwater **Recycled/Reused Water**	Surface Water Groundwater **Recycled/Reused Water**
Sacramento River	Surface Water Groundwater Imports (SWP/CVP) **Recycled/Reused Water**	Surface Water Groundwater Imports (SWP/CVP) **Recycled/Reused Water**
North Lahontan	Surface Water Groundwater **Recycled/Reused Water**	Surface Water Groundwater **Recycled/Reused Water**
San Francisco Bay	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water **Brackish Surface + GW**	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water **Brackish Surface + GW**
San Joaquin River	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water **Brackish Groundwater**	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water **Brackish Groundwater**
Tulare Lake	Surface Water Groundwater Imports (SWP/CVP) Brackish Groundwater **Recycled/Reused water**	Surface Water Groundwater Imports (SWP/CVP) Brackish Groundwater **Recycled/Reused water**
South Lahontan	Surface Water Groundwater Imports (SWP) **Recycled/Reused water**	Surface Water Groundwater Imports (SWP) **Recycled/Reused water**
Central Coast	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**
South Coast	Surface Water Groundwater Imports (SWP/CVP/CR) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**	Surface Water Groundwater Imports (SWP/CVP/CR) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**
Colorado River	Surface Water Groundwater Imports (SWP/CR) Recycled/Reused Water **Brackish Groundwater**	Surface Water Groundwater Imports (SWP/CR) Recycled/Reused Water **Brackish Groundwater**

Embedded Energy Avoided Cost Tool

The purpose of the tool is to calculate the avoided cost of the embedded energy in water saved by conservation measures.

This is accomplished by multiplying the marginal embedded energy savings by the avoided cost of energy as shown below.

Avoided Embedded Energy Cost ($) = Marginal Embedded Energy Savings (kWh) X Avoided Cost of Energy ($/kWh)

Attachment A

Workshop Agenda

Agenda for 4/25/14 Water Energy Nexus Workshop (1:00 p.m. – 4:00 p.m.)

CPUC Auditorium @ 505 Van Ness Avenue, San Francisco, CA

Time	**Topic**	**Outcome**
1:00 – 1:10 pm	Welcome by Commission Staff • Logistics/Safety • Introductions • Project and Workshop Overview	Attendees understand scope and context of today's presentation.
1:10 – 2:55 pm	Presentation by Navigant • Project Overview (5 minutes) • Defining Marginal Water Supply (10 minutes) • Marginal Supply Selection (60 minutes) • Embedded Energy Avoided Cost Tool Methodology (20 minutes)	Attendees understand the marginal water selection process and preview the embedded energy avoided cost methodology.
2:55 – 3:05 pm	Break	
3:05 – 3:45 pm	Questions, Discussion, & Feedback	Attendees validate methods and findings or identify issues.
3:45 – 4:00 pm	Next Steps	Attendees understand the Water Energy next steps.

Conference Phone Line: 866-687-1443 Participant Code: 1049466

Webex: Meeting Number: 740 431 702 Meeting Password: nexus

To join the online meeting
Go to https://van.webex.com/van/j.php?MTID=mcef9b602a4eb3d2aa7dfd4925c2e5434

Staff Contact: Patrick Hoglund
Email: Patrick.hoglund@cpuc.ca.gov
Telephone: 415-703-2479

Attachment B

Navigant/GEI Presentation

NAVIGANT

ENERGY

Water-Energy Cost Effectiveness Analysis

Public Workshop Presentation of Future Water Supply Selection

April 25, 2014

DISPUTES & INVESTIGATIONS • ECONOMICS • FINANCIAL ADVISORY • MANAGEMENT CONSULTING

Content of Report

This presentation was prepared by Navigant Consulting, Inc. exclusively for the benefit and use of the California Public Utilities Commission and/or its affiliates or subsidiaries. The work presented in this report represents our best efforts and judgments based on the information available at the time this report was prepared. Navigant Consulting, Inc. is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report.

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April 25, 2014

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The goal of our research effort is to develop a method of valuing the monetary benefits of water savings via CPUC cost effectiveness tests.

- CPUC decision 12-05-01 stated it is *"not prudent to spend significant amounts of [energy] ratepayer funds on expanded water-energy nexus programs until the cost-effectiveness of these programs, and particularly the net benefits that accrue to energy utility ratepayers, are better understood."*
- Past water-energy studies have focused on a "snapshot" of water infrastructure and its energy requirements at that point in time.
- This analysis looks to the future: what future costs associated with water and energy infrastructure can be avoided as a result of water conservation?

California IOUs can already rebate high efficiency clothes washers …

… does it benefit energy ratepayers for IOUs to rebate high efficiency toilets?

Our core objective is to recommend modifications to existing Cost Effectiveness (CE) frameworks to include consideration of water.

- Existing cost effectiveness frameworks value "Site Energy" savings using the avoided cost (AC) of energy.
- Avoided cost of energy is based on the characteristics of California's marginal energy supply.

$$Benefit\ Cost\ Ratio = \frac{Site\ Energy\ AC}{Equipment\ Cost + Program\ Cost}$$

Where:

$$Site\ Energy\ AC = Site\ Energy\ Savings\ x\ Avoided\ Cost\ of\ Energy$$

- Modifications to the benefits portion of the equation are needed to account for water savings.

$$Benefit\ Cost\ Ratio = \frac{Site\ Energy\ AC + Embedded\ Energy\ AC + Water\ Capacity\ AC + Environmental\ Benefits}{Equipment\ Cost + Program\ Cost}$$

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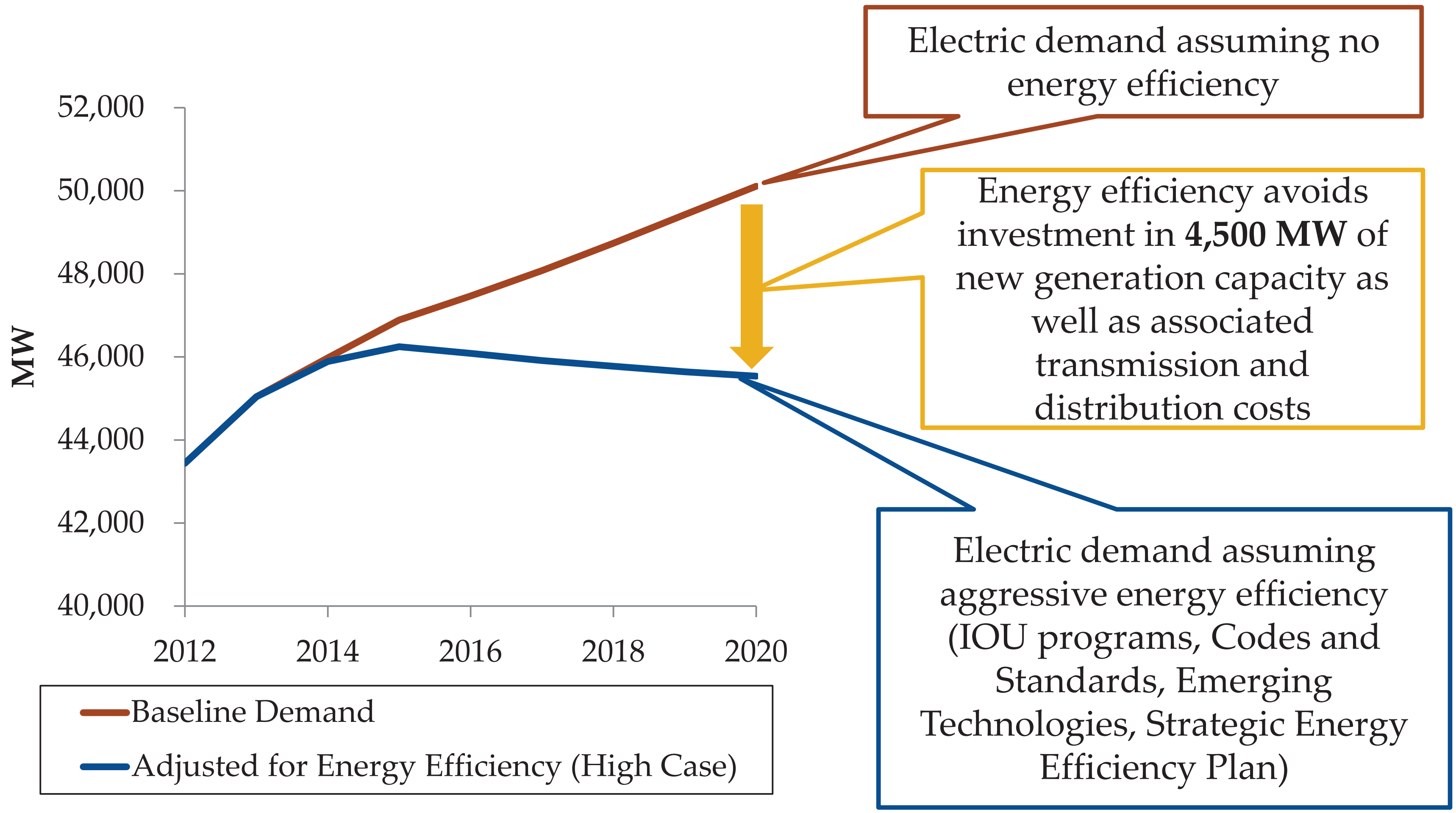
First, we look to California's electric sector to understand how energy efficiency is valued (we present a simplified interpretation).



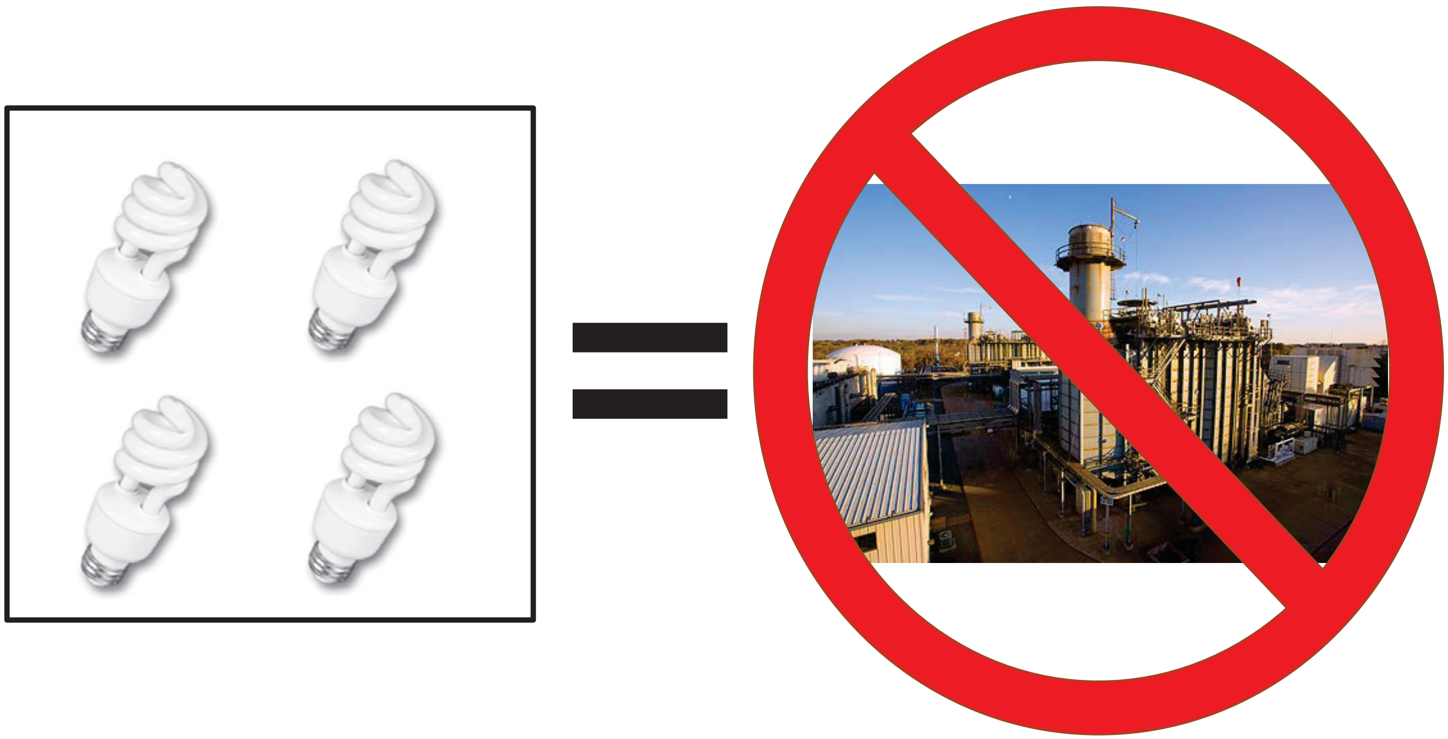
CEC. *California Energy Demand 2014–2024 Final Forecast*. January 2014

The avoided cost of energy places an economic value on each unit of energy saved (avoided investment in generation, transmission, etc.)

- Standard practice assumes energy efficiency reduces reliance of energy supply "on the margin" (i.e. the Marginal Electric Supply)
- California has diverse electric generation options: natural gas, hydro, nuclear, solar, geothermal, coal, etc.
- Need an assumption: which of these supply types is actually avoided as a result of energy efficiency (i.e. what is the Marginal Electric Supply)?

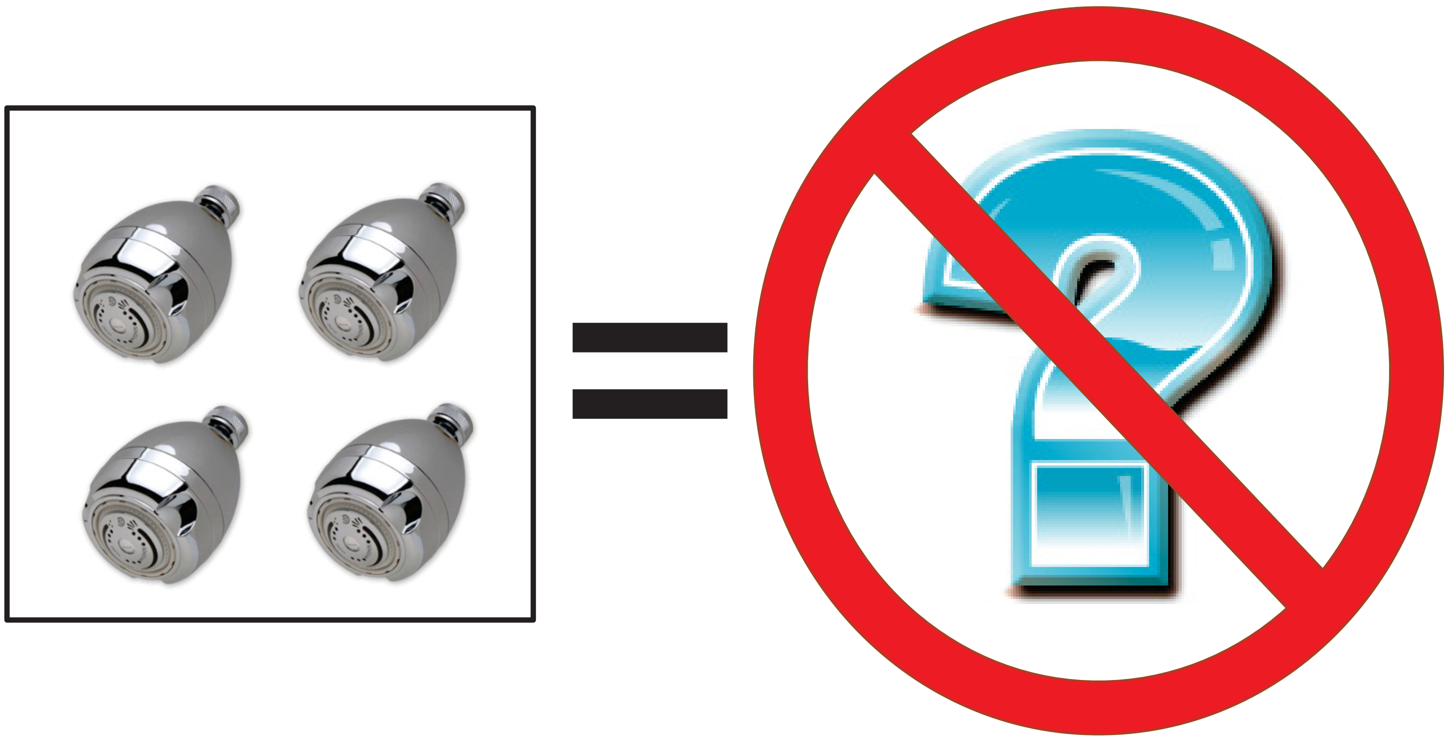
For example, the CPUC has determined a natural gas combined cycle power plant is the Marginal Electric Supply

Energy efficiency avoids development of the marginal supply.



Knowing the marginal supply allows us to value the economic benefit of energy efficiency (how much the marginal supply would have cost to build/expand and operate in the absence of energy efficiency).

We will follow a similar approach for water.



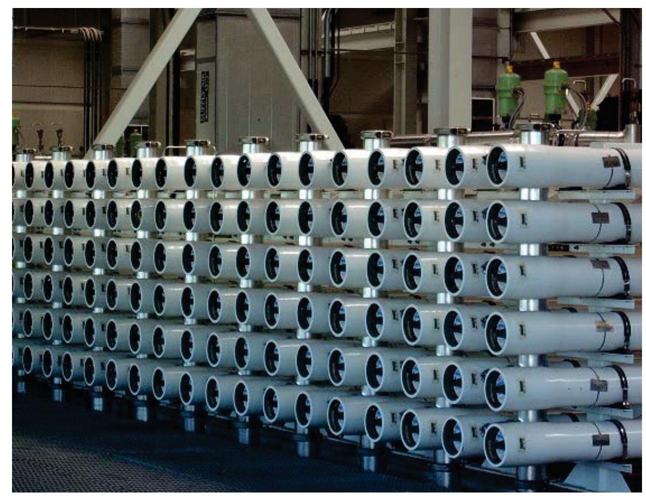
Like energy supplies, California has numerous water supply types (surface water, groundwater, imported water, recycled water, ocean desalination, brackish desalination, etc.)

We need to determine which supply type is the Marginal Water Supply.

We are applying the industry standard practice of energy avoided cost development to water avoided cost development.

- The CPUC assumes that water efficiency reduces reliance of water supply "on the margin"
- "Marginal Water Supply" refers to the future water supply we would otherwise need to develop in the absence of water conservation.
- When we conserve water, the state can avoid:
  - Development of the marginal water supply
  - Expansion of potable treatment plants
  - (Possibly) investment in distribution systems
  - Expansion of wastewater systems

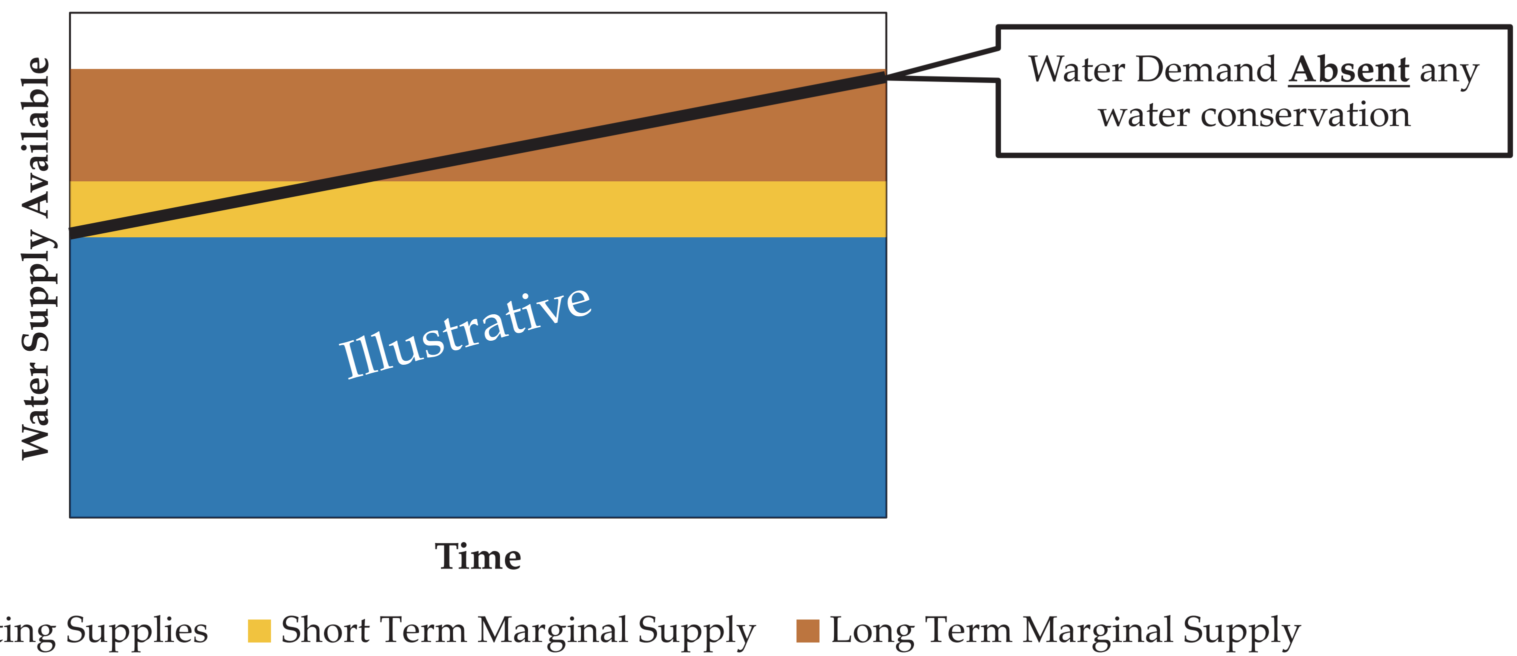
Determining the marginal supply is the most important aspect of our analysis.



The team researched the short term (< 10 years) and long term (> 10 years) marginal water supply.

- Like energy supplies, it takes time to develop additional water supplies
- The long term marginal supplies may be more uncertain; but determining these supplies is necessary because efficiency measures are expected to last >10yrs.

Illustrative Relationships of Demand and Supply Options



The marginal supply directly informs two major aspects of the cost effectiveness test.

$$\text{Benefit Cost Ratio} = \frac{\text{Site Energy AC} + \text{Embedded Energy AC} + \text{Water Capacity AC} + \text{Environmental Benefits}}{\text{Costs}}$$

Represents the avoided energy consumption that the marginal supply would have used.

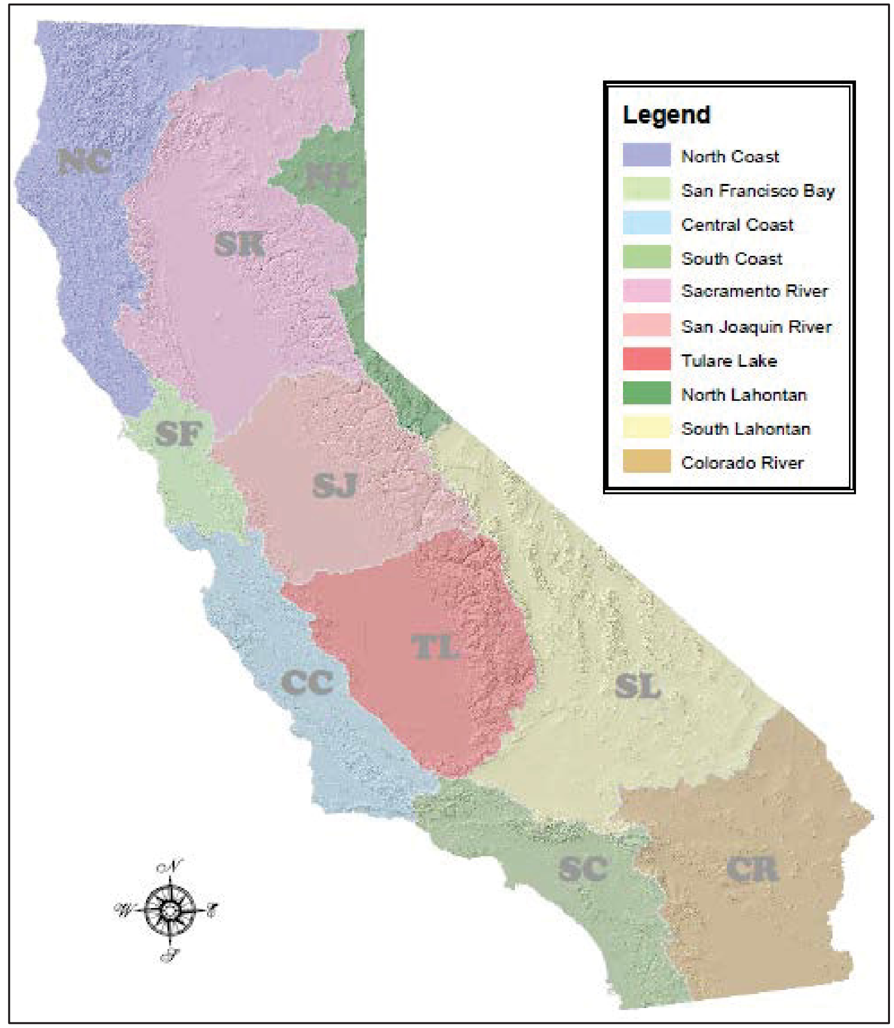
Embedded Energy AC = Water Savings x **Marginal Energy Intensity** x Avoided Cost of Energy

Represents the avoided investment cost that would have been required to develop and operate the marginal supply.

Water Capacity AC = Water Savings x **Avoided Water Capacity Cost (Capital + O&M)**

The team is conducting analysis at the California Department of Water Resources Hydrologic Region level.

- » Types of supplies available to each region differ
- » Many water supply planning activities and data are available at this level; water supply options are relatively consistent within a hydrologic region.
- » The Navigant team leveraged the multitude of existing studies and reports that already document water supplies and their energy intensities at the hydrologic region.



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California's Future: Water

"CALIFORNIA FACES GROWING WATER MANAGEMENT CHALLENGES…

California has made progress on water management. But population growth and climate change are likely to intensify the challenges, and solutions will require difficult and sometimes costly tradeoffs."

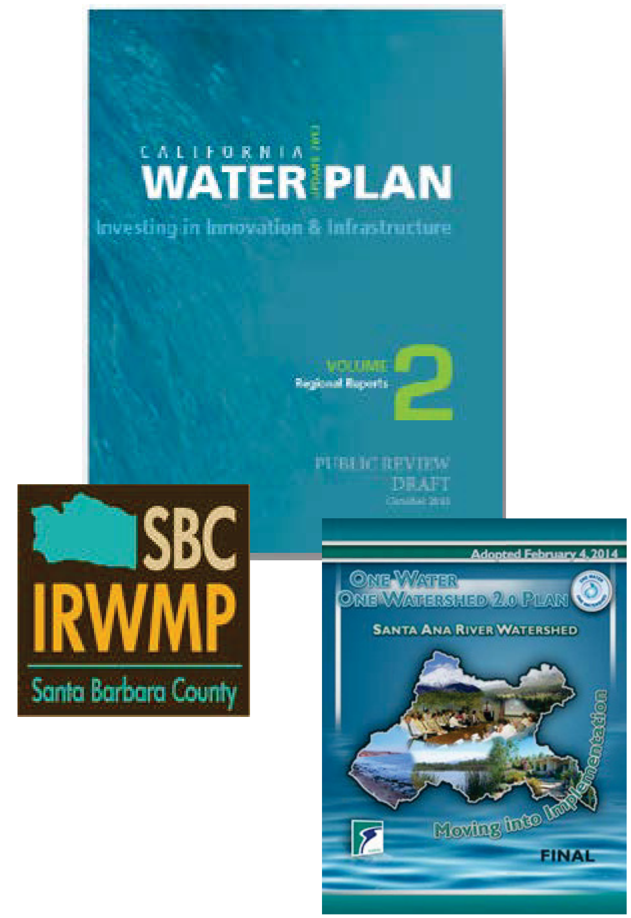
By: Ellen Hanak,
PPIC, January 2014

Determining Future Supplies

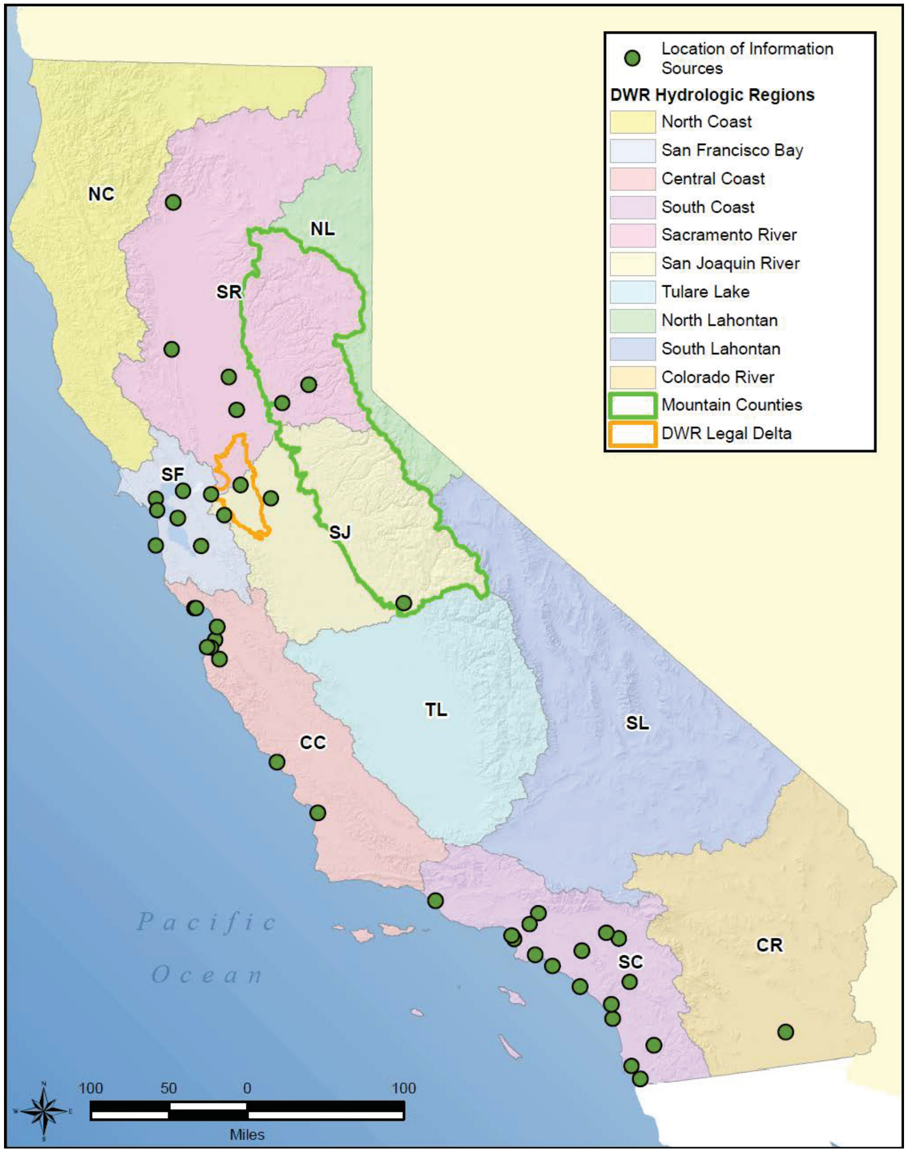
1. Gather information from readily available public information such as DWR reports, IRWMPs and UWMPs
2. Identify the supply options available in each hydrologic region for the 0-10 year and 11-20+ year time frames
3. Evaluate the economic and physical characteristics of each supply as well as legal and institutional issues
4. Using supply characteristics, determine draft short and long term marginal supply for each region
5. Vet marginal supply selections with the CPUC, PCG, and other experts such as DWR staff, regional water planners, and large wholesale and retail water agencies.

Sources of Information

- DWR California Water Plan Update 2013 (Public Review Draft, December 2013)
  - Bulletin 160-13: Volume 2 - Regional Reports. Draft 2013
  - IRWMPs, CIPs and other water management plans
- Discussions/interviews with Water Managers and Analyst
  - DWR Staff
  - Local Water Agency Representatives
  - Non-governmental Organizations
  - Academics



Sources of Information: Regional Distribution



- The team collected information from across the state
- Efforts were made to collect data from a variety of hydrologic regions

Recognized Differences

» Water Supply – the actual source of the water
  - Surface: fresh, impaired/contaminated, recycled, saline, ocean/sea
  - Ground: fresh, impaired, saline
  - Others?

» Resource Management Strategies: "A project, program, or policy that helps federal, State or local agencies manage water and related resources." - DWR
  - Reducing end-use water demand
  - Conjunctive management of surface and groundwater
  - Capture and storage
  - Improving water quality
  - Transfers

Total Water Demand

2005-2010 Annual Average Groundwater + Surface Water + Reused Water

2005-2010 Average	Agriculture	Urban
Hydrologic Regions	**TAF**	**TAF**
North Coast	736	152
San Francisco	103	1,146
Central Coast	996	298
South Coast	716	3,959
Sacramento River	7,612	906
San Joaquin	7,125	716
Tulare Lake	10,929	740
North Lahontan	447	44
South Lahontan	376	292
Colorado River	3,664	578
Statewide	**32,703**	**8,830**

Source: Department of Water Resources, April 2014

California's Groundwater Use

2005 – 2010 Average Annual

Hydrologic Regions	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Total Water Use[4] Met by Groundwater	
HR Name	TAF[1]	%[2]	TAF[1]	%[2]	TAF[1]	%[2]
North Coast	301.3	41%	60.0	40%	363.8	32%
San Francisco	76.1	74%	183.5	16%	259.5	21%
Central Coast	906.2	91%	211.3	71%	1,117.4	86%
South Coast	385.4	54%	1,219.6	31%	1,605.0	34%
Sacramento River	2,294.2	30%	428.6	47%	2,742.9	30%
San Joaquin	2,591.3	36%	414.1	58%	3,196.1	38%
Tulare Lake	5,662.5	52%	604.1	82%	6,295.5	54%
North Lahontan	118.4	27%	37.1	84%	166.2	32%
South Lahontan	270.6	72%	170.3	58%	440.9	66%
Colorado River	50.1	1%	329.7	57%	379.7	9%
2005-10 Ave. Total:	12,656.0	39%	3,658.1	41%	16,567	39%

Notes: 1) TAF = thousand acre-feet
2) Percent use is the percent of the total water supply that is met by groundwater, by type of use.
3) Statewide Precipitation for 2005-10 period equals 96% of the 30-yr average.
4) Total Water Use = Groundwater + Surface Water + Reuse

Supplies by Hydrologic Regions

	Supply Development Options	
Region	Short Term (0-10 years)	Long Term (10+ Years)
North Coast	Surface Water Groundwater **Recycled/Reused Water**	Surface Water Groundwater **Recycled/Reused Water**
Sacramento River	Surface Water Groundwater Imports (SWP/CVP) **Recycled/Reused Water**	Surface Water Groundwater Imports (SWP/CVP) **Recycled/Reused Water**
North Lahontan	Surface Water Groundwater **Recycled/Reused Water**	Surface Water Groundwater **Recycled/Reused Water**

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Supplies by Hydrologic Regions

	Supply Development Options	
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San Francisco Bay	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water **Brackish Surface + GW**	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water **Brackish Surface + GW**
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Supplies by Hydrologic Regions

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Tulare Lake	Surface Water Groundwater Imports (SWP/CVP) Brackish Groundwater **Recycled/Reused water**	Surface Water Groundwater Imports (SWP/CVP) Brackish Groundwater **Recycled/Reused water**
South Lahontan	Surface Water Groundwater Imports (SWP) **Recycled/Reused water**	Surface Water Groundwater Imports (SWP) **Recycled/Reused water**

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Supplies by Hydrologic Regions

	Supply Development Options	
Region	Short Term (0-10 years)	Long Term (10+ Years)
Central Coast	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**
South Coast	Surface Water Groundwater Imports (SWP/CVP/CR) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**	Surface Water Groundwater Imports (SWP/CVP/CR) Recycled/Reused Water Brackish Groundwater **Ocean/Sea Water**

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Colorado River	Surface Water Groundwater Imports (SWP/CR) Recycled/Reused Water **Brackish Groundwater**	Surface Water Groundwater Imports (SWP/CR) Recycled/Reused Water **Brackish Groundwater**

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Initial Input from Water Managers to date…

- *Overall lists appear reasonable and fairly accurate.*
- *Some have questioned why the short and long term appear to be the same list.*
  - For example, in the San Diego region surface, imports and groundwater may not be future supply options; only ocean desalination, and treated Contaminated and brackish groundwater.
- *Why choose only one marginal supply (gets to the portfolio approach agencies – many things at once).*
  - Not a matter of can they avoid developing – it is a matter of what's available.
- *Stormwater going to a salt sink or out to the ocean currently should be included as a new supply since it is neither part of surface nor groundwater.*

Initial Input from Water Managers to date…(continued)

- *Define the appropriate simplifying assumptions that can be put in the model.*
- *The order of supplies may need to be changed for some regions currently using imported resources.*
  - Areas such as SC, TL, SJ, and SL tend to use imported CVP, SWP and CRA before groundwater.
- *Permits and regulatory mandates are restricting future use of surface and or groundwater resources, pushing regions to more expensive options such as ocean desalination and treatment of brackish/contaminated groundwater.*
- *Some regions are planning no significant changes to water supplies in the defined time horizon.*
- *Future imported supplies may not be available to certain region in the 11-20 year time frame (CC and CR).*

"Anyone who can solve the problems of water will be worthy of two Nobel Prizes – one for peace and one for science."

–John F. Kennedy

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The purpose of the tool is to calculate the avoided cost of the embedded energy in water saved by conservation measures.

» **The user will select an IOU, then input the following for each measure:**
- Measure Name
- Annual Water Savings (gallons)
- Measure Life (years)
- Installation Year
- Hydrologic Region
- Water Quality
- Water Use
- Incremental Equipment Cost ($)
- Installation Cost ($)
- Program Administration Cost ($)
- Rebate ($)

The Tool will:

1. Use the appropriate values for marginal supply energy intensity to determine a **system-wide energy intensity** value.
2. Combine that with the provided data on water savings to calculate **embedded energy savings**.
3. Multiply the amount of energy saved by the avoided cost of energy to calculate the **total avoided cost of that embedded energy**.

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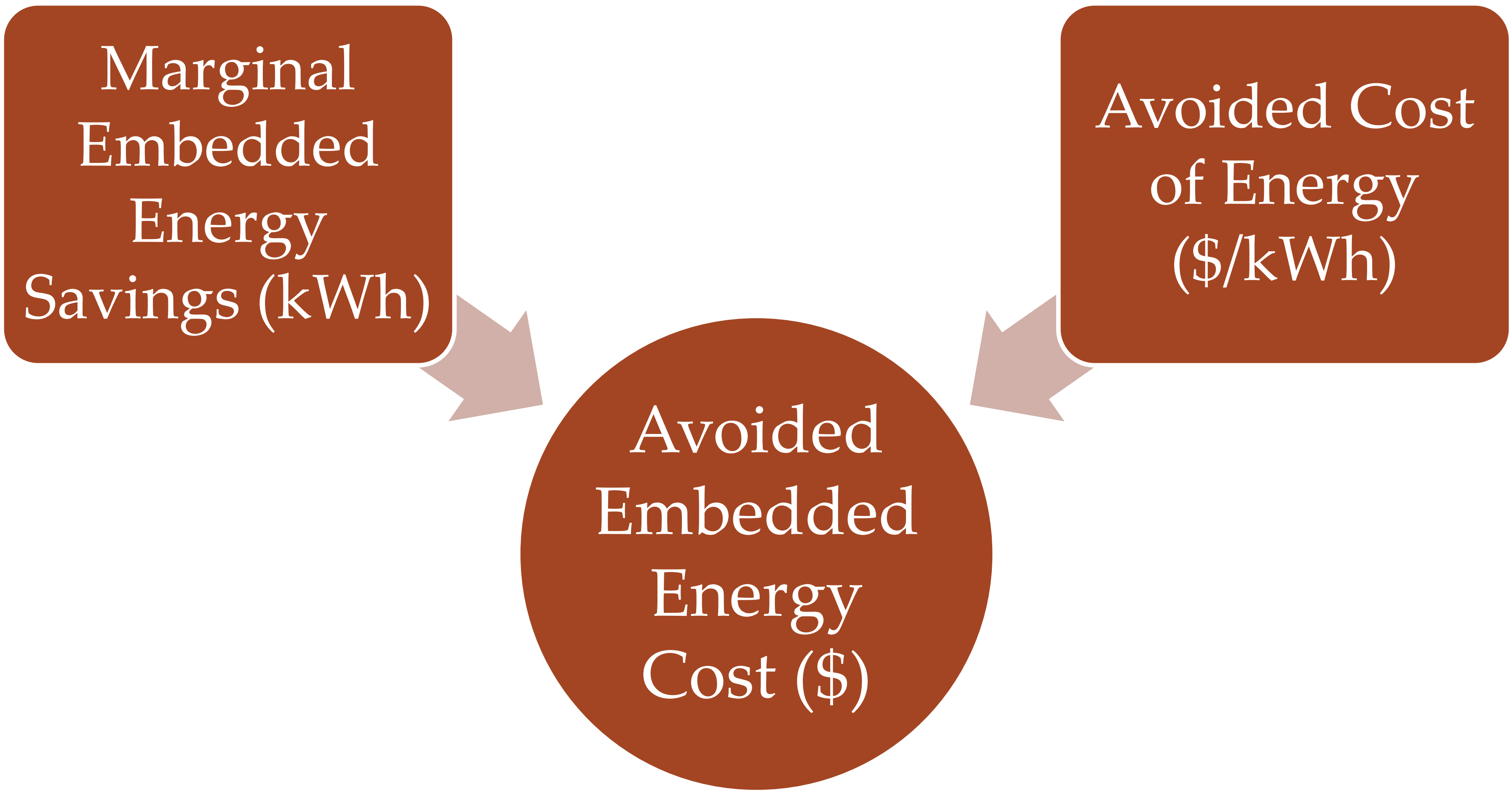
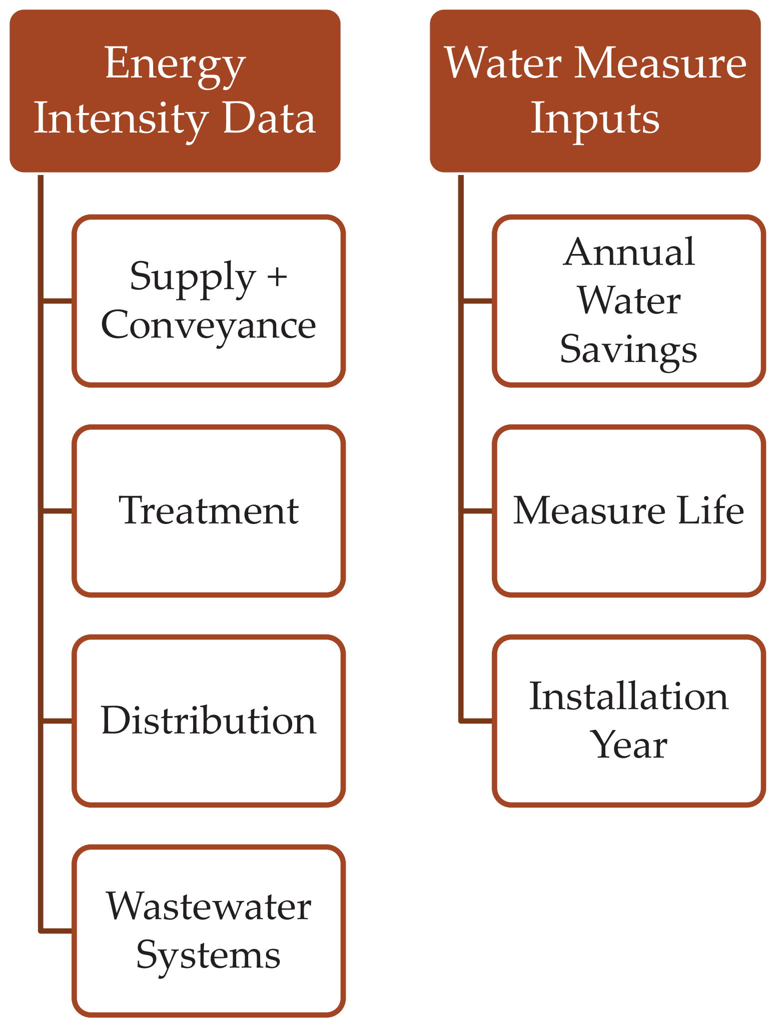
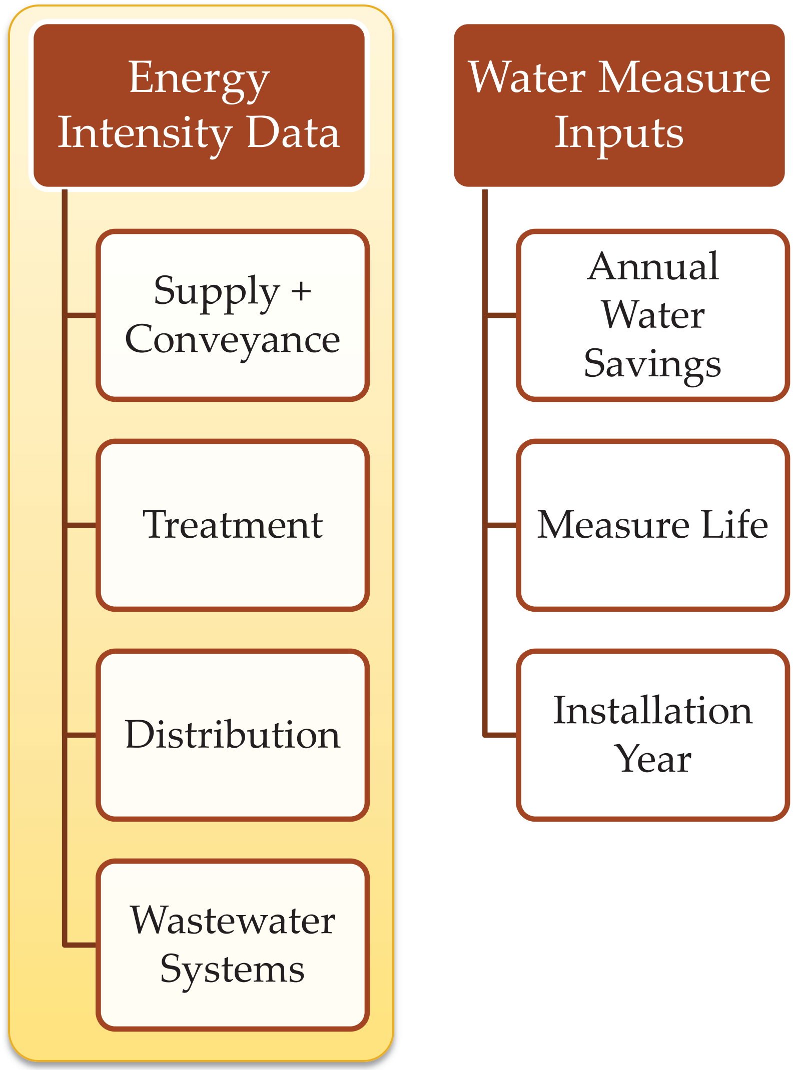
The avoided embedded energy cost is calculated from an energy and a cost component.



This tool will calculate the embedded energy savings from a water conservation measure from the following components.



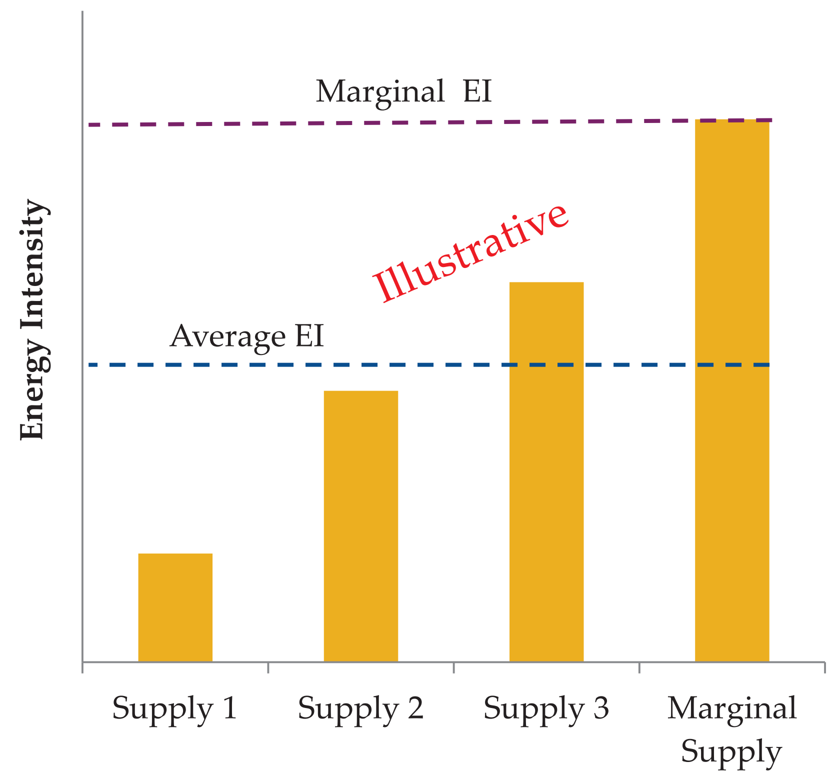
Energy intensity (EI) is calculated for each component of the water system.



Supply EI is represented by the EI of the marginal supply; Average EI will also be calculated.

» **Marginal EI**
  - The EI of the selected marginal supply for the region.
  - May be time-dependent if short and long term marginal supply differ

» **Average EI**
  - Represents the weighted average present-day EI value of the regions' water



Treatment EI is a function of the quality of the water being conserved and the supply type.

+	O
- Measure saves treated water - Supply type produces water that needs further treatment	- Measure saves untreated water

Distribution EI is dependent on region topography; each region is assigned a topography and thus a set EI value for the distribution component of the water system.

Wastewater system EI is a function of the use environment of the water being conserved.

- Water use is indoors

- Water use is outdoors

EI data is aggregated based on the specifics of each measure being analyzed.

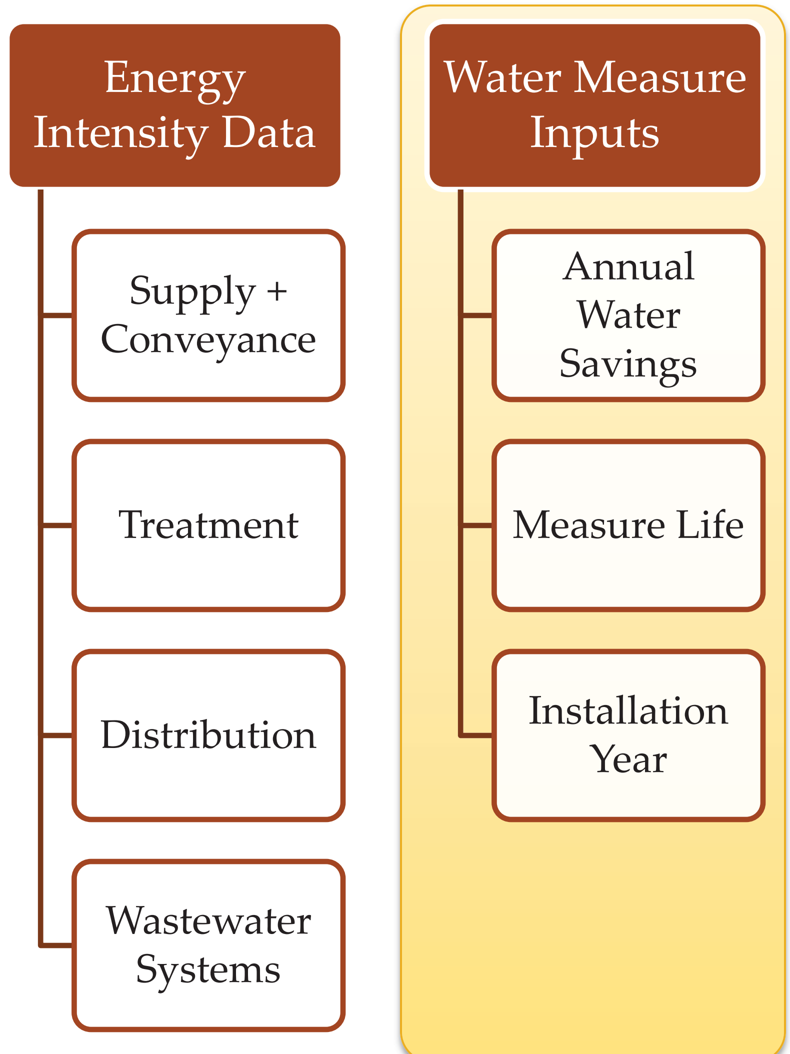
Example: Water Quality = Potable, Water Use = Indoor

	2014	2015	…	2023	2024	2025	2026	…
Supply	1000	1000	…	1000	2000	2000	2000	…
Treatment	300	300	…	300	300	300	300	…
Distribution	500	500	…	500	500	500	500	…
Wastewater	1500	1500	…	1500	1500	1500	1500	…
Total	3300	3300	…	3300	4300	4300	4300	…

Example: Water Quality = Non-Potable, Water Use = Outdoor

	2014	2015	…	2023	2024	2025	2026	…
Supply	1000	1000	…	1000	2000	2000	2000	…
Treatment	0	0	…	0	0	0	0	…
Distribution	500	500	…	500	500	500	500	…
Wastewater	0	0	…	0	0	0	0	…
Total	1500	1500	…	1500	2500	2500	2500	…

The region, water quality, and water use are only a few of the required measure inputs related to water savings.



For calculating <u>marginal</u> embedded energy, water measure inputs are used to generate a temporal mapping of the water savings.

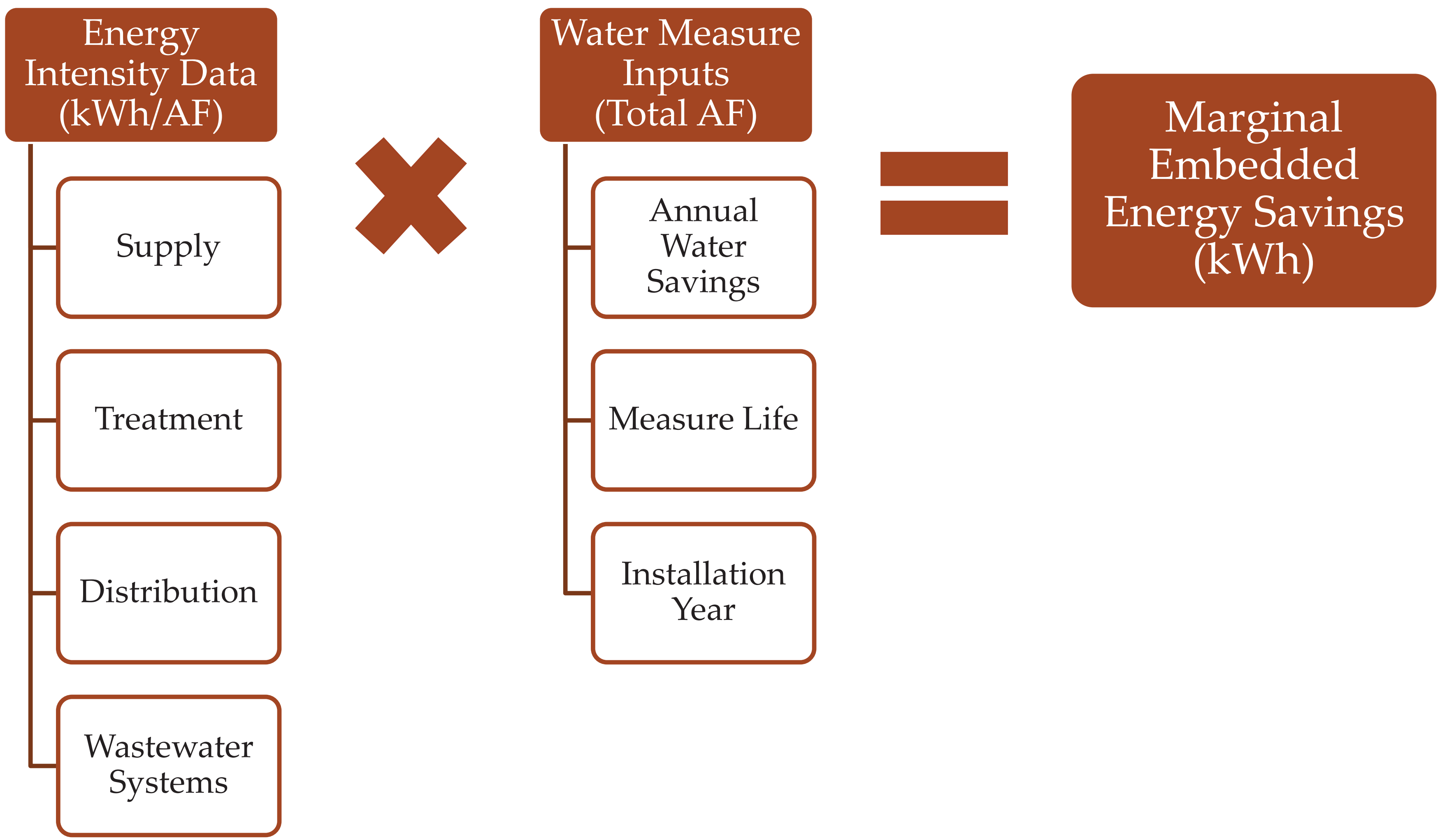
Water Measure Inputs

Measure	Annual Water Savings (gallons)	Measure Life (years)	Installation Year
#1	1000	9	2015
#2	500	6	2018
#3	200	6	2015

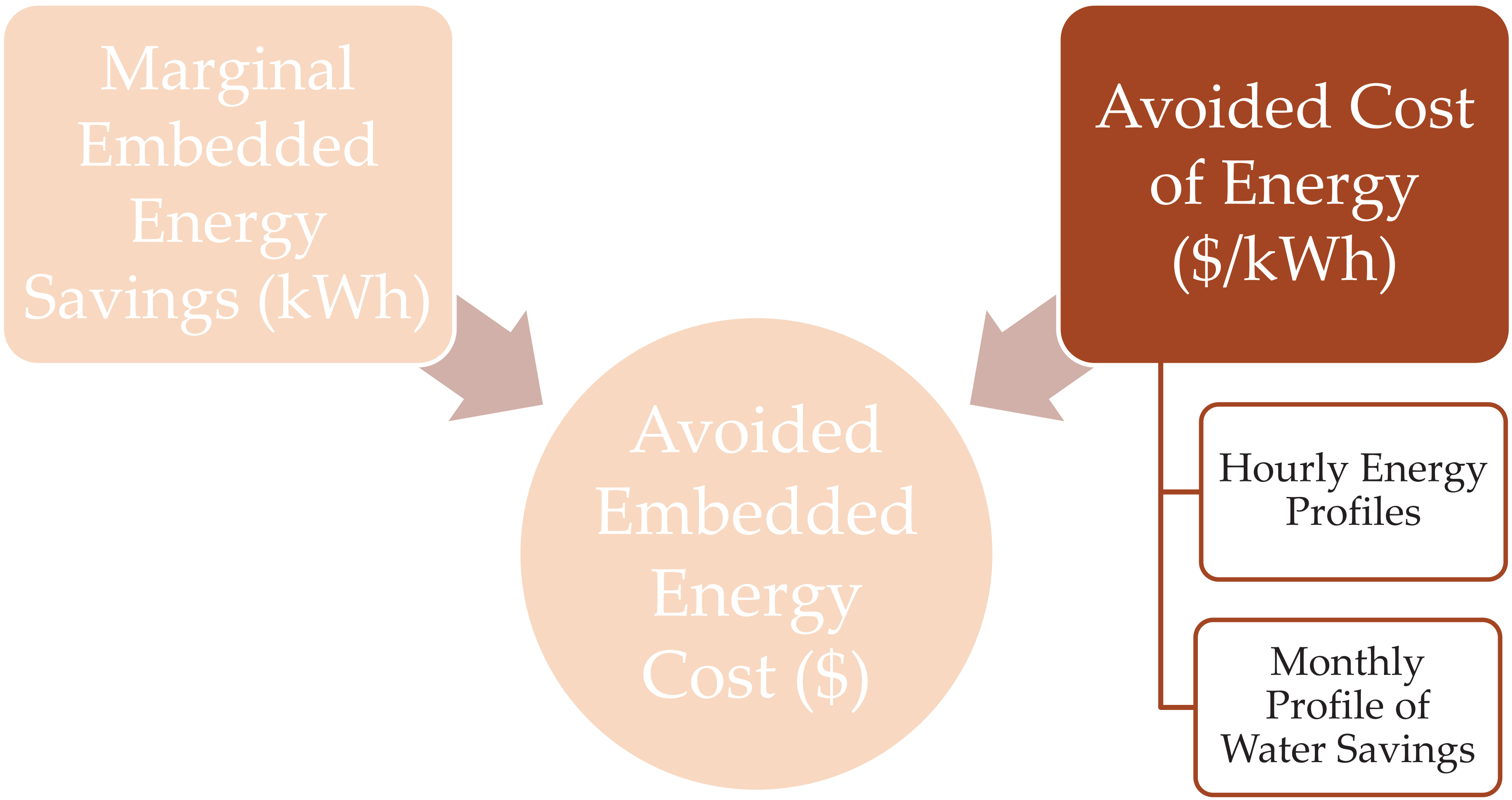
Annual Water Savings by Measure (gallons)

Measure	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
#1	-	1000	1000	1000	1000	1000	1000	1000	1000	1000
#2	-	-	-	-	500	500	500	500	500	500
#3	-	200	200	200	200	200	200	-	-	-

The energy intensity and water savings are combined to calculate embedded energy savings.

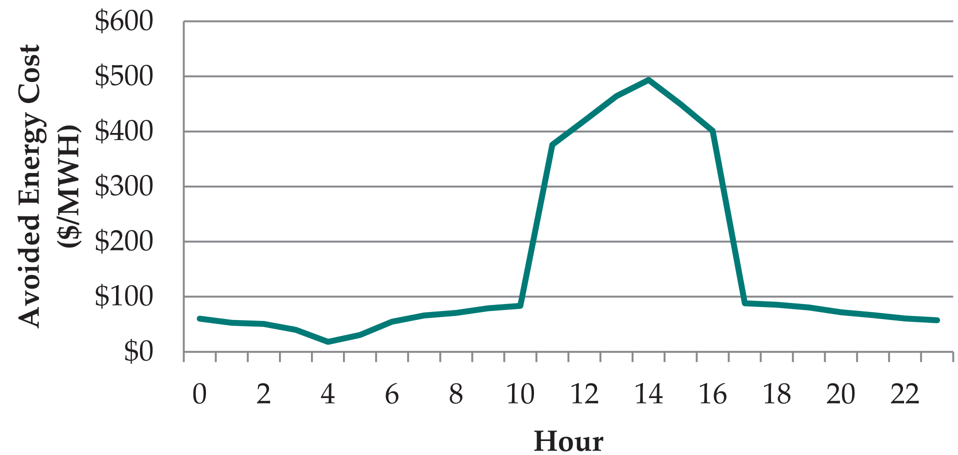


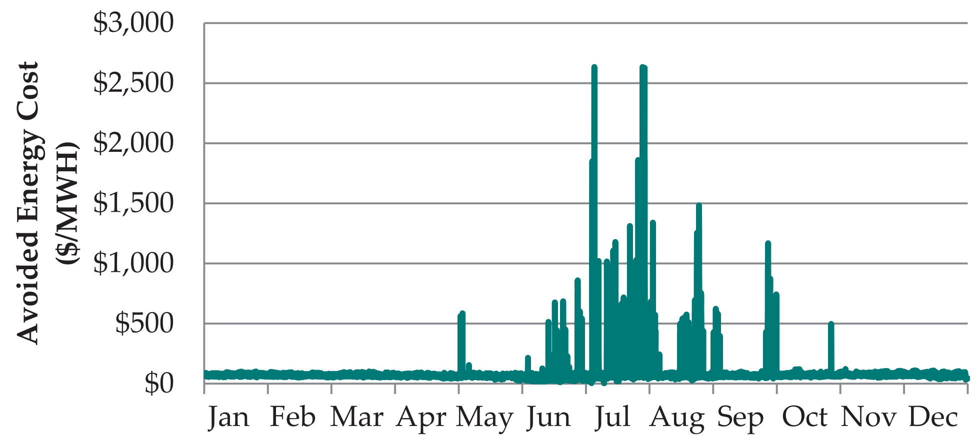
The avoided cost of energy will be sourced from existing CPUC avoided cost models and will incorporate water-related load profiles.



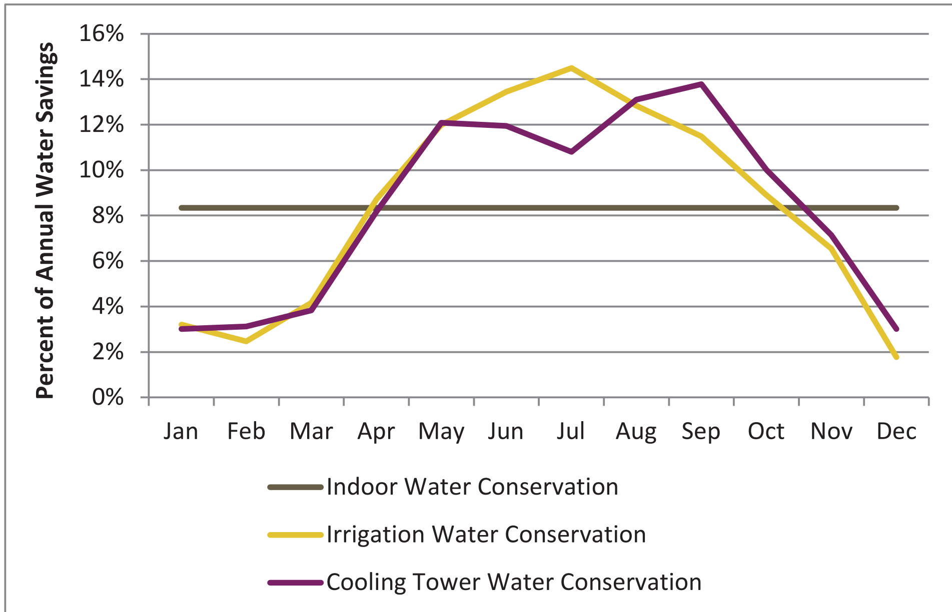
Embedded energy savings during the summer months and peak hours can provide higher benefits.

- Generally, the avoided cost of energy is higher during peak hours of the day
  - Embedded energy savings during peak hours result in higher benefits.
- Avoided cost of energy is higher in the summer months (June through September).
  - Embedded energy savings during the summer months result in higher benefits.



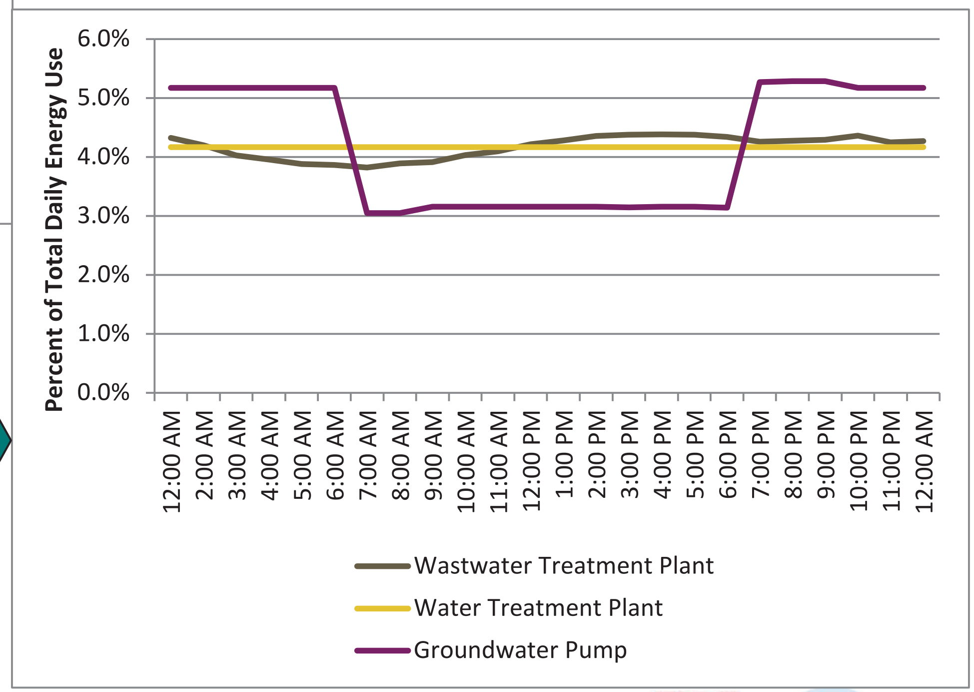


Monthly and hourly profiles are available from secondary data sources.



Illustrative monthly water savings for various end uses. Adapted from California Sustainability Alliance.

Illustrative hourly energy consumption of water system components. Adapted from CPUC Embedded Energy in Water Study 2.



Discussion

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NAVIGANT ENERGY

The following sources were reviewed as part of the marginal supply selection process.

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- Harvey-Williams, Brenda, Phylis Hallowell, and Mona Tse. "Pasadena ADOPTED CAPITAL IMPROVEMENT PROGRAM BUDGET FISCAL YEARS 2014-2018: Water Systems." CAPITAL IMPROVEMENT PROGRAM (CIP). City of Pasadena, 20 May 2013.
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The following sources were reviewed as part of the marginal supply selection process.

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- Bradley J. Hudson, . City of Riverside, "Capital Improvement Program 2011/12 - 2015/16." Last modified June 21, 2011.
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Attachment C

Supporting Data – Marginal Water Supply

GEI Consultants

Geotechnical
Environmental
Water Resources
Ecological

Future Marginal Water Supplies by Hydrologic Regions

Water/Energy Cost Effectiveness Framework

FINAL

Submitted to:
Navigant Consulting, Inc.

Submitted by:
GEI Consultants, Inc.
2868 Prospect Park Drive, Suite 400
Rancho Cordova, CA 95670

June 9, 2014
Project No. 1332570

M. Lorraine White
Water-Energy Program Manager

GEI Consultants

Geotechnical
Environmental
Water Resources
Ecological

The Water/Energy Cost Effectiveness Framework Project is being conducted by the Navigant Team which includes GEI Consultants, Inc. under a subcontract with Itron, Inc. (Task Order 067-1), which is operating under a contract with the California Public Utilities Commission.

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1.0 Introduction

GEI Consultants, Inc., the Pacific Institute and Navigant Consulting, Inc. (project team) are preparing a water-energy cost effectiveness model for the California Public Utilities Commission (CPUC) through a contract with Itron, Inc. As stated in the request for proposal issued by Itron, Inc., "(t)he goal of this project is to develop a comprehensive Cost Effectiveness Framework for analyzing the value of demand side programs that save energy and water simultaneously, by developing avoided cost values for both energy and water, and thus enabling energy Investor Owned Utilities (IOU) to evaluate joint programs alongside water agencies."[1] In order to develop this framework, the project team is determining:

- Values for the avoided costs of embedded energy in water (Task 1.1)
- Values for the avoided water capacity costs (Task 1.2)
- Inputs needed to integrate above values into existing cost-effectiveness calculators for demand side programs (Task 2)

To determine the avoided costs needed for the model, the project team must also determine what water supplies will be relied upon by Californians in the future and what costs are associated with these supplies. This paper presents the results of an assessment of water supplies California will rely upon in the future to support Tasks 1.1 and 1.2 of the project and the development of the Framework. At a later date, an addendum to this paper will be issued that provides cost-related information.

1.1 Water in California

Californians rely on a combination of two sources of water - surface and groundwater - to meet our water needs. These supplies can vary regionally both in quantity and quality (see Table 1), but all are replenished by precipitation (i.e., rain and snow). California's hydrologic conditions result in two-thirds of California's overall water supplies located in the northern part of the state while two-thirds of the demand occurs in the southern part of the state.[2] As a result, an expansive and elaborate system of storage facilities, conveyance structures, interties, and distribution systems have been built to move water from where it occurs to where it is used. Contractual mechanisms (i.e., water transfers and exchanges) have also been developed to facilitate the transactions needed to move water from where it naturally occurs to areas of high demand. California's water market has allowed water managers the increased flexibility needed to address temporary and long-term water scarcity conditions in their

[1] Itron Request for Proposal, "Notice to Prospective Bidders for Subcontractors to Conduct Analysis on Water/Energy Cost Effectiveness", August 28, 2013.
[2] Water Education Foundation. August 13, 2008. "Where Does California's Water Come From?" http://www.aquafornia.com/index.php/where-does-californias-water-come-from/ Accessed March 15, 2014.

communities.[3] Even with California's existing infrastructure, approximately half of this precipitation returns to the atmosphere or flows to the ocean.[4]

Table 1: California's Water Supply Options

Surface Water Supply Types	Groundwater Supply Types
• Fresh (these can be local or imported resources) • Degraded (can be contaminated or poor quality water) • Wastewater (sources suitable for re-use and recycling) • Brackish • Ocean/Sea	• Fresh (local) • Degraded (can be contaminated or poor quality) • Brackish

In addition to this existing infrastructure, California has developed and implements numerous "Resource Management Strategies" (RMS)[5], such as:

- Reducing water demand through efficiency and conservation
- Managing surface and groundwater conjunctively to increase groundwater storage and supply reliability
- Increasing storm water capture, retention, and storage within a community (this can include changes to or new methods for management of rainfall, flood flows, and urban run-off) to increase local supplies
- Desalinating brackish and ocean water to increase local supplies
- Improving water quality through various treatment methods
- Transferring water supplies from one region to another
- Treating wastewater to allow for increased recycling and re-use to increase local supplies and water use efficiency

1.2 California's Hydrologic Regions

Water availability and distribution varies throughout California. To assist in identifying the supply options available to a given region and the options for future supplies, the project team used the geographical breakdown developed by the California Department of Water Resources (DWR). These ten Hydrologic Regions (see Figure 1) correspond to the state's major drainage basins comprised of watersheds with similar clime that support water management planning.[6] As defined by DWR, the Hydrologic Regions of California are:

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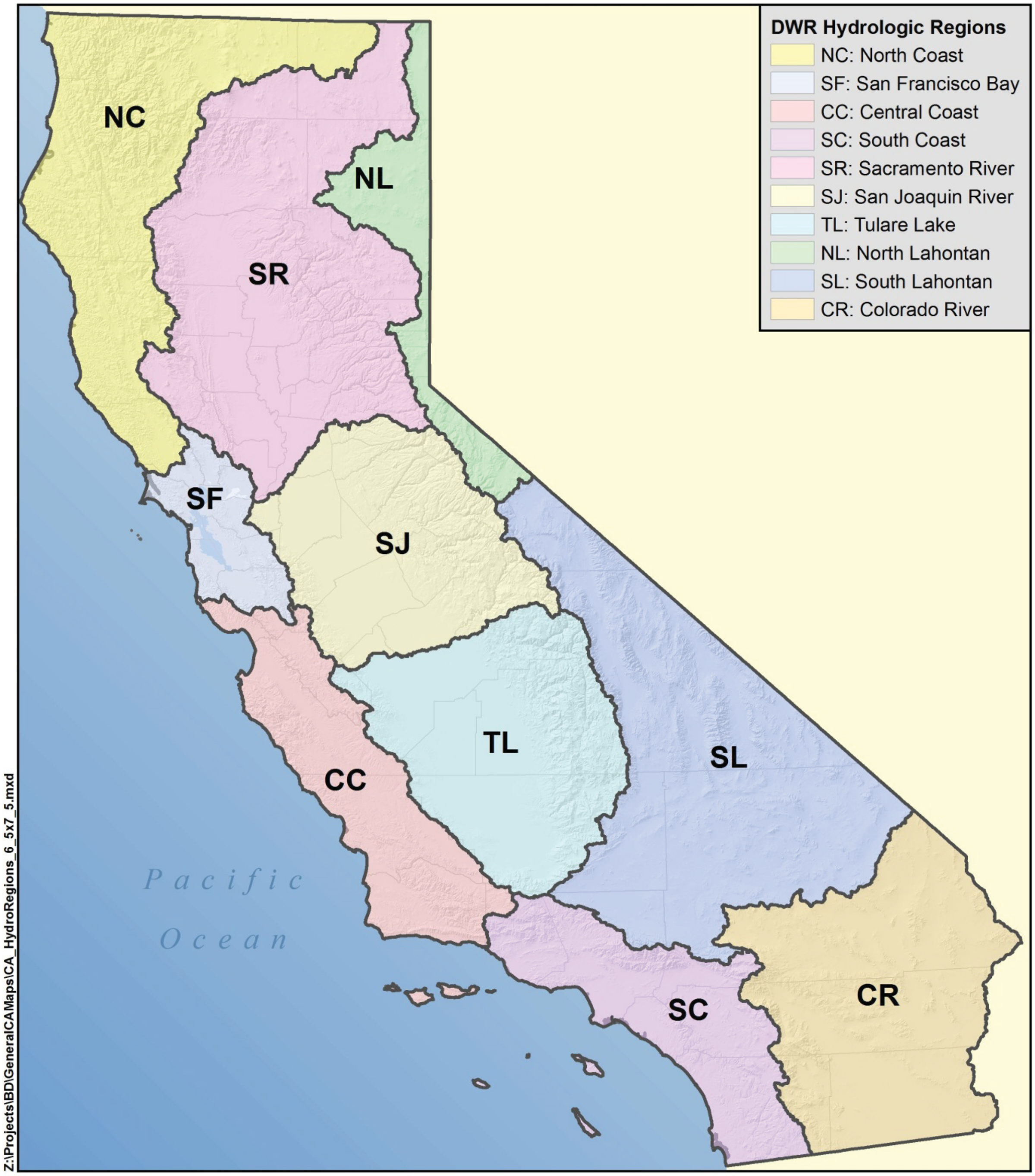
[3] Hanak, Ellen and Elizabeth Stryjewski. November 2012. *California's Water Market, By the Numbers: Update 2012*. Public Policy Institute of California.
[4] Brostrom, Peter. February 14, 2013. "California Water Demand: Water 101 – the Basics and Beyond." Presentation for the Water Education Foundation. DWR.
[5] As defined by DWR, an RMS is a project, program, or policy that helps federal, State or local agencies manage water and related resources.
[6] DWR. December 2013. "*California Water Plan Update 2013*". Public Review Draft.

1. **North Coast**. Klamath River and Lost River basins, and all basins draining into the Pacific Ocean from Oregon south through the Russian River basin.
2. **San Francisco Bay**. Basins draining into San Francisco, San Pablo, and Suisun bays, and into the Sacramento River downstream from Collinsville in western Contra Costa County, and basins directly tributary to the Pacific Ocean below the Russian River watershed to the southern boundary of the Pescadero Creek basin.
3. **Central Coast**. Basins draining into the Pacific Ocean below the Pescadero Creek watershed to the southeastern boundary of Rincon Creek basin in western Ventura County.
4. **South Coast**. Basins draining into the Pacific Ocean from the southeastern boundary of Rincon Creek basin to the Mexico border.
5. **Sacramento River**. Basins draining into the Sacramento River system in the Central Valley, including the Pit River drainage, from the Oregon border south through the American River drainage basin.
6. **San Joaquin River**. Basins draining into the San Joaquin River system from the Cosumnes River basin on the north through the southern boundary of the San Joaquin River watershed.
7. **Tulare Lake**. The closed drainage basin at the south end of the San Joaquin Valley, south of the San Joaquin River watershed, encompassing basins draining to Kern lakebed, Tulare lakebed, and Buena Vista lakebed.
8. **North Lahontan**. Basins east of the Sierra Nevada crest and west of the Nevada state line from the Oregon border south to the southern boundary of the Walker River watershed.
9. **South Lahontan**. The interior drainage basins east of the Sierra Nevada crest, south of the Walker River watershed, northeast of the Transverse Ranges, and north of the Colorado River region. The main basins are the Owens and the Mojave River basins.
10. **Colorado River**. Basins south and east of the South Coast and South Lahontan regions, areas that drain into the Colorado River, Salton Sea, and other closed basins north of the Mexico border.

Figure 1: California's Hydrologic Regions



2.0 Approach and Assumptions

Prior to initiating work on this project, the team in consultation with the CPUC and the Water/Energy Project Coordination Group (PCG) developed an approach to determine the regional water supplies, now and in the future. This approach and associated tasks were included in a work plan for the project and are summarized in this section.

2.1 Approach to Determining Water Supplies

As part of the project, the project team was tasked with identifying water supplies available to and developed in California's Hydrologic Regions and which of these supplies are the marginal or the next incremental supply to be developed. In addition, the project team was to determine how these marginal supplies may change over time. As defined in the project work plan, the project team:

- Collected regional historic water supply and use data from DWR reports, regional water management plans, and other relevant sources
- Solicited input directly from water managers and others expert in California water resource management as well as the CPUC and PCG
- Used this information to determine the current and future supply options for each Hydrologic Region
- Characterized the order in which each region develops these supplies considering economic and physical characteristics of each supply as well as legal and institutional issues
- Identified the marginal water supply developed in each region within the 0 to 10 year and 10 to 20+ year timeframes
- Updated the marginal supply selection based on feedback as needed

As defined by the project team, "marginal water supply" does not refer to water quality, but rather is the next increment or unit of water supply developed within a region to meet demand in the absence of water conservation and efficiency. This definition is consistent with the definition of marginal power supply used in the electricity industry for determining marginal cost and price.[7] Additional details defining and describing "marginal water supply" can be found in the project team's public workshop presentation dated April 25th, 2014.[8]

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[7] California Energy Commission. Copyright 1994-2014. "Marginal Cost", Glossary of Energy Terms. California ISO. "Locational Marginal Pricing (LMP): Basics of Nodal Price Calculation". CRR Educational Class #2, CAISO Market Operations. http://www.caiso.com/docs/2004/02/13/200402131607358643.pdf . Accessed May 15, 2014.
[8] Navigant, GEI, Pacific Institute. *Water-Energy Cost Effectiveness Analysis Public Workshop Presentation of Future Water Supply Selection.* April 25, 2014.

2.1.1 Data Sources and References Consulted

The project team relied primarily on the DWR *2013 California Water Plan Update* and integrated regional water management plans (IRWMPs) distributed among the Hydrologic Regions. These plans provided information on available water supplies, demand, RMS, regional priorities and challenges, and infrastructure requirements. Additionally, the project team obtained information on costs and characteristics of these supplies from capital improvement plans and engineering reports obtained from local agencies and entities which will be provided as an addendum to this paper (additional references will be provided as well).

Additional information was obtained through internet searches, primarily local water agency websites and those of non-governmental organizations, such as the Natural Resources Defense Council (NRDC) and Public Policy Institute of California (PPIC). These resources provided more statewide perspectives, information, and analysis.

2.1.2 Assumptions

Due to the availability of information, the schedule, and the scope of the project some assumptions were needed.

- Since the project team primarily used publicly available plans that have gone through a public vetting process of their data, analyses, and results, these plans were assumed to be valid, credible and defensible. Thus, no additional analysis on the part of the project team was required of the data and results presented in these plans.
- It also is assumed that the IRWMPs relied upon by the project team complied with DWR's guidelines available at the time the reports were prepared and are the best available regional assessments of water portfolios and future plans for a given region.[9]
- The marginal supplies identified by the project team are the most likely supplies to be developed in the absence of conservation/efficiency efforts.
- Potable grade water is used for urban residential outdoor landscape irrigation.
- Developing specific projections of future water demand in the various Hydrologic Regions is outside the scope of this project. The project team instead has relied on the future demand projections developed by DWR. DWR's methods and assumptions used for their scenario planning are well documented and publicly vetted.[10] It is assumed that these projections are appropriate for use and represent the best available information.

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[9] For example, several IRWMPs consulted follow the 2012 Integrated Regional Water Management Guidelines for Proposition 84 and 1E (DWR Guidelines) published by DWR in November 2012.

[10] For more information regarding DWR's methods and assumptions, please see
http://www.waterplan.water.ca.gov/docs/cwpu2013/ae/future_scenarios-plan_of-study.pdf
http://www.lao.ca.gov/2008/rsrc/water_primer/water_primer_102208.aspx
http://www.acwa.com/news/delta/state-water-contractors-release-fact-sheet-comparing-economic-analyses-bdcp
http://westernfarmpress.com/irrigation/california-s-water-supply-and-demand

2.1.3 Near and Long-Term Defined

Recognizing that the marginal water supplies may change over time, the project team identified two future timeframes. The project team noted that the planning horizon for many of the documents consulted extended 20 years into the future, and the time required to develop certain infrastructure projects exceeds five years in many cases (i.e., large conveyance and storage structures, treatment facilities, etc.). Considering this information, the project team defined the future timeframes as follows:

- Near term is 0 to 10 years
- Long-term is 10 to 20+ years

2.2 Expert Input and Public Vetting

Based on the information gathered, a preliminary list was prepared of developed and future water supply options for each region. Using this preliminary list, the project team conducted targeted interviews with California water experts to obtain additional input and insights used to refine the list of supplies. The project team then presented this information at a public workshop held by the CPUC on April 25, 2014, to gather more input and address participants' comments. This paper incorporates this input and presents the project team's marginal water supply determination for inclusion in the Water/Energy Cost Effectiveness Framework. Table 2 provides a listing of the organizations these individuals represent.

Table 2: Water Experts Consulted

Organizations
San Diego County Water Authority
Sonoma County Water Agency
Eastern Municipal Water District
Victor Valley Wastewater Reclamation Authority
Inland Empire Utility Agency/ Association of California Water Agencies
California American Water
Metropolitan Water District
USD Law
UC Santa Barbara
UC Davis
Natural Resources Defense Council
California Farm Bureau
Office of Ratepayer Advocates
US EPA Region 9
Department of Water Resources

3.0 Findings

Based on the materials reviewed and input from the interviews and public workshop, the project team identified several factors that influence the choices made by water managers regarding their regional supply portfolios. In addition, the project team observed trends among the regions and conditions that dictate future water supply options. Using this information, the project team compiled the list of water supplies relied upon in each region.

3.1 Factors that Influence Water Resources Development

Several factors influence the types of water resources developed as part of a region's water supply portfolio. These include, but are not limited to:

- Demand and end use application of the developed water (agricultural, industrial, commercial, institutional, residential)
- Location and availability of the water supplies
- Quality of the water supply and associated treatment requirements
- Costs (including extraction, conveyance, transfer/exchange, treatment, and delivery costs)
- Regulations and legal restrictions

As a result of these factors, water managers tend to develop initially those resources that are the best quality, locally available, and the least costly. Not surprisingly, those resources that require the most amount of treatment and have the highest associated costs tend to be developed last for both urban and agricultural uses. This is true for local supplies such as recycled or reclaimed water, brackish or contaminated groundwater, and saline surface supplies like ocean water.

3.1.1 Demand Drives Water Resource Development

The California Department of Finance projects California's population to increase from 38 million in 2013[11] to more than 52 million by 2060, tipping the 50 million mark in 2049.[12] This growth is expected to occur mostly in California's urban centers, putting pressure on the state's agriculture sector. According to DWR, water use by agriculture is expected to decrease over time while urban uses are expected to increase as population grows.[13] Urban

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[11] Department of Finance, December 12, 2013 Press Release. Downloaded April 14, 2014. http://www.dof.ca.gov/research/demographic/reports/estimates/e-2/documents/E2_press_release_Jul2013.pdf

[12] Department of Finance, January 31, 2013 Press Release. Downloaded April 14, 2014. http://www.dof.ca.gov/research/demographic/reports/projections/P-1/documents/Projections_Press_Release_2010 to 2060.pdf

[13] DWR 2013.

uses tend to require higher quality resources, with water supplied to urban customers treated to potable standards, even if the end use doesn't require potable water.[14]

California's water demand tends to vary over time, influenced by water year type (wet, dry, average, etc.), location (inland or coastal), and end use. Even with current conservation and efficiency efforts, population growth is likely to increase urban water demand and increase the tension between urban and agricultural use in some regions.[15] Water demand is highest during the driest years, driven mostly because of irrigation (both urban and agricultural) requirements.[16] Storing water in wet years to meet demands during dry years is a common RMS.

Table 3: California's Total Water Demand: 2005-2010 Annual Average Groundwater + Surface Water + Reused Water (in thousand acre-feet)[17]

2005-2010 Average Hydrologic Regions	Agriculture TAF	Urban TAF
North Coast	736	152
San Francisco	103	1,146
Central Coast	996	298
South Coast	716	3,959
Sacramento River	7,612	906
San Joaquin	7,125	716
Tulare Lake	10,929	740
North Lahontan	447	44
South Lahontan	376	292
Colorado River	3,664	578
Statewide	**32,703**	**8,830**

DWR developed a series of scenarios as part of the *California Water Plan* process to identify potential future water demand. Table 4 presents DWR estimates for future agricultural and urban demand statewide and the ten Hydrologic Regions under different urban growth and climate change scenarios. Water resource managers use this type of information to develop their plans and implement strategies to meet projected demands.

[14] Urban water uses can include: residential landscape; large landscape; indoor residential (toilets, showers, leaks, faucets, clothes washers, etc...); commercial, institutional, and industrial and other, unspecified uses.
[15] Hanak, Ellen. January 2014. "*California's Future: Water*", Public Policy Institute of California.
[16] California Legislative Analyst's Office. 2008. "California Water: An LAO Primer", October 2008.
[17] McManus, Dan. April 2014. DWR, Personal Communications.

Table 4: Ranges of California's Projected Water Demand

Hydrologic Regions	Historical Avg (TAF) 1998-2005 (Ag)	Historical Avg (TAF) 1998-2005 (Urb)	Demand Range (TAF) 2043-2050 (Ag)	Demand Range (TAF) 2043-2051 (Urb)
North Coast	748	149	571 - 808	145 - 228
San Francisco	121	1066	93 - 135	1033 – 1844
Central Coast	1031	271	766 - 995	299 - 487
South Coast	786	3846	351 - 605	3716 – 6058
Sacramento River	7493	838	6928 – 8083	1118 – 1831
San Joaquin	6347	589	5100 – 6057	966 – 1439
Tulare Lake	9466	676	8069 - 9241	957 – 1479
North Lahonton	432	38	398 – 464	32 – 70
South Lahonton	348	231	289 – 644	304 – 653
Colorado River	3489	494	1718 - 1890	510 - 847
Statewide	**30261**	**8197**	**24381 - 28237**	**9239 - 14903**

3.1.2 Regional Water Supply Options

In each region of the state, local, high-quality (fresh) surface water supplies are the first-choice supply and significant infrastructure has been put in place to capture and store these supplies (including storm water, flood flows, and run-off). When possible these local supplies are augmented by imports of other surface water supplies through intra- and inter-basin transfers. Imported resources can also be used to reduce the amount of local groundwater that needs to be pumped and, when possible, may be used to add to the local stored supplies (both groundwater and surface). For example, the State Water Project (SWP) water contractors routinely request delivery of their full allotments regardless of availability of local surface or groundwater supplies. This imported water allows these contractors to displace the use of and, whenever possible, recharge of local groundwater.[18]

Nearly 40 percent of California's overall water demand is met by groundwater (see Appendix B); during dry years this percentage is as much as 60 percent. Unfortunately, groundwater in California is largely unregulated and supplies in many parts of the state are over-drafted.[19] As a result of conflicts between groundwater users in these regions, 22 groundwater basins are adjudicated where the courts have decided those that can extract from the basins, how much each can extract and who will oversee these extractions.[20, 21] Recent reports draw

[18] Lin, Jin Lu. April 24, 2014. DWR. Personal Communication.
[19] Groundwater Resources Association of California. March 23, 2006. "California Groundwater Management," Second Edition, p.9.
[20] Public Policy Institute of California. "California Water" Part I, p. 78. http://www.ppic.org/content/pubs/report/R_211EHChapter2R.pdf. Accessed May 15, 2014.
[21] DWR, http://www.water.ca.gov/groundwater/gwmanagement/court_adjudications.cfm. Accessed May 23, 2014.

attention to these issues and make several recommendations to address the threats to groundwater supplies.[22]

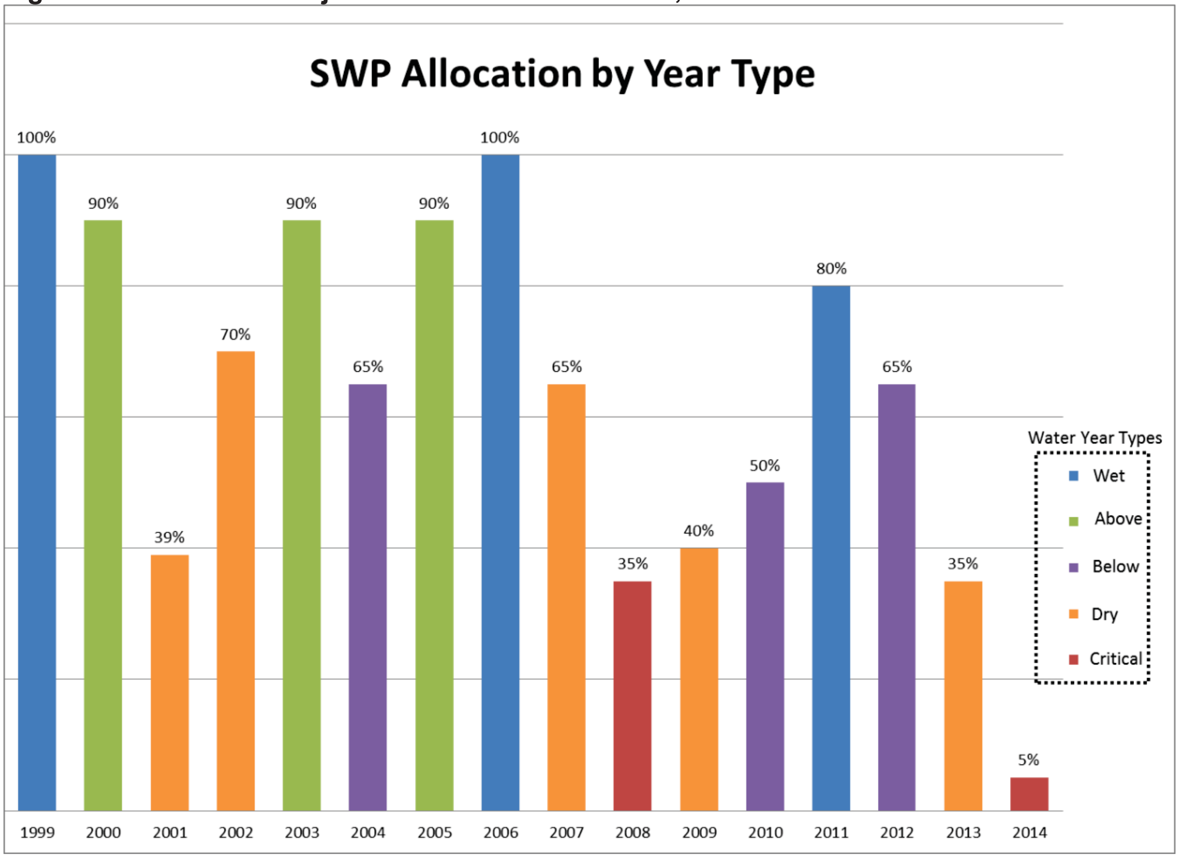
Use of lesser-quality water supplies, whether surface or groundwater, requires treatment prior to most urban uses, but these supplies may be of sufficient quality for direct agricultural applications. As regional water supply portfolios expand to include more types of sources, water managers can work with customers to better match the quality of supplies to specific end uses (also referred to as supply switching). As a result, some resource managers are using degraded supplies for non-potable uses, such as agriculture or industrial processes, to reserve the higher quality supplies for potable uses. However, even some poor quality supplies require some degree of treatment regardless of end uses. This is especially true of brackish and ocean water supplies that require treatment for both urban and agricultural use.

3.1.3 Imported Water Supplies Resources

All but two Hydrologic Regions import surface water supplies to supplement regional supplies. Primary sources for these imported water supplies exchanged among regions include the Colorado River (Southern California), Sacramento-San Joaquin River Delta (most regions south of the Delta), Sierra Nevada/Hetch Hetchy Reservoir (Bay Area), and Owens River Valley (Los Angeles). As much as 60 percent of Southern California's water supply is imported. However, these supplies are increasingly constrained and at risk because of ecosystem deterioration, hydrologic conditions, regulatory requirements (particularly those related to water quality and endangered species), and aging infrastructure.[23] As seen in Figure 2, these constraints have had a significant impact on the reliability of State Water Project deliveries in recent years. These constraints and risks are likely to continue to make these resources less reliable in the future.

[22] Water in the West. April 2014. "Before the Well Runs Dry: Improving the Linkage Between Groundwater and Land Use Planning." A joint program of the Stanford Woods Institute for the Environment and the Bill Lane Center for the American West.
[23] Freeman, Gregory. January 2008. "Securing Reliable Water Supplies for Southern California," Los Angeles County Economic Development Corporation. Prepared for the Southern California Leadership Council Future Issues Committee.

Figure 2: State Water Project Allocations 1999-2014[24, 25]



3.1.4 State Water Resources Control Board's Recycled Water Policy

As discussed above, approximately half of the precipitation that falls in California makes its way directly to the ocean or evaporates without first being exploited for urban or agricultural use. In addition, most of California's treated sanitary wastewater is discharged to rivers and streams despite options to re-use or recycle these local supplies.

In 2013, the State Water Resources Control Board (SWRCB) adopted an amendment to the Recycled Water Policy to reduce demands on imported supplies and encourage local water managers to take full advantage of locally available water supplies to enhance local reliability and resiliency. As stated in the revised policy, the SWRCB "strongly encourage(s) local and regional water agencies to move toward clean, abundant, local water for California by emphasizing appropriate water recycling, water conservation, and maintenance of supply infrastructure and the use of storm water (including dry-weather urban runoff) in [salt/nutrient management] plans; these sources of supply are drought-proof, reliable, and minimize our carbon footprint and can be sustained over the long-term."[26]

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[24] Leahigh, John. October 2013. "State Water Project Operations Outlook for 2014", DWR. Presentation.
[25] DWR. Notice to State Water Project Contractors. Number 14-07, April 18, 2014. http://www.water.ca.gov/swpao/docs/notices/14-07.pdf. Accessed April 29, 2014.
[26] SWRCB. Amended April 25, 2013. Policy for Water Quality Control for Recycled Water. p. 1.

To meet these goals, the SWRCB established specific targets for the increased development of sanitary wastewater recycling – more than two million acre-feet a year by 2030 – and increasing the local capture and use of storm water by at least one million acre-feet by 2030.[27] Local water managers are modifying their approach to the management of storm water locally, seeking not to merely move the water downstream as efficiently as possible, but to capture and retain these supplies locally through expansion of reservoirs and additional groundwater recharge programs.

3.1.5 Desalination

Advances in treatment technologies have made less traditional sources of water supplies, such as wastewater and brackish or saline water, a more viable option in many parts of California. More than 20 brackish groundwater facilities are located in California, with the majority located in the greater Los Angeles area (see Figure 3). DWR reports that as many as 20 additional facilities are planned to be constructed by 2040. Most of California's current ocean water desalination supports non-potable uses, with only four facilities used for potable supplies.[28] Technological improvements, reduced reliability and availability of imported supplies, and pressures in the water market are making ocean water desalting more cost competitive (see Table 5). As a result, interest in developing these sources is high (see discussion above regarding recycled water), with 15 ocean desalination projects proposed along California's coast[29] and one under construction in San Diego County.

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[27] Ibid.

[28] DWR. December 2013. *California Water Plan Update 2013*, Volume 3, Chapter 10, p. 10-14 &15

[29] Pacific Institute. May 2013. "Key Issues in Seawater Desalination in California: Energy and Greenhouse Gas Emissions", http://pacinst.org/publication/energy-and-greenhouse-gas-emissions-of-seawater-desalination-in-california/. Accessed April 14, 2014.

Figure 3: Existing Brackish and Sea Water Treatment Facilities[30]

Table 5: Cost Comparison of Water Supply Options – San Diego[31]

Water source	Cost per acre-foot
Imported water	$875-$975
Surface water	$400-$800
Groundwater	$375-$1,100
Desalinated water	$1,800-$2,800
Recycled water	$1,200-$2,600

3.2 California's Water Supplies by Hydrologic Regions

3.2.1 General Observations

After gathering and reviewing numerous resources, the project team made several observations:

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[30] DWR. December 2013. *California Water Plan 2013,* Volume 3, Chapter 10. Public Review Draft. Figure 10-5.

[31] Equinox Center. July 2010. "San Diego's Water Sources: Assessing the Options". http://www.equinoxcenter.org/assets/files/pdf/AssessingtheOptionsfinal.pdf. Accessed April 29, 2014.

- Types of water supplies common to all regions include surface (rivers, reservoirs) and groundwater (fresh, high quality), and wastewater supplies that are being recycled or reclaimed to some degree. Additional types of water supplies that may be available to certain regions can include imported water supplies (State Water Project, Central Valley Project, and the Colorado River); treated brackish and contaminated groundwater; and ocean desalination.
- Water resource managers tend to develop water portfolios through the use of a variety of strategies to maximize the beneficial uses of water supplies available to them.
- Water resource managers are implementing more RMS aimed at maximizing the use of local supplies such as recycled water and storm water. These strategies include intra- and inter-basin transfers of surface water supplies primarily, and groundwater to the extent possible; developing and expanding conjunctive use and groundwater banking programs to maximize surface and groundwater supplies simultaneously; and developing new and expanding existing reclaimed/recycled wastewater resources (starting from secondary treatment levels in most cases).
- Brackish water supplies (mostly brackish groundwater) are commonly desalted to augment fresh water supplies, mostly in Southern California, with several regions planning to significantly increase development of these supplies.[32]
- Ocean/sea water is desalted today in the Central Coast and South Coast regions for potable and non-potable water supplies. A large desalination plant is under construction in the South Coast Region with plans to begin delivery of potable water to the San Diego area in 2016. A couple of inactive operational facilities exist along the coast and can be activated if needed, especially under drought conditions. Several water agencies are considering the construction of additional plants to meet future water demands, although the size, timing, and likelihood of development remains uncertain.[33]
- All regions reported the need for making their systems more sustainable and included projects such as above-ground storage tanks, new wells, and additional distribution lines to support required water services to customers.

3.2.2 Current Water Supply Portfolios

These initial observations related to regional water supplies were discussed with the CPUC project team on March 26, 2014, to get their preliminary feedback and assist in refining information on the regional water supply portfolios. The current water supply portfolios relied upon by the various Hydrologic Regions is listed in Table 6. The order in which these supply types are listed appears to be the order in which these regions generally develop these resources. Those that are listed last for a given region are those resources that tend to be the most expensive and needed to meet growing demand in the face of constraints on more traditional supply options.

[32] DWR. December 2013. *California Water Plan Update 2013*, Chapter 10. Public Review Draft.
[33] Ibid.

Table 6: Hydrologic Region Water Supply Portfolios

Hydrologic Region	Water Supply Types
North Coast	Surface Water (includes Storm water) Groundwater Recycled/Reused Water
San Francisco Bay	Surface Water (includes Storm water) Imports Groundwater Recycled/Reused Water Brackish Surface and Groundwater
Central Coast	Surface Water (includes Storm water) Imports Groundwater Recycled/Reused Water Brackish Groundwater Ocean/Sea Water
South Coast	Surface Water (includes Storm water) Imports Groundwater Recycled/Reused Water Brackish Groundwater Ocean/Sea Water
Sacramento River	Surface Water (includes Storm water) Imports Groundwater Recycled/Reused Water
San Joaquin River	Surface Water Imports Groundwater Recycled/Reused Water Brackish Groundwater
Tulare Lake	Surface Water (includes Storm water) Imports Groundwater Brackish Groundwater Recycled/Reused Water
North Lahontan	Surface Water (includes Storm water) Groundwater Recycled/Reused Water
South Lahontan	Surface Water Imports Groundwater Recycled/Reused Water
Colorado River	Surface Water (includes Storm water) Imports Groundwater Recycled/Reused Water Brackish Groundwater

4.0 Future Regional Marginal Water Supplies

To a large extent, current water supply portfolios reflect the future water supply portfolios water resource planners and managers will support both in the near and long-term futures for a given Hydrologic Region. Using state and regional plans representative of certain regions, the project team developed characterizations of future marginal water supplies for the regions as seen in Table 7. As stated earlier in this paper, marginal water supplies are defined as those supplies needed to meet the next increment of water demand in the absence of conservation and efficiency. This information was discussed with water experts and vetted at the CPUC's April public workshop. The extent to which these marginal water supplies will be developed in the future depends on customer demands, climatic conditions, availability, and cost.

Table 7: Future Marginal Water Supplies by Hydrologic Region

	Supply Development Options	
Region	**Short-Term (0 to 10 years)**	**Long-Term (10+ Years)**
North Coast	*Recycled/Reused Water*	*Recycled/Reused Water*
San Francisco Bay	*Brackish Surface and Groundwater*	*Brackish Surface and Groundwater*
Central Coast	*Ocean/Sea Water*	*Ocean/Sea Water*
South Coast	*Ocean/Sea Water*	*Ocean/Sea Water*
Sacramento River	*Recycled/Reused Water*	*Recycled/Reused Water*
San Joaquin River	*Recycled/Reused Water*	*Recycled/Reused Water*
Tulare Lake	*Brackish Groundwater*	*Brackish Groundwater*
North Lahontan	*Recycled/Reused Water*	*Recycled/Reused Water*
South Lahontan	*Recycled/Reused Water*	*Recycled/Reused Water*
Colorado River	*Brackish Groundwater*	*Brackish Groundwater*

4.1 General Discussion

Most individuals interviewed believe that the water portfolios listed in Table 6 appear reasonable and accurate. The project team was questioned about why the near and long-term marginal supplies are identical. This was best addressed by several water managers who confirmed that all reasonably cost-effective water supplies in a given region are developed to meet demands, hence resulting in similar lists for both the near and long-term in the regions. It is the degree to which any one of these resources will be relied upon in the future that is likely to change. For example, as demand grows, and surface and groundwater resources are increasingly constrained in the San Diego area of the South Coast region, the degree to which this region depends on non-traditional supplies like recycled water, treated degraded groundwater, and ocean desalination will increase.[34]

Interviewees also mentioned that depending on the water year (wet or dry), the order of the supplies listed may change. For example, regions such as South Coast, Tulare Lake, San Joaquin, and South Lahontan tend to use imported water before groundwater. As imported supplies become more constrained, these regions may have no choice, but to increase reliance on available groundwater supplies, especially degraded and brackish resources. Some regions such as the Central Coast and Colorado River may not have access to imported supplies in the 10 to 20 year timeframe and are thus seeking ways to increase local supplies. Regardless of the degree to which the order changed for the more traditional water resources, the marginal water supply (the next increment of water supply developed) did not change.

The project team was also encouraged to call out storm water as a separate water supply[35]; however, as discussed earlier in this report, storm water replenishes the state's surface and groundwater resources and is therefore already counted as part of these resources. In addition, several standard RMS already exist to either increase the amount of precipitation a region may receive (i.e., cloud seeding) or the amount that is captured and stored locally (surface and groundwater storage, limits on hardscape, or treat and reuse storm flows). These strategies seek to increase local supplies by capturing and storing additional storm water which currently may be going to a salt sink or out to the ocean. As a result, the project team believes these resources are appropriately considered part of the surface water supplies.

As a result, the project team suggests that two timeframes may be unnecessary. It is recommended that the assessment of marginal water supplies be revisited on a 5-year basis to ensure accuracy.

4.2 Regional Details

4.2.1 North Coast Region

Total water supplies for the region are estimated at one million acre-feet per year, with 35 percent of this supply developed from groundwater resources. Several communities are producing recycled water from their sanitary wastewater to help meet demand. Currently, the North Coast Regional Water Quality Control Basin (RWQCB) Plan requires tertiary treatment of discharges to the Russian River and restricts discharges to other rivers to protect water quality.[36] Recycled water is used for agriculture, golf courses, landscaping, and to recharge The Geysers steam fields in Sonoma and Lake counties.[37] The North Coast IRWMP calls for increased development of recycled and reclaimed wastewater to meet future demand and to help resolve environmental management challenges. The region expects to have

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[34] Swanson, Lori and Toby Roy. April 23, 2014. Personal Communication. San Diego County Water Authority.
[35] Public comments, April 25, 2014. CPUC public workshop.
[36] North Coast Regional Water Quality Control Board. May 2011. Water Quality Control Plan for the North Coast Region.
[37] DWR. December 2013. *California Water Plan Update 2013,* Volume 2 – Regional Reports, North Coast. Public Review Draft.

sufficient local resources to meet future demand in the near and long-term with its current water portfolio; there are no plans to import water supplies or develop any brackish or ocean water sources in the foreseeable future.[38]

4.2.2 San Francisco Bay

Approximately 70 percent of the San Francisco Bay region's water supply is imported from the Bay-Delta or the Sierra Nevada Mountains (Tuolumne and Mokelumne river supplies). To reduce the demand for imported supplies, local water managers are implementing projects to boost local supplies. These projects include recycling of wastewater, collection and storage of storm water, and desalting of brackish groundwater.[39,40] The region is projecting the need to continue to develop these types of local supplies to ensure reliability and resiliency in the face of uncertain imported supply availability and growing demand.[41] As stated in the region's IRWMP, "(a)s a high-quality, drought-proof local supply, desalination is an increasingly competitive water supply alternative for Bay Area Region water agencies." Regional water managers are considering additional regional desalination projects using the brackish Bay waters as the primary source to improve water supply reliability in the future. For example, the Bay Area Water Supply and Conservation Agency (BAWSCA) is conducting a Brackish Groundwater Field Investigation Project (Brackish Groundwater Project) which is evaluating the use of brackish surface water desalination to provide additional supplies for the Bay Area.[42]

4.2.3 Central Coast

Approximately 83 percent of the Central Coast Regions water supply comes for groundwater. The region is also dependent on imported surface water supplies. Small amounts of recycled wastewater are also available and currently ocean water is desalted to meet a small portion of the non-potable water demand, as mentioned earlier in this report.[43]

All of the sub-regions in the Central Coast Region are using or exploring additional desalted ocean water to address increase water demands due to population growth, constraints on existing supplies from the Carmel River, and reduced opportunities for new water imports.[44] For example, the City of Santa Barbara owns a desalination facility that can be brought into

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[38] North Coast Regional Partnership. July 2007. *North Coast Integrated Regional Water Management Plan: Phase 1*. Del Norte, Humboldt, Mendocino, Modoc, Siskiyou, Sonoma and Trinity Counties.
[39] Kennedy/Jenks Consultants. September 2013. *San Francisco Bay Area Integrated Regional Water Management Plan*.
[40] DWR. December 2013. *California Water Plan Update 2013*, Volume 2 – Regional Reports, San Francisco Bay. Public Review Draft
[41] Reinhard, M. et al. (2008). "Evaluation of Reverse Osmosis for Brackish Groundwater Desalination at Gilroy and Hollister, CA." Final Report submitted to Santa Clara Valley Water District, August 2008.
[42] Kennedy/Jenks Consultants, et al. September 2013. *San Francisco Bay Area Integrated Regional Water Management Plan.*
[43] DWR. December 2013. *California Water Plan Update 2013*, Volume 2 – Regional Reports, Central Coast. Public Review Draft.
[44] Robinson, Susan. February 22, 2008. *Comparison of the Six Central Coast Integrated Regional Water Management Plans and Recommendations for Collaborative Programs.*

operation if needed during severe drought or water shortage conditions; the high costs for desalination, and the time needed to bring the plant into operation, make the desalination plant the last supply option to be used during drought periods.[45] The City of Morro Bay, on the other hand, operates an ocean water and brackish groundwater treatment facility to augment local supplies and is actively pursuing energy recovery technologies that could lower the operational and maintenance costs from approximately $1,700 an acre-foot to approximately $1,200 an acre-foot.[46][47] In 2010, Sand City's Coastal Desalination Plant began producing potable water for the city's supply. The plant is capable of producing as much as 300 AFY using reverse osmosis technology.[48,49] The San Luis Obispo IRWMP update includes a project to study desalination options to boost local supplies.[50]

4.2.4 South Coast

Numerous water supply challenges face the South Coast Region and have resulted in a history of water managers leveraging all available supplies. Recognizing that surface water supplies are likely to decrease over time while demand increases, the region is implementing strategies to reduce their dependency on imported water supplies and boost local supplies. Even with conservation and efficiency, the region has set aggressive targets for increasing recycled water production, storm water capture, and ocean water desalination.[51] Groundwater accounts for approximately 28 percent of the total water supplies for the region and active conjunctive use programs are needed to address issues of overdraft and declining water quality. Currently, recycled wastewater helps to offset non-potable water demands, predominately for agriculture and landscaping. However, Orange County has been injecting highly treated recycled water into their local aquifer to combat salt water intrusion and augment the potable groundwater supplies.[52] The region already has several groundwater desalters that are needed to supplement potable supplies and prevent the migration of

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[45] RMC Water and Environment, Dudek, and GEI Consultants, Inc. 2013. *The Santa Barbara County Integrated Regional Water Management (IRWM) Plan 2013.* Prepared for the Santa Barbara County Water Agency.
[46] DWR. December 2013. *California Water Plan Update 2013*, Volume 2 – Regional Reports, Central Coast. Public Review Draft.
[47] Hemping, Ashley 2011. "Economic Analysis of Reverse Osmosis Desalination of Water for Agricultural Irrigation Applications," California Polytechnic State University. March 2011.
[48] "Sand City Coastal Desalination Plant" (2014). water-technology.net is a product of Kable. Copyright 2014 Kable, a trading division of Kable Intelligence Limited. Accessed June 9, 2014.
[49] City of Sand City. (2014) "Sand City Water Supply Project" http://www.sandcity.org/News_and_Events/Sand_City_Water_Supply_Project.aspx Accessed June 9, 2014.
[50] San Luis Obispo IRWMP Update: Full Project List Finalized. Volume 5, October-December 2013. http://www.slocountywater.org/site/Frequent%20Downloads/Integrated%20Regional%20Water%20Management%20Plan/IRWM%20Plan%20Update%202014/pdf/SLOC%20IRWMP%20Vol%205%20Brochure%20d10.pdf. Accessed March 17, 2014.
[51] Santa Ana Watershed Project Authority (SAWPA). 2014. "One Water One Watershed (OWOW) 2.0 Plan: the Integrated Regional Water Management Plan for the Santa Ana River Watershed". Adopted February 4, 2014.
[52] Environmental Protection Agency (2014). "Water Recycling and Reuse: The Environmental Benefits" http://www.epa.gov/region9/water/recycling/. Accessed June 9, 2014.

brackish groundwater to areas of higher groundwater quality. [53] Additional investments in desalting facilities are planned.[54]

Currently, a $1 billion ocean water desalination facility is under construction in the City of Carlsbad and is expected to provide the region with approximately 50 million gallons of water daily. The availability of the desalinated water is expected to address diminishing imported water supplies and significantly boost the reliability of local water supplies.[55] By reducing the dependency of imported water in various communities in the South Coast, the water managers can use transfers and exchanges to address demands in other portions of the region.

4.2.5 Sacramento River

The Sacramento River Region relies predominately on surface and groundwater to meet its water needs. However, with increasing demands and concerns regarding the long-term sustainability and reliability of these supplies, the region is pursuing additional water supplies. These efforts include expanding the development of recycled water supplies and seeking additional applications and markets for these supplies. The region is also remediating contaminated groundwater for re-use to the extent possible.[56, 57]

4.2.6 San Joaquin River

Water demand in the San Joaquin River Basin is dominated by agriculture. Local surface water supplies are insufficient to meet demand so the region imports water through state and federal programs. These supplies also support the conjunctive use programs and groundwater storage in the region.[58] Certain communities in the region are treating wastewater to tertiary standards to comply with waste discharge requirements, making this supply more attractive for recycling and re-use. As a result, increased production of recycled water is a key part of the region's efforts to increase local water supplies.[59] Other resources, such as brackish or saline supplies, are not considered practical supply options for the region in the foreseeable future.

4.2.7 Tulare Lake

Increasing demand and reduced imported supplies have significantly intensified the competition for available water supplies in the Tulare Lake Region. This coupled with

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[53] DWR. December 2013. *California Water Plan Update 2013*, Volume 2 – Regional Reports, South Coast. Public Review Draft.
[54] SAWPA 2014.
[55] http://carlsbaddesal.com/. Accessed March 17, 2014.
[56] Regional Water Authority. 2013. *The American River Basin IRWMP – 2013 Update*.
[57] Yuba County IRWMP Water Management Group. February 2008. *Yuba County Integrated Regional Water Management Plan*.
[58] WRIME. July 2007. *Upper Kings Basin Integrated Regional Water Management Plan (IRWMP)*. Prepared for the Upper Kings Basin Water Forum and Kings River Conservation District.
[59] Nakagawa, Brandon P.E., et al. July 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. Prepared for the Northeastern San Joaquin County Groundwater Banking Authority.

declining groundwater levels has required increased dependence on alternate water supplies that require much more treatment, such as recycled water and degraded groundwater, and expanded interconnections among the agencies.[60] As a result, recycled wastewater has become an important part of the region's water supply. This supply is used to recharge groundwater and irrigate crops. Beginning in the 1980s, water districts in the region began receiving oil field produced water that they then blended to provide water of sufficient quality to be re-used for groundwater recharge and irrigation purposes.[61] With constrained imported supplies, the region is now investigating cost-effective treatment methods to increase the amount of produced water that can be re-used to meet demands without relying on imported higher quality water supplies for blending. For purposes of this report, re-usable and recycled water supplies are classified together.

4.2.8 North Lahontan

Characterized by the smallest population of the 10 Hydrologic Regions, the North Lahontan region is home to only 0.3 percent of the state's residents. With widespread forests and a short growing season, the primary agricultural activity is cattle ranching. The region expects to have sufficient local resources to meet future demand in the near and long-term with its current water portfolio, consisting primarily of surface and groundwater and limited recycled water production.[62]

4.2.9 South Lahontan

Nearly a million people live in the South Lahontan Region, a region that has shown steady growth over the last decade concentrated mostly in its southern portion. With its arid climate, the South Lahontan region relies on surface and groundwater, imported, and recycled water supplies to meet the water needs of its communities and irrigated agricultural lands. Recycled water uses are increasing, providing needed water for groundwater recharge as well as for landscape irrigation. In the future, the demand for recycled water is expected to increase as fresh water supplies (especially imports) become more constrained and new uses, such as equipment cooling, and existing uses expand.[63]

4.2.10 Colorado River

The Colorado River and groundwater are the primary supplies for the Colorado River Region.[64] Other supplies include a small amount of imports from the Delta and recycled water. Water resource managers in the Colorado River Region anticipate significant increases in overall water demand as a result of population growth despite per capita demand reductions required under state law and increased development of energy projects in the area.

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[60] GEI Consultants, Inc. July 2007. *Poso Creek Integrated Regional Water Management Plan*.
[61] Kennedy/Jenks Consultants. November 2011. *Kern Integrated Regional Water Management Plan*.
[62] DWR. December 2013. *California Water Plan Update 2013,* Volume 2 – Regional Reports, North Lahontan. Public Review Draft.
[63] DWR. December 2013. *California Water Plan Update 2013,* Volume 2 – Regional Reports, South Lahontan. Public Review Draft.
[64] DWR. December 2013. *California Water Plan Update 2013*. Volume 2 - Regional Reports, Colorado River. Public Review Draft.

Agricultural water use is decreasing in part due to fallowing programs and changes in land use. Water from the Colorado River is also used for groundwater recharge and banking efforts are expected to be increased. Additional recycled water supplies and desalination of irrigation drain water and brackish groundwater are identified strategies to provide needed supplies in the future.[65]

4.3 Conclusions

The marginal water supply for half of the Hydrologic Regions of California is recycled water. Coastal regions with the exception of the North Coast have and are desalting ocean and brackish water supplies, with several communities actively investigating future desalination options. Increased water conservation and efficiency could avoid the need to develop additional desalination capacity. In general terms, as less expensive water resources are fully exploited, such as fresh surface and groundwater, regions are expected to increase investments in more expensive resources, such as poorer quality supplies that require more extensive treatment such as recycled or brackish/saline supplies, to meet demands.

[65] GEI Consultants, Inc. October 2012. *Imperial Irrigation District's Integrated Regional Water Management Plan.*

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Appendix A Approach for Vetting Regional Water Supply Options

Interviews and Public Workshop

As part of determining the water supply options for California's Hydrologic Regions, GEI Consultants, Inc. (GEI) first consulted readily available information to determine an initial list of supplies and the approach regions take in developing those supplies. Once compiled, GEI then contacted water management experts (including members of the Water/Energy Project Coordination Group [PCG]) to vet this supply information through informal interviews. In addition, GEI presented the results of this work at the April 25, 2014, PCG meeting and public workshop held by the California Public Utilities Commission later that day.

Questions explored during the informal interviews and meetings included:

- Are the supply options listed in the table representative of the various Hydrologic Regions' water supply portfolios being used or planned to be used for both the 0 to 10 year and 10 to 20 year timeframes in your opinion? If not, what would you change?
- Is the order in which the supply options listed roughly the order in which a region would choose to develop or expand its water resources portfolio? Is this order consistent with your agency's approach? If not, what is the ordering of the supply development options you pursue?
- What are your region's contingencies, not including conservation or efficiency (assuming these are not effective) for new water supplies?
- What water supply source would you most likely avoid developing if you could in your Hydrologic Region?

Appendix B California's Groundwater Use

2005-2010 Average Annual (Source: DWR, April 2014)

Hydrologic Regions	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Total Water Use[4] Met by Groundwater	
HR Name	TAF[1]	%[2]	TAF[1]	%[2]	TAF[1]	%[2]
North Coast	301.3	41%	60.0	40%	363.8	32%
San Francisco	76.1	74%	183.5	16%	259.5	21%
Central Coast	906.2	91%	211.3	71%	1,117.4	86%
South Coast	385.4	54%	1,219.6	31%	1,605.0	34%
Sacramento River	2,294.2	30%	428.6	47%	2,742.9	30%
San Joaquin	2,591.3	36%	414.1	58%	3,196.1	38%
Tulare Lake	5,662.5	52%	604.1	82%	6,295.5	54%
North Lahontan	118.4	27%	37.1	84%	166.2	32%
South Lahontan	270.6	72%	170.3	58%	440.9	66%
Colorado River	50.1	1%	329.7	57%	379.7	9%
2005-10 Ave. Total:	12,656.0	39%	3,658.1	41%	16,567	39%

Notes: 1) TAF = thousand acre-feet

2) Percent use is the percent of the total water supply that is met by groundwater, by type of use.

3) Statewide Precipitation for 2005-10 period equals 96% of the 30-yr average.

4) Total Water Use = Groundwater + Surface Water + Reuse