San Diego's Water Sources: Assessing the Options

Sponsored and published by the **Equinox Center**
Researched and produced by the **Fermanian Business & Economic Institute**

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Equinox Center is pleased to partner with the Fermanian Business and Economic Institute (FBEI) to present groundbreaking, independent research on San Diego County's water supply options. Our region's imported water supply is increasingly vulnerable due to structural, environmental and legal issues and is rapidly escalating in cost. This is creating a sense of urgency to develop more local, reliable and sustainable sources of water.

"San Diego's Water Sources: Assessing the Options" is the initial publication of Equinox Center's H2Overview Project, which will provide balanced, easy-to-understand research on San Diego County's water supply to help inform the decision-making process. The Fermanian Business and Economic Institute provides a sharp and thorough economic analysis and offers a new lens with which to view our different water sources.

As the region adds 750,000 more people in the next 20 years, it is important to prepare today for the difficult decisions our region faces to properly steward our water resources well into the future. We thank the many experts that were consulted during this process for their assistance in producing this research.

About Equinox Center

To ensure a healthy environment, vibrant communities and a strong economy for the San Diego Region, Equinox Center researches and advances innovative solutions to balance regional growth with our finite natural resources. We are proponents for our region's responsible growth and we support the conscientious care-taking of the natural and economic assets that we have inherited.

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The Fermanian Business & Economic Institute of PLNU

The Fermanian Business & Economic Institute is pleased to present its original research report, San Diego's Water Sources: Assessing the Options. Sponsored and published by the Equinox Center, our intention is to provide to the San Diego community a document that is in keeping with the highest levels of economic research, econometrics, modeling and analysis and yet present it in a highly readable format accessible to the widest possible audience. We have carefully considered the key issues related to the pressures associated with water as a scarce resource demanded by a growing regional population and attempted to research and address them so that all stakeholders have the information to make the critical decisions that will enhance our community and region. At the Fermanian Business & Economic Institute this is what we refer to as "actionable economics." We are grateful to the Equinox Center for its vital leadership on water issues, and look forward to additional opportunities to serve our community.

Randy M. Ataide, J.D.
Executive Director

About the Fermanian Business & Economic Institute

The Fermanian Business & Economic Institute (FBEI) is a strategic unit of Point Loma Nazarene University, providing the following services:

> Economic forecasting and events
> Expert business and economic commentary and speeches
> Professional and executive development events
> Business and economic roundtables
> Economic consulting and related services
> Economic studies and research
> Special projects

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EXECUTIVE SUMMARY

> Water is likely to be the most critical resource challenge that the San Diego region will face during the next two decades as it strives to achieve sustainable growth.

> Economic and environmental factors suggest that dependence on imports for the bulk of San Diego County's water is neither optimal nor sustainable. While imported water is likely to remain an important source for the region for some time, diversification into other sources will be necessary.

> Seven primary sources exist to address San Diego County's water demands: imported water, surface water, goundwater, desalinated sea water, recycled non-potable water, recycled potable water, and conservation.

> Imports from the Sacramento-San Joaquin River Delta and the Colorado River currently account for nearly 80% of San Diego County's water supply. Recycled water, only for non-potable purposes, meets about 4% of the region's demand. Desalinated sea water is not presently a source, although a desalination plant is expected to be completed in Carlsbad by 2012.

> Marginal cost estimates vary widely, but current estimates put the cost of desalinated sea water as the

Marginal Costs and Energy Intensity of San Diego County's Water Alternatives, 2010e

		Imported	Surface Water	Groundwater	Desalinated	Recycled Non-potable	Recycled Potable	Conservation
Marginal Cost ($/acre foot)	low	875	400	375	1,800	1,600	1,200	150
	high	975	800	1,100	2,800	2,600	1,800	1,000
Energy Intensity (kWh/acre foot)	low	2,000	500	400	4,100	600	1,500	negligible
	high	3,300	1,000	1,200	5,100	1,000	2,000	

e=estimated range

Source: FBEI

highest cost option at about $1,800 to $2,800 per acre foot. The cost of retrofitting the water infrastructure to a dual-pipe system also puts the estimated cost of recycled non-potable water at a relatively high level. While converting recycled water to potable levels entails additional treatment costs, the ability to use the existing water distribution system results in a somewhat more moderate marginal cost. In contrast, conservation carries a low marginal cost of $150 to $1,000 per acre foot. Surface and groundwater also have comparatively low costs, but they do not have the capacity to serve as major sources for San Diego County's water requirements.

> Concerns about the availability and cost of energy, as well as greenhouse gas emissions, make energy intensity a key issue in assessing the different water options. Desalination is the most energy intense solution, with an estimated requirement of 4,100 to 5,100 (kilowatt hours) per acre foot. In contrast, the energy intensity of recycled non-potable water is comparatively low at 600 to 1,000 kWh per acre foot. Direct energy costs for conservation are considered negligible.

> Legal, regulatory, technical, health, social, and environmental factors also are important to assessing the optimal mix of water options for San Diego County. The report presents a matrix ranking the alternatives across these various dimensions.

> Assessing marginal dollar cost, energy intensity, and the array of other major factors yields an overall ranking of the seven water alternatives. On a scale of 1 to 5, where 5 represents the most favorable/lowest-cost option, imported water and sea water desalination carry the lowest scores at 2.6 and 2.7, respectively.

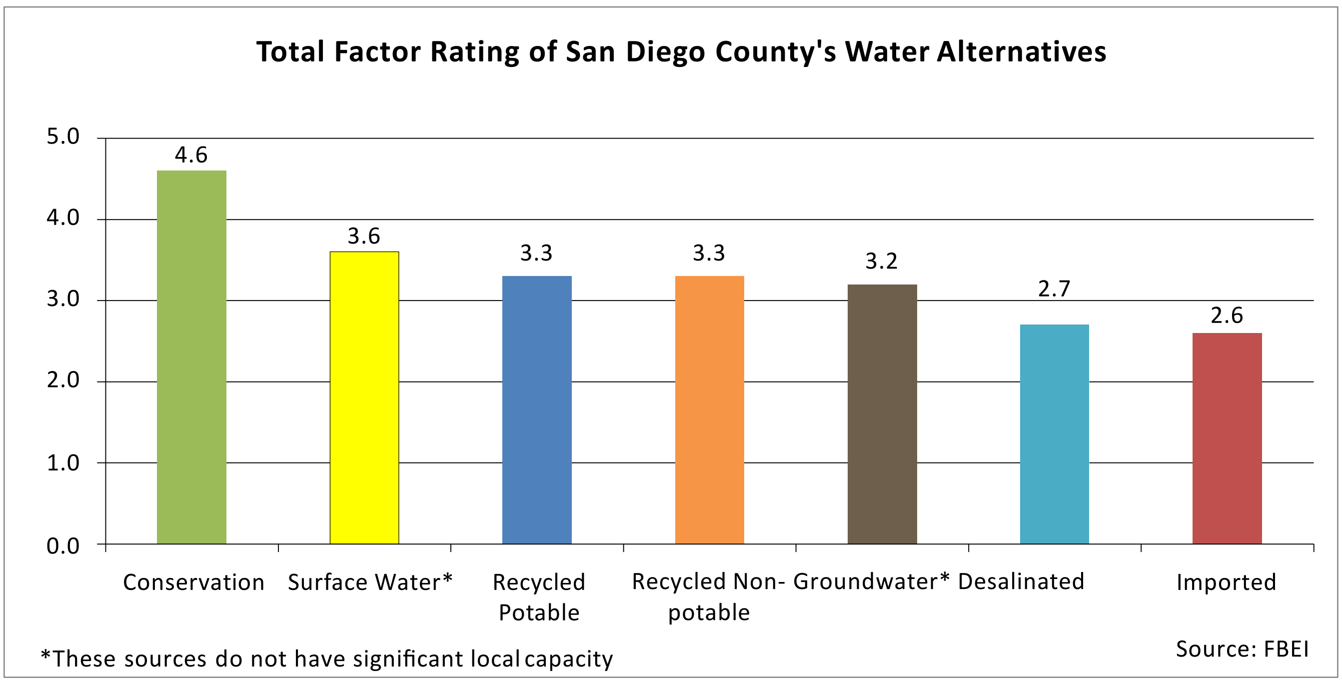
> Surface water and groundwater have relatively favorable scores of 3.6 and 3.2, respectively. However,

neither source has the capacity to supply a substantial proportion of the region's water supply over time.

> Recycled non-potable and potable water carry moderately attractive scores of 3.3 each. At $2 million/mile, the cost of the dual-pipe system poses the largest constraint to non-potable recycled water. Requirements that new residential construction incorporate dual-piping systems could help make the use of recycled non-potable water more feasible over time and locating satellite water recycling plants close to users could also help reduce water transportation costs. Public concerns over the safety of potable water pose the greatest challenge to that source, although public opinion appears to be shifting to more support.

> Conservation currently is and will remain the most favorable and least costly option over the next two decades. It carries a rating of 4.6. However, the extent to which conservation can reduce the region's water consumption as the population continues to grow over the next 20 years remains to be determined.

> These findings suggest that solving San Diego County's water challenge may also rest significantly on the demand side. Pricing water closer to its true marginal cost will be necessary to ration this most valuable and scarce resource.



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INTRODUCTION

Water is the world's most valuable commodity (*The Economist*, May 22nd-28th, 2010). As the pressures of a growing population clash with a limited resource and concerns about energy usage and the environment, it is vital that San Diego County plan strategically for its water future. Considering economic costs, energy intensity, legal, technical, social and other factors, what options should the region pursue to meet its future water demands? This report presents an analytical framework to address those questions and provides its conclusions on the optimal approach.

REPORT STRUCTURE AND METHODOLOGY

The first part of this report examines the current marginal costs of the different present or possible water sources for San Diego County. Projections for 2020 and 2030 are provided to shed light on how the relative costs of the various energy sources may change during the next ten and twenty years.

The second section analyzes the energy intensity of the different sources both to capture the impact on energy supplies and the magnitude of the "carbon footprint." The third section follows a less quantitative approach but analyzes the feasibility of the different water solutions based on legal, technical, safety, social, environmental, and other factors. The report ends with a section summarizing the rankings of the various water supply options according to these various criteria and concludes with recommendations for San Diego's water policy.

Estimates of marginal costs, energy intensity, and other factors were based on inputs from a number of different studies and water authorities from within San Diego County and elsewhere. (See Sources and References at the end of this report.) These estimates vary widely; the authors of this report used their best judgment based on the current state of knowledge in the field and projections of various economic and financial factors. Attention was paid to ensure that definitions of various concepts, such as marginal cost and energy intensity, were treated consistently across the different water source options. In most cases, estimates and forecasts are presented as ranges to portray the considerable uncertainty surrounding these issues and the different conditions that exist in the various local jurisdictions of San Diego County.

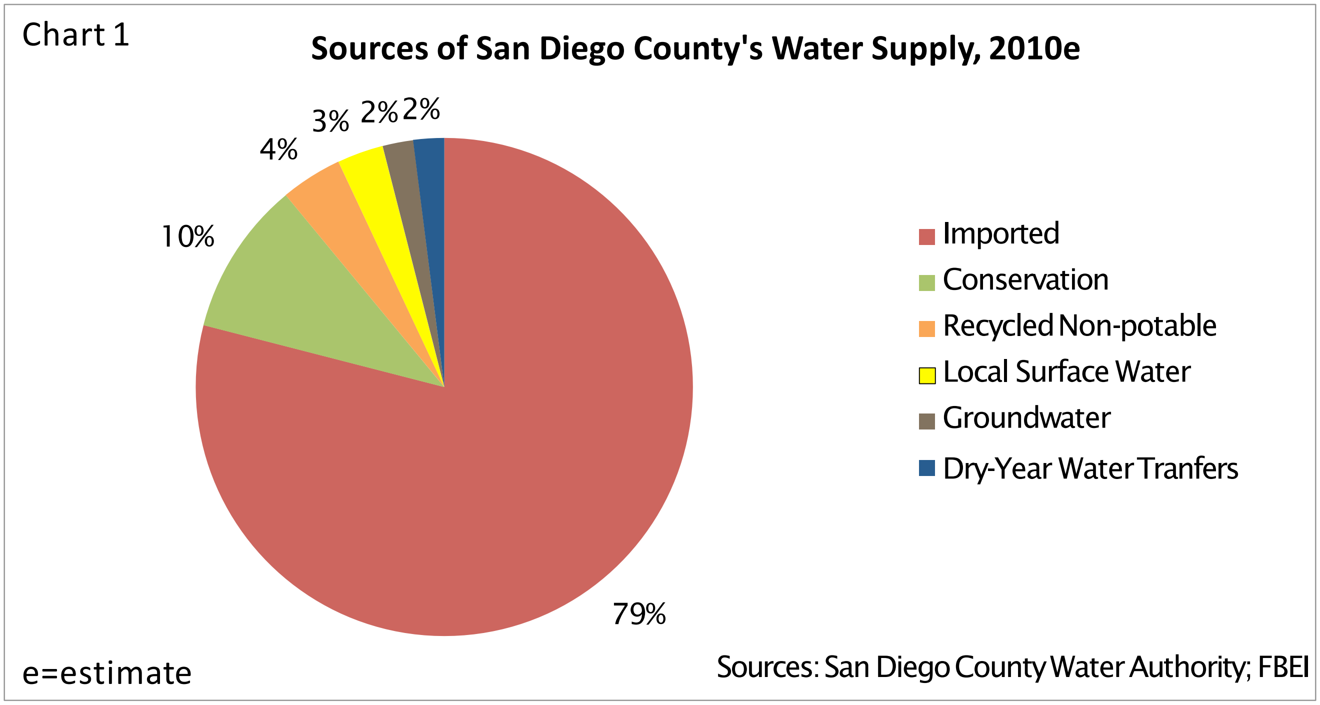
SAN DIEGO COUNTY'S WATER SUPPLY OPTIONS

Seven solutions to meet the water demands of San Diego County are examined.

Imported Water: Water from other areas can be imported into the region if available. Currently, San Diego County receives about 80% of its water supply from this source. (See Chart 1.) In 1991, 95% of the region's water was imported. About two-thirds of San Diego County's current imports come from the Sacramento-San Joaquin River Delta; the remainder comes from the Colorado River.

Surface Water: Surface water refers to water accumulated in local streams, rivers, and lakes from precipitation in various watersheds throughout San Diego County. It will represent about 3% of the region's total water supply in 2010. Drought conditions in recent years have reduced the contribution of surface water from a more typical 5% share. Two percent of this year's total water consumption will represent "dry-year transfers," refering to water brought in from substitute sources outside the region.

Groundwater: Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations. Some of it only requires that certain minerals be extracted to obtain potable water of desired standards, while other is brackish, requiring desalination. Groundwater currently accounts for about 2% of San Diego County's water supply.



Desalinated Sea Water: Potable water can be extracted from sea water as implemented in several facilities in North America. However, this is currently not a water source in this region. In San Diego County, a water desalination plant was approved in 2009 for Carlsbad, with completion set for 2012.

Recycled Water, Non-Potable: Wastewater can be recycled, partially treated, and used for landscaping, industrial, and other uses. Currently, San Diego County relies on this source for about 4% of its total water supply.

Recycled Water, Potable: Recycled water can be treated to potable levels, although this is currently notbeing done in San Diego County. With advanced treatment, recycled water can be added to existing water supplies in either underground basins ("goundwater recharge") or to open reservoirs. This is referred to as Indirect Potable Reuse, or IPR.

Conservation: Conservation, achieved by using less water or by using water more efficiently, is another option to meet San Diego County's water challenge. Currently, conservation has been able to replace about 10% of the region's potential demand.

WATER MARGINAL COSTS

This section analyzes the marginal costs of the seven alternative water solutions as of 2010. (See Table 1a and Chart 2.) Marginal cost is the cost of producing an additional acre foot of water (the volume of one acre of water that is one foot deep) and includes both operating costs and amortized fixed capital costs. Subsidies are not included. Operating costs encompass various expenses involved in the extraction, treatment, transportation, and distribution of water. The allocation of fixed capital costs represents both the investment in infrastructure and financing costs over time. The ranges indicated below allow for significant variation that may exist in different areas of San Diego County arising from, among other factors, variations in distance from water sources and treatment facilities.

Imported Water: Imported water currently carries a marginal cost with a range of $875 to $975 per acre foot. This reflects a marginal cost of about $535 per acre foot for untreated water from different sources, $215 for treatment, and $175 for other expenses, including transportation, storage, customer service, and the amortized costs of expanding conveyance capacity. The total represents primarily the wholesale cost the Metropolitan Water District charges the San Diego County Water Authority, which in turn is passed on to the 24 water districts in the San Diego region.

Table 1a

Marginal Costs and Energy Intensity of San Diego County's Water Alternatives, 2010e

		Imported	Surface Water	Groundwater	Desalinated	Recycled Non-potable	Recycled Potable	Conservation
Marginal Cost	low	875	400	375	1,800	1,600	1,200	150
($/acre foot)	high	975	800	1,100	2,800	2,600	1,800	1,000
Energy Intensity	low	2,000	500	400	4,100	600	1,500	negligible
(kWh/acre foot)	high	3,300	1,000	1,200	5,100	1,000	2,000	

e=estimated range

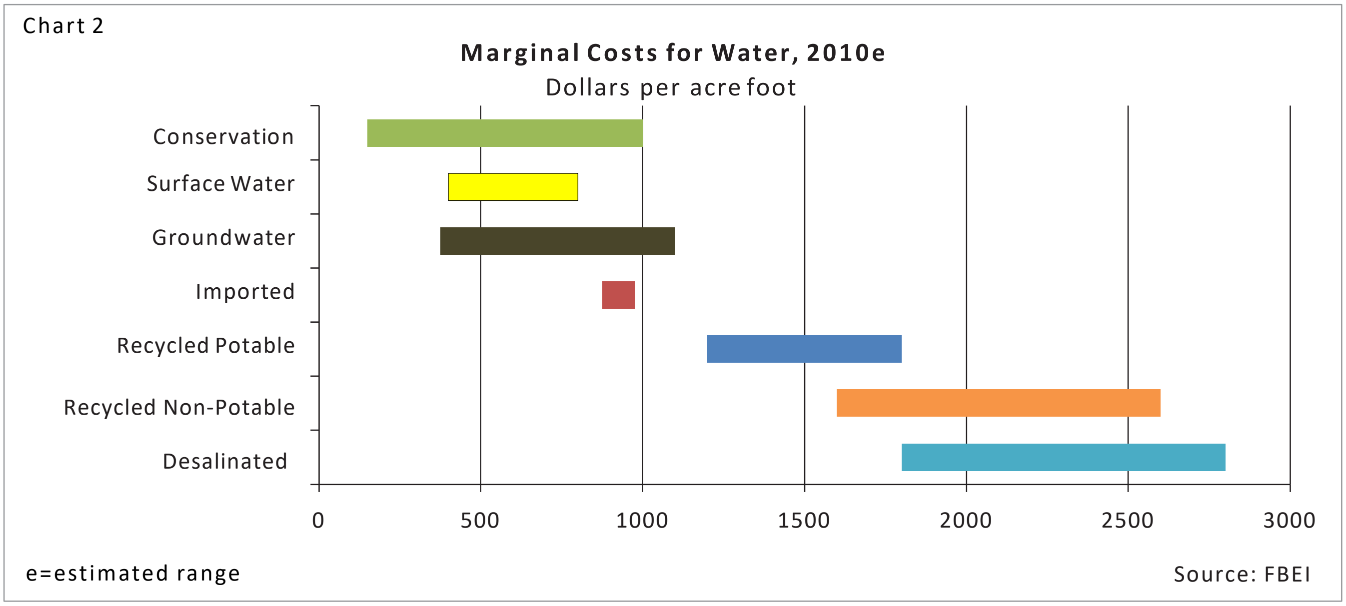
Source: FBEI

Surface Water: Surface water has a marginal cost estimated to range between $400 and $800 per acre foot. This represents treatment, pumping, distribution, and reservoir costs. Reservoir expenses encompass payments to the state for river usage rights and dam safety, brush clearance, habitat restoration, dikes to prevent contamination from diesel fuel and other elements, and dam improvements over time. The lowand high ends of the range represent primarily the differences between reservoir water levels in any given year, with pumping costs per unit considerably higher when reservoir levels are low.

Groundwater: Groundwater has a marginal cost that generally ranges from about $375 to $1,100 per acre foot. Much of the cost and variation reflect differences in required treatment methods to bring the water to potable standards. Fresh water may only need to be disinfected (usually with chloramines) and can have a lower cost than surface water which may require more treatment. This is the case for some of the less expensive water supply available, for example, from the Sweetwater Authority. Demineralization, however, may be required to remove iron and manganese. Where water is brackish, reverse osmosis is necessary along with disposal costs of the brine. Distribution and transportation expense of the water to and from the treatment facility also adds both to the total cost and its variability across the region.

Desalinated Sea Water: Desalinated sea water has a marginal cost ranging from about $1,800 to $2,800 per acre foot. Although advances in technology have helped reduce the cost of desalination over the past 15 years, the high energy requirements of this source make it the most expensive of the seven energy alternatives investigated in this report. A significant part of the cost and variability in costs of this option reflects the distances that sea water and potable water must be moved. For example, if a desalination plant is connected with a power plant, it can use the outflow from the once-through cooling system of the power plant to dilute the salty brine from the desalination plant before it is discharged back to the ocean. Where dilutants for the brine need to be brought to the plant, costs are substantially higher. It should be noted that California's State Water Resources Control Board voted in May 2010 to phase out once-through cooling systems, where ocean water is cycled through the plant and then returned to the sea, because of envirnomental concerns.

The choice of intake systems is also significant in terms of both the potential environmental impact and marginal cost. Large sea water desalination plants have typically used open sea, surface water intake systems, which can trap marine organisms in the intake screens. Subsurface intake systems, involving horizontal or vertical beach wells, infiltration galleries, or seabed filtration, can eliminate much of the impact on marine life, although costs will generally be higher than those associated with open sea, surface water arrangements. Such a design to mitigate ecological damage is being incorporated in a new plant in Adelaide, Australia, and is being considered for the proposed Camp Pendleton Desalination Project.



<u>Recycled Water, Non-Potable</u>: Recycled, non-potable water carries a marginal cost estimated at $1,600 to $2,600 per acre foot for the San Diego region. The size and variation of the cost of recycled non-potable water depend on the quality of the wastewater received, the standards required by the end users (such as with varying degrees of health concerns), the cost of treatment, and the distance between the recycling facility and potential users. Although there is a large supply of wastewater available for recycling, the capital costs required to install new distribution systems in San Diego County make the marginal cost of this source relatively high. Recycled water that is not treated to potable levels must be conveyed in a separate pipe system ("purple pipes") labeled and readily distinguished from traditional water lines.

In Orange County, the ability to install the necessary pipes as new communities were initially built in the Irvine Ranch Water District has helped to contain the cost of recycled water. About 25% of this district's water supply represents recycled water. The capital costs of retrofitting much of San Diego County's water system with new piping systems would be substantial, with it costing about $2 million per mile to install these pipes. Dual-piping systems (accommodating potable and non-potable water) could be installed at much lower costs at the beginning of new property developments. Currently, the Olivenhain Water District supplies about two million gallons per day of non-potable recycled water for irrigation to several cities in North San Diego County.

Last November, California's Building Standards Commission adopted a dual-plumbing code for the state. This should help clarify the requirements for installing potable and non-potable systems in commercial, retail, office, hotel, apartment, educational, and other facilities.

<u>Recycled Water, Potable</u>: Recycled potable water has a marginal cost estimated at about $1,200 to $1,800 per acre foot. Although the cost of treatment to potable levels adds about 10% to 15% to the cost of non-potable recycled water, the expense of conveying recycled potable water for reservoir augmentation is less than that required to construct an entirely separate system for distribution to customers as required for non-potable systems. Conveyance costs are still a factor for this source. In the specific case of reservoir augmentation at San Vicente Dam, a large pipeline would need to be constructed to transport the water to the reservoir and pumping costs would also be considerable. For other projects that have a closer source of recycled water or that are injecting recycled water into groundwater aquifers, such as is the case with the Helix Water District's proposed project, the conveyance costs would be significantly less.

Conservation: Conservation programs carry a current marginal cost of about $150 to $1,000 per acre foot. This measure reflects the estimated expenditures on educational initiative or subsidies to promote conservation divided by the cumulative water savings of the programs. For example, the marginal cost of a program to achieve greater water efficiency of dishwashers would be calculated as the total expenditures on rebates divided by the total water savings of the dishwashers over their lifetimes. Information on or distribution of water-efficient plants for landscaping represents a lower cost option. Mandatory restrictions have also been used, with their marginal cost reflecting the expense of publicizing and enforcing the restrictions.

Marginal Costs: 2020 and 2030

Table 1b

Marginal Cost Forecasts, 2020 and 2030
Constant 2010 dollars

		Imported	Surface Water	Groundwater	Desalinated	Recycled Non-potable	Recycled Potable	Conservation
Marginal Cost	low	1,479	600	530	3,391	2,861	1,929	336
($/acre foot), 2020	high	2,079	1,200	1,600	4,391	3,661	2,729	1,136
Marginal Cost	low	2,839	875	900	4,988	4,327	3,048	608
($/acre foot), 2030	high	3,839	1,750	2,500	5,988	5,327	3,848	1,508

e=estimated range

Source: FBEI

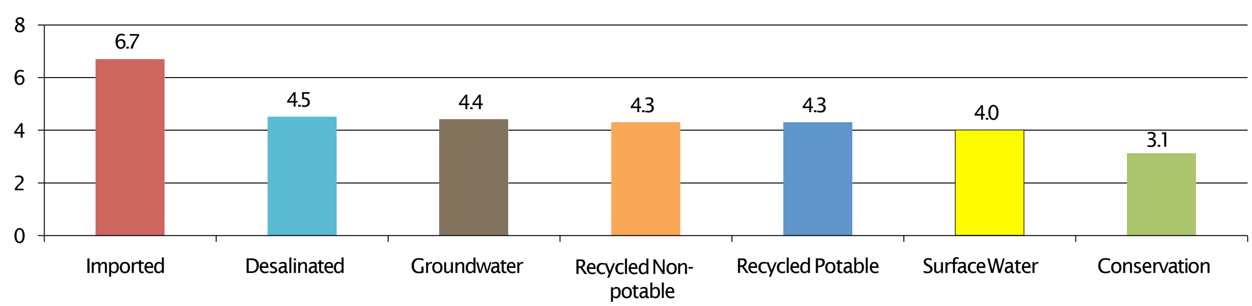
Based on the estimated path of energy costs, labor, interest rates, water demands from competing users, and other factors, marginal costs for the seven different water alternatives were projected for the next ten and twenty years for the San Diego region. These numbers are presented in terms of 2010 dollars. (See Table 1b, Chart 3, and Chart 4.)

Although the relative cost rankings of the different sources do not change (with desalinated sea water still the most costly option and conservation the least expensive), there is some change in the relative dispersion of costs across the alternatives. In particular, by 2030, the marginal cost of recycled potable water could be competitive with that of imported water.

The cost of imported water is projected to rise at a real (in addition to inflation) rate averaging 6.7% over the next twenty years. The ongoing growth of California's population will continue to press supplies available from the Sacramento-San Joaquin River Delta, while continued rights to supplies from the Colorado River are challenged.

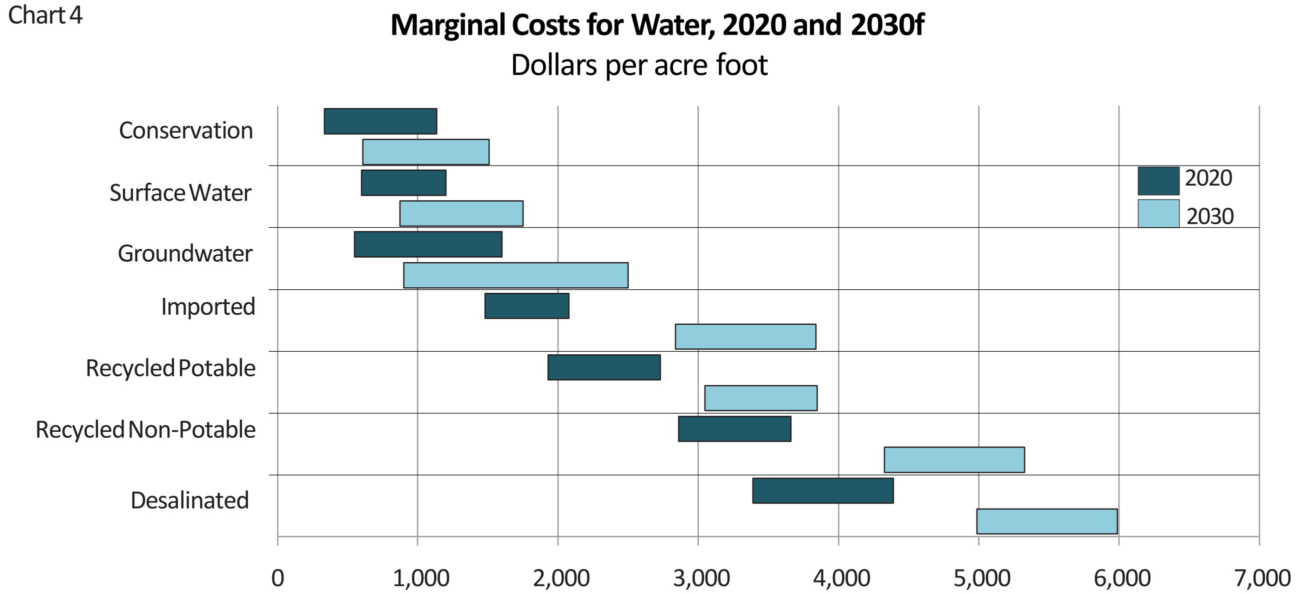
Chart 3

Projected Real Cost Increases, 2010-2030
Average annual percent change



Source: FBEI

Chart 4



f=forecasted range

Source: FBEI

The costs of labor, amortized expense of dam building and repair, and energy costs for pumping and treatment are forecast to push the cost of surface water up at an average rate of 4.0% over the next twenty years. Depletion of fresh goundwater could drive the cost of that source up at an average annual rate of 4.4% in the period through 2020, with greater pumping and treatment requirements.

The cost of desalinated water is forecast to rise at a relatively rapid real rate averaging 4.5% over the time period to 2030. Although technological advances could lower capital and operating costs, interest and energy expenses are expected to drive costs up at a significant pace.

The cost of recycled, potable and non-potable water is expected to increase at a 4.3% pace in real terms on average over the next twenty years. Although energy costs can be expected to continue to rise at a considerable pace, the cost increases could moderate in the second half of the twenty-year period if most of the infrastructure building and retrofitting was done earlier in the period.

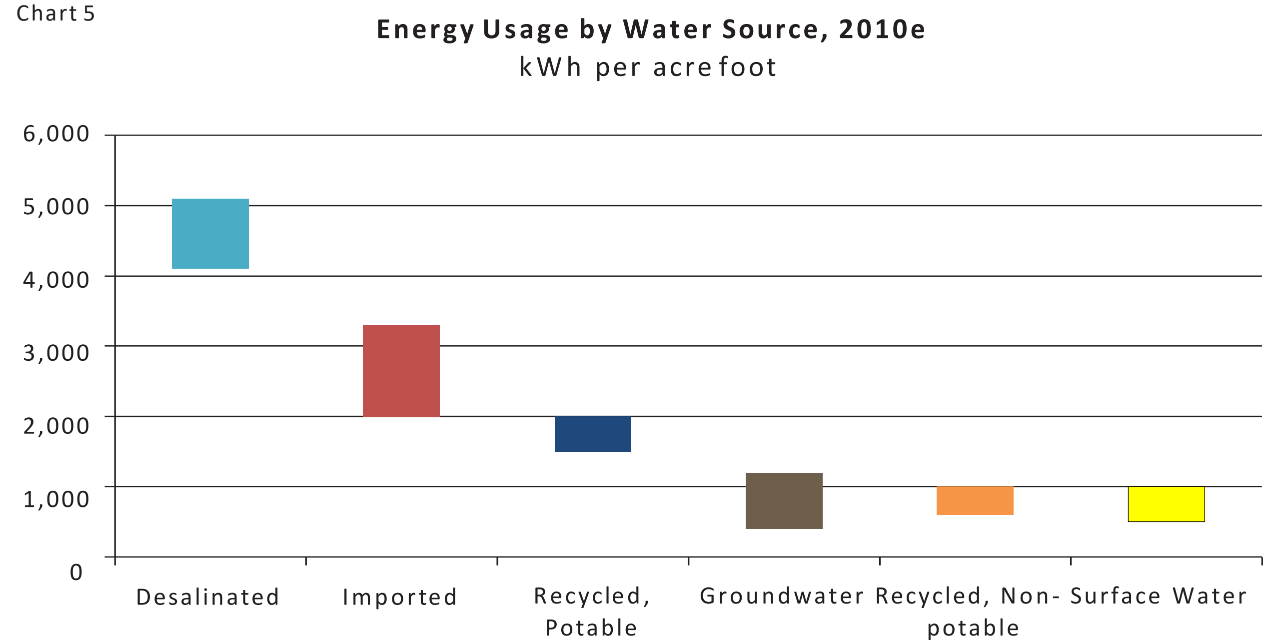
The marginal cost of conservation programs is projected to rise at a 3.1% real pace over the twenty-year period. Although new technologies could enhance water saving efforts, conservation programs could start to run into diminishing returns over the next two decades as the easiest and least costly options for water users are implemented.

ENERGY INTENSITY

According to a California Energy Commission 2005 report, water-related energy consumption accounts for nearly one-fifth of the state's total electricity usage. Energy usage for water is important to understand not only because of the implications for the state's total energy demands but also because of the implications for greenhouse gas emissions and the climate goals of the region. Estimates of the energy intensity of the different water alternatives are analyzed in this section in terms of kilowatt hours (kWh) per acre foot for 2010. (See Chart 5 and Table 1a.)

Imported Water: Imported water is quite energy intensive, requiring approximately 2,000 to 3,300 kWh per acre foot. Considerable transporatation costs keep this as a high-energy alternative.

Chart 5



e=estimated range

Source: FBEI

Surface Water: In contrast, the energy requirements of surface water are considerably lower, with a range of 500 kWh to 1,000 kWh per acre foot because of lower transportation and distribution requirements. Pumping accounts for most of the energy requirements from this water source, with treatment, transportation, and distribution responsible for the remainder.

Groundwater: The contrast of pumping fresh water to the requirements of possible demineralization and reverse osmosis take the energy range of goundwater from about 400 to 1,200 kWh per acre foot. The higher end of the range represents the energy demands from treating brackish water.

Desalinated Sea Water: Desalinated sea water carries the highest energy cost at 4,100 to 5,100 kWh per acre foot. Transportation costs and the plant energy costs involved in converting saltwater to potable water drive up the total. As noted above, "co-locating" a desalination plant with a power plant can eliminate the conveyance costs of water needed to dilute the brine, although the banning of "once-through" cooling systems could limit that advantage. Other transportation costs plus the energy intensity of the desalination process result in this water source being a high user of energy with a large "carbon footprint."

Recycled Water, Non-Potable: Recycled, non-potable, water is a relatively low energy user at 600 to 1,000 kWh per acre foot. Locating primary or satellite recycling plants relatively close to end users can help keep energy costs at the lower end of this range.

Recycled Water, Potable: Recycled potable water requires considerably more energy than its non-potable sibling because of the transportation costs necessary to convey the treated water to a storage reservoir, if this is the chosen treatment strategy. Energy costs for this source are estimated at 1,500 to 2,000 kWh per acre foot. Where significant pumping is required, such as is the case with the San Vicente Reservoir, energy expenditures could be substantial. The extent of treatment costs necessary to achieve desired quality standards for potability also adds to energy requirements.

Conservation: Conservation has no direct energy costs, although the manufacturing process of producing various energy-saving devices entails some energy usage. For the purposes of this study, the energy consumed by conservation is considered to be negligible.

OTHER FACTORS

In addition to marginal cost and energy considerations, a number of other factors are important in assessing the feasibility and desirability of different water solutions. This section discusses those factors, assessing them both as they exist currently and are expected to develop over the next twenty years. Table 2 presents a matrix which scores the seven water options on a scale of 1 (least favorable or highest cost) to 5 (most favorable or lowest cost). A wide range of sources and experts were consulted (see Sources and References) in developing these estimates.

Table 2

Factor Matrix for San Diego County Water Options*

	Conservation	Surface Water	Recyled Potable	Recycled Non-potable	Groundwater	Desalinated	Imported
Marginal Cost	5	4	3	2	4	1	4
Energy Intensity	5	4	3	4	4	1	2
Legal/Regulatory	5	3	2	3	3	2	2
Technical	4	5	3	2	4	2	3
Health/Safety	5	4	4	3	3	4	3
Social Acceptance	4	5	2	3	4	3	4
Environment	5	3	4	4	3	2	1
Availability	4	2	5	5	2	5	3
Reliability	4	2	4	4	2	4	1
Average	**4.6**	**3.6**	**3.3**	**3.3**	**3.2**	**2.7**	**2.6**

*Scale of 1 to 5, with 5 representing the most favorable/lowest cost

Source: FBEI

Legal and Regulatory: Water projects and solutions fall under the jurisdiction of local, state, and/or federal laws. Permit processes can often be lengthy with a number of legal challenges following. Desalinated sea water facilities face relatively high legal and regulatory constraints. For example, the Carlsbad desalination plant required 11 years of litigation and negotiation before the permit was received in 2009. Lawsuits have continued into 2010. Imported water also faces many legal hurdles in the period ahead as various parties dispute the rights to water from the Sacramento-San Joaquin River Delta and the Colorado River. Recycled potable water will be regulated by rigid health standards. Recycled non-potable, goundwater, and surface water are expected to face moderate legal and regulatory constraints. Conservation probably faces limited legal issues unless personal rights are disputed in the case of mandatory restrictions.

Technical: Technical factors refer to design or operational elements related to each water source alternative. Technical issues pose both upside and downside risk to some of the water options analyzed in this report. Technological advances could, for example, substantially lower costs over time for desalination and recycling. At the same time, problems can plague various water facilities, particularly as new technologies are applied or projects are moved from small-scale test facilities to large-scale operations. Desalination sea water plants are categorized with relatively high technical costs. For example, the plant in Tampa, Florida, the largest desalination sea water facility in North America, has encountered a number of design and construction problems. Non-potable recycling systems could encounter considerable technical issues. A risk for such systems is the possibility of "cross-connections" or an accidental connecting of potable and non-potable water systems, leading to contamination of potable water. Although the probability of such an event is low, the consequences could be serious.

Potable water recycling technologies also face considerable technical issues, particularly where users require that stringent standards are met, as well as possible contamination events. Imported water could face significant technical challenges in the future as the Sacramento-San Joaquin River Delta could require sophisticated redesign and construction (involving either a canal built above or tunnel below very soft substrata). Other sources face more limited technical challenges. Conservation, for example, may require the development of new technologies to achieve even greater water efficiencies than offered by the current array of available appliances. Technical issues with groundwater will primarily involve future treatment options. The technology involved in the storage and use of surface water is expected to change little in the period ahead.
Health and Safety: While all water alternatives, except conservation, carry some health risk, the extent of

water treatment processes put the quality of both desalinated and recycled potable water at comparatively high levels. Recycled non-potable water is not treated to the same level of standards because of its designated applications. Possible contaminants in groundwater, surface water, and from imported sources put them at a moderate level of health and safety risks, although treatment processes generally ensure that they are safe to consume.

Social: Social factors reflect the general public attitude towards different water options based either on confidence in the quality of water or impact on local residents (the "nimby''—"not in my backyard" mentality). Incorporating potable recycled water into the general water supply could face public resistance, although attitudes appear to be changing. A 2009 public opinion poll conducted by the San Diego County Water Authority found that 63% of respondants favor augmenting our potable water supply with recycled water, compared with only 28% who endorsed that approach in 2005. Desalinated water and recycled non-potable water plants could face opposition from local residents over possible concerns related to traffic, safety, or general views of the landscape. The other options face moderate social acceptance. Some consumers may be starting to be concerned over the pollutant discharges that occur in water from the Colorado River and Northern California. In the case of conservation, while many Californians see the need to conserve water, others will need to see a compelling case before they make significant changes in their lifestyles. Groundwater probably faces relatively little public resistance although there could be some concerns over contamination of underground aquifers. Surface water probably ranks highest in terms of social acceptance because of its long history as a community's water source.

Environment: The different water alternatives can affect various aspects of the environment in addition to energy and greenhouse gas emissions. The choice of water solutions can impact wildlife, vegetation, and the general ecosystem. Particularly because of their current and potential impact on various plant and animal species, both sea water desalination and imported water have relatively high environmental costs. The tapping of groundwater supplies could also have some significant effects on the environment. Capturing of surface water has possible environmental implications because of effects on water levels and wildlife habitats. Conservation clearly has the most positive impact on the environment. Recycling (both potable and non-potable) also carries benefits by considerably reducing the amount of untreated or only partially treated effluents that otherwise might be discharged into streams, rivers, and the ocean.

Availability: Availability refers to the amount of water that can be potentially supplied from each source. This factor measures the amount of the raw material resource assuming that the infrastructure to treat and convey it is in place. Availability is included in the scoring matrix because of the potential, or lack thereof, of the various options to play a significant role in meeting San Diego County's water demands. For example, limited supplies of both groundwater and surface water suggest that these sources will each account for only a small percentage of San Diego County's total usage on an ongoing basis. While San Diego County can be expected to continue to import large amounts of water, this source could be significantly constrained over time by global warming, climate change, and less precipitation. Reduced snow accumulations could substantially restrict the supply of water from the Sacramento-San Joaquin River Delta, while the Colorado River also faces reduced flows. In contrast, sea water and recycled water (both potable and non-potable) have abundant sources of supply. Conservation also has significant latitude to achieve changes in water consumption and practices.

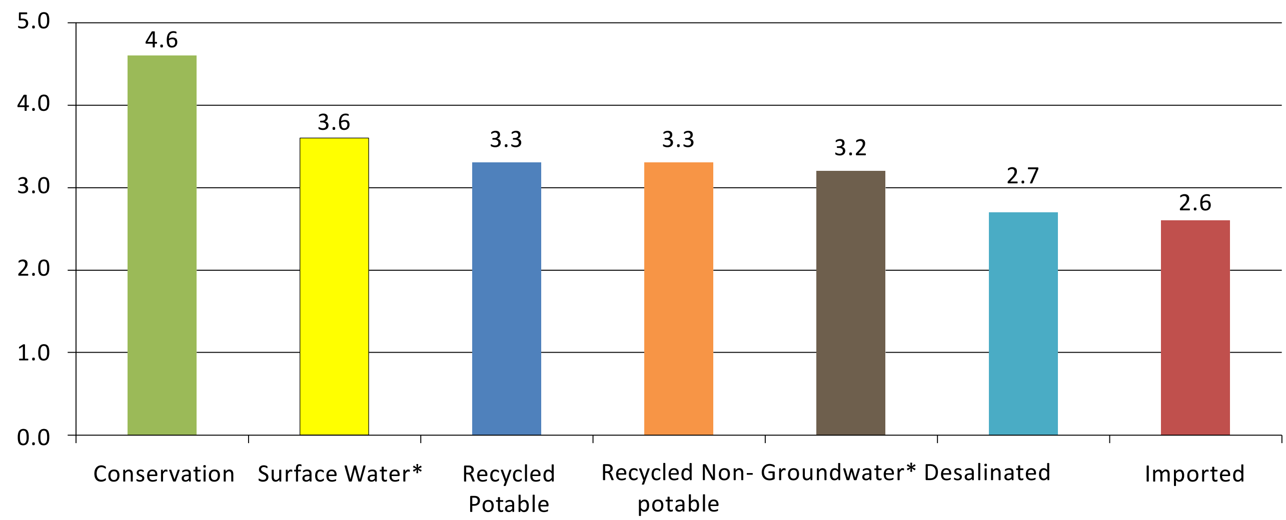
Reliability: Reliability refers to the amount of possible volatility in water supply from the various options. Many businesses are concerned about the access to a reliable source of water to run their operations, while individual consumers assume a ready access to water at all times. None of the water sources can be totally guaranteed. Imported water appears to face the greatest risk because of the possibility of drought conditions and natural disasters that would result in sea water intrusion in the Sacramento-San Joaquin River Delta or destroy pipelines and canals either in Northern or Southern California, thus impeding flows to the San Diego area. Groundwater and surface water face significant swings in availability because of changes in weather, climate, and precipitation. Desalination and recycling facilities could face temporary disruptions due to power failures, earthquakes, or technical problems. Even conservation cannot be relied on totally because of the failure of consumers to adhere to water restrictions or to change their behavior substantially. The inability of one single water source or option to be completely reliable argues for the importance of a diversified approach to meeting the region's waterdemands.

CONSOLIDATING THE RESULTS

Different water districts may have different priorities and resources. The matrix decision tool discussed in the previous section and shown as Table 2 allows policymakers and other interested parties to place different weights on the various factors, such as marginal cost or the environment, as they see appropriate. Using an equal-weighting scheme, where a simple average is taken of the nine different factors analyzed, the following results are produced. (See Chart 6.)

Chart 6

Total Factor Rating of San Diego County's Water Alternatives



*These sources do not have significant local capacity

Source: FBEI

Conservation appears as the most favorable/lowest cost option, based on this analysis, with a score of 4.6, a number substantially above that of any of the other alternatives.

Surface water has a moderately high score of 3.6. However, as noted above, it can only be counted on for a limited amount of the region's total water supply. Both potable and non-potable recycled water also have moderately favorable scores of 3.3 each. Groundwater's 3.2 score is relatively good, but like surface water, it is likely going to be able to contribute only about 5% to San Diego County's water consumption in a typical year.

Desalinated and imported water are the least favorable/highest cost options, with ratings of 2.7 and 2.6, respectively.

CONCLUSIONS

An analysis of current and projected marginal costs, energy intensity, social, health, legal, environmental, and other factors yields clear differences among the water policy options and directions San Diegan water districts may wish to pursue.

Economic and environmental factors suggest that dependence on imports for about 80% of San Diego County's water is neither optimal nor sustainable. While imported water is likely to remain an important source for the region for some time, diversification into other sources would appear to be necessary. A combination of different sources would be desirable, rather than relying on one approach. The results of this study, however, suggest that some approaches may merit more focus than others.

Although sea water desalination still might play a role in meeting our region's water demands, its high marginal cost and energy intensity, combined with a number of other considerations, render it the least favorable option along with imported water. While groundwater and surface water are moderately attractive alternatives, their limited availability will prohibit them from playing major roles in meeting San Diego County's water demands.

Recycled water, both potable and non-potable, has a moderately favorable ranking after considering the broad array of factors and would appear to have considerable potential in being part of the region's water "portfolio." The biggest constraint facing recycled water treated to potable levels is one of social acceptance. Clearly, to achieve a significantly higher use of potable recycled water a major educational drive would be necessary.

For non-potable purposes, the cost of retrofitting the region with a dual-pipe system to accommodate widespread use of recycled water poses the largest constraint to that source. Locating satellite recycling plants closer to large water users (such as agricultural entities) or to large numbers of households and commercial users could help mitigate some of the considerable transportation and distribution costs of recycled water.

Conservation appears as the most attractive of the seven water solutions analyzed for San Diego County by a wide margin. These findings suggest that solving San Diego County's water challenge may rest significantly on the demand side. For example, previous Equinox Center research revealed that appropriate water pricing (see www.equinoxcenter.org) is one tool that can spur significant water conservation. More research and modeling is needed before we can confidently project the extent to which conservation could reduce the region's demand for water as the population continues to grow over the next twenty years.

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