Bipartisan Legislative Summit

The State of Water in San Diego

Co-Chaired by:
Senator Christine Kehoe (D-San Diego)
Assemblyman Nathan Fletcher (R-San Diego)

Thursday, September 30, 2010

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2825 Dewey Rd, Ste 200, San Diego, CA, 92106
www.sdcoastkeeper.org : 619-758-7743

Welcome!

The San Diego region is at a crossroads when it comes to water supply, water quality and protecting our watersheds. Decisions made now will affect future generations and the ability of the biotech and high tech industries to thrive. We face a challenge to accommodate the estimated one million more people that planners predict will live here within another twenty years.

We take great pleasure in welcoming you to the region's first bipartisan Legislative Summit on the State of Water in Our Region. The discussions today will feature experts in water quality and water supply issues, whose insights on wastewater treatment options, stormwater discharge and resource conservation will help form the groundwork for potential action.

We thank the gracious sponsors of today's summit and applaud the diversity of those in attendance representing our business community, environmental advocates, community members, representatives from local agencies and elected officials from every level of government.

The culminating event of today's summit is a news conference to highlight how legislative actions at every level of government can provide the San Diego region with the tools necessary to meet the water supply and water quality challenges of the future.

It all begins with protecting our watersheds, working to diversify our water sources and assuring that there will be adequate water to meet the present and future needs of communities and businesses.

By working together, we will make San Diego the Clean Water Capital of America!

Sincerely,

CHRISTINE KEHOE	NATHAN FLETCHER	BRUCE REZNIK
Senator, 39th District	Assemblymember, 75th District	San Diego Coastkeeper
		Executive Director

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Agenda

Inaugural Legislative Summit
"The State of Water in San Diego"
UCSD Faculty Club, Atkinson Pavilion
Thursday, September 30th, 2010

Breakfast

7:30	Guests arrive, breakfast buffet open	
7:50-7:55	Welcome and Introduction……………..	David Field, *San Diego Coastkeeper President*
7:55-8:15	Summit overview & State of our Water..	Bruce Reznik, *San Diego Coastkeeper Executive Director*
8:15-8:30	Welcome……………………………….......	CA Senator Christine Kehoe California, *Co-Chair* CA Assemblymember Nathan Fletcher, *Co-Chair*
8:30	Breakfast adjourns	
8:30-9:00	Visit Courtyard stations	Stations Feature SDCK Programs that benefit San Diego's coastal and inland waters

Summit

9:00-10:00	***Session I: "Securing San Diego's Water Future"*** San Diego's water supply challenges and what are viable, sustainable & cost-effective options for the future.	**Moderator**: Assemblymember Nathan Fletcher **Overview**: Bruce Reznik, *SDCK* **Panelists**: Dennis Cushman, *San Diego County Water Authority*; Marion Paul *Equinox Center* & Dr. Lynn Reaser, *Fermanian Business Institute of Point Loma Nazarene University*; Michael Markus, *Orange County Water District*
10:00-10:10	********BREAK************	
10:00-10:55	***Session II: "Watershed Approach to Clean Water"*** How San Diego can use a watershed approach to effectively address water pollution and supply issues simultaneously.	**Moderator**: Senator Christine Kehoe **Overview**: Bruce Reznik, *SDCK* **Panelists**: David Gibson, *San Diego Regional Water Quality Control Board*; Noah Garrison, *Natural Resources Defense Council*
10:55-11:05	********BREAK************	
11:05-12:00	***Wrap-up & Next Steps*** ➢ Summary of Issues ➢ Legislative Solutions (towards a bi-partisan approach)	**Moderators**: Senator Christine Kehoe; Assemblymember Nathan Fletcher; Bruce Reznik **Legislative Solutions**: Linda Sheehan, *CCKA*
12:00	Summit concludes	

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Legislative Summit Co-Chair Biographies

Senator Christine Kehoe

Christine Kehoe was elected to the State Senate in 2004 to represent the 39th Senate District. She previously served in the State Assembly for two terms. From 1993 to 2000, she was on the San Diego City Council. She also served on the California Coastal Commission from 1997 to 2000.

When Senator Kehoe was elected to the State Assembly in 2000, she began to work on statewide water conservation efforts. It took two bills, AB 514 in 2003 and AB 2572 in 2004, but Senator Kehoe was successful in getting legislation passed that requires all areas of the state to have water meters installed on structures under certain timelines. It also requires that urban water suppliers bill customers based on the amount of water used.

In 2003, she carried legislation, AB 314, specifying that it is the policy of the state that desalination projects developed by or for public water entities be given the same opportunities for state assistance and state funding as other water supply and water reliability projects

When Senator Kehoe was elected to the Senate in 2004, there was no statewide coordination to access and use data for monitoring water quality. In 2006, Senator Kehoe's SB 1070 established the California Water Quality Monitoring Council which makes the data available to agencies and the public.

Last year, Senator Kehoe was part of a Delta Governance Working Group that met to help ensure that the Bay-Delta can get the infrastructure improvements it needs to continue to provide drinking water to 25 million southern California residents.

Senator Kehoe currently chairs the State Senate's Appropriations Committee and the Joint Legislative Committee on Emergency Management. She serves on the Senate Committee on Natural Resources and Water; the Select Committee on Coastal Protection and Watershed Conservation; the Select Committee on the Colorado River; the Joint Committee on Fisheries and Aquaculture; and the 2009 and 2010 Energy and Environment Task Force for the Council of State Governments. She served on the Governor's Blue Ribbon Fire Commission immediately following the 2003 wildland fires, and was the first chair of the Legislative LGBT Caucus.

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Assemblyman Nathan Fletcher

Nathan Fletcher is the State Assemblyman representing California's 75th District. He is the first combat veteran of the Global War on Terror to serve in the California State Legislature.

In his first months in office, Assemblyman Fletcher was instrumental in passing a major tax code revision that will help create jobs in the biotech and high tech industries. For this effort, he was named BIOCOM's Legislator of the Year. Additionally, he joint authored Assembly Bill 23 to help small business employees who've suffered layoffs retain their private health insurance.

So far in his first term, Fletcher has had eleven pieces of legislation signed into law. These include legislation relating to veterans, job creation, water infrastructure and health care. In the current year, he is focused on rebuilding California's public safety system, pension reform and modernizing state government. He is the author of Chelsea's Law - comprehensive legislation to reform the way California deals with violent sexual predators who target children. This landmark bill includes a true life without parole sentencing option for the most serious first-time offenders, fifty-one separate penalty increases for sex crimes perpetrated against children, the allowance for lifetime parole and polygraph testing for sex offenders on parole.

In 2007, Assemblyman Fletcher completed his service in the United States Marine Corps, where he worked as a Counterintelligence/Human Intelligence Specialist. On his last deployment, he served in the Horn of Africa region. For this duty he was awarded the Joint Service Commendation Medal and Global War on Terrorism Expeditionary Medal.

In 2004, he served eight months in the Sunni Triangle region of Iraq. Among the awards he received for this tour are the Navy/Marine Corps Achievement Medal with Combat "V" for valor, the Combat Action Ribbon and the Iraqi Campaign Medal. Nathan is a recipient of additional military awards including the Benton R. Montgomery Award for Excellence and the Walter Morris Honor Graduate Award. He is also a graduate of the US Army Airborne Course and Marine Corps Mountain Warfare Training Center.

Nathan is a tireless advocate for America's veterans and is a member of both the American Legion and the Veterans of Foreign Wars. Before being elected to the state legislature, Nathan served as an appointed member of the San Diego County Veterans Advisory Council, where he provided a strong voice for veterans of the Global War on Terror.

In his community, Nathan is a member of Nice Guys, a San Diego charitable organization which has provided millions of dollars to worthy causes. He is also active in the Lincoln Club of San Diego County and is a past Board of Directors member for YMCA Youth Summer Camps.

Assemblyman Fletcher serves as Vice Chairman of the Assembly Health Committee and the Select Committee on Biotechnology. He is a member of the Accountability & Administrative Review, Water, Parks & Wildlife and Utilities & Commerce Standing Committees.

Session I: "Securing San Diego's Water Future"

Dennis A. Cushman, Assistant General Manager, San Diego County Water Authority

Dennis Cushman is assistant general manager of the San Diego County Water Authority, a public agency that provides water to more than 3.2 million residents and supports a $174 billion economy. Mr. Cushman leads the Water Authority's externally focused water policy initiatives and programs designed to diversify and improve the reliability of the region's water supply. He oversees the Water Authority's imported supplies from the Metropolitan Water District of Southern California and leads the Water Authority's dry-year water transfer program, serving as lead negotiator on water transfer acquisitions.

Cushman directs the legislative advocacy programs of the Water Authority in Sacramento, California, and Washington, D.C., and oversees the agency's Public Affairs Department.

From 1997 to 2001, Cushman was director of the Water Authority's Public Affairs Department. Prior to his appointment as assistant general manager in August 2002, he was associate vice president of marketing and communications at San Diego State University, one of the largest universities in the U.S. Cushman has 20 years experience in public affairs and management in the public and private sectors. He holds a bachelor's degree in journalism from San Diego State University. Cushman and his wife, Deborah, have two children; they live in El Cajon.

Michael R. Markus, P.E., D.WRE, F.ASCE, General Manager, Orange County Water District

Currently Mike is responsible for the management of all operations in the District including a staff of 216. The District's primary role is to manage the local groundwater basin, which provides approximately 350,000 AFY of water supply to the area. OCWD's annual operating budget is $120 million.

During his 22-year career at the District, Mike was responsible for managing the implementation of the $480 million Groundwater Replenishment System program. This program included a $35 million design effort and the construction of seven individual projects, which amounted to approximately $400 million. The largest of the projects was the $300 million, 70 million gallon per day, Advanced Water Purification Facility. This project is the largest planned indirect potable reuse project in the world and has won many awards including the 2008 Stockholm Industry Water Award and the 2009 ASCE Outstanding Civil Engineering Achievement Award.

Mike obtained a Bachelor of Science degree in Civil Engineering from California State Polytechnic University at Pomona and a Master of Science degree in Civil Engineering from the University of Southern California. He is also a registered Civil Engineer in the State of California.

Marion Paul, Executive Director, Equinox Center

Marion Paul joined the Equinox Center in February 2009 as its first executive director. Marion has an extensive policy background, serving as senior policy analyst in the Colorado Governor's Office, executive director of Jobs for Colorado's Future, and as public affairs manager at the Denver Metro Chamber of Commerce. Her background includes planning for the Denver International Airport, developing regional cooperation, and assessing the cumulative impacts of multiple large projects in the Denver region.

Equinox Center is a non-partisan policy and research center helping San Diego County craft an intelligent and sustainable future, while enhancing economic opportunities for our residents. Equinox Center empowers community leaders, policy makers, and the public with trusted research, innovative approaches and hands-on tools to create a sustainable future, starting today. Equinox Center works at the heart of four major issue areas - water, land use, energy and transportation - through the lens of our three core values: healthy environment, strong economy, and vibrant communities.

Marion is a former board member of the San Diego Social Venture Partners, the San Diego Women's Foundation, and a member of the PLNU School of Business Advisory Committee. Marion holds a BA in Political Science and a BS in Geology from the University of Illinois.

Lynn Reaser, Ph.D., Chief Economist for Point Loma Nazarene University (PLNU) at the Fermanian Business & Economic Institute (FBEI).

The Fermanian Business & Economic Institute engages in economic analysis, modeling, and forecasting with practical and actionable recommendations for corporations, non-profit organizations, and government agencies. Dr. Reaser has deep experience in the financial services sector, including work during the past ten years as Chief Economist of the Investment Strategies Group at Bank of America. In this role, she provided the global and U.S. economic framework for investment strategy for high net-worth, institutional, and brokerage clients, encompassing over $500 billion under management.

Lynn is active in many professional organizations, including serving as current President of the National Association for Business Economics. She has been an advisor to many government policy officials and currently a member of the Council of Economic Advisors for California's State Controller. Dr. Reaser received her bachelor's, masters' and doctoral degrees in economics from the University of California, Los Angeles.

Session II: "Watershed Approach to Clean Water"

Noah Garrison, Project Attorney, Natural Resources Defense Council, Water Program

Working from each of NRDC's U.S. offices, the Water Program seeks to ensure safe and sufficient water for people and ecosystems in the United States. Noah Gibson joined NRDC in 2007, and has spent the past three years working on water related issues that include urban runoff and storm water, Green Infrastructure and Low Impact Development (LID) implementation and its relationship to water supply, energy use, and climate change, and enforcement of the Clean Water Act and California Porter-Cologne Act. Noah is a graduate of Wesleyan University and the University of California at Los Angeles School of Law, and holds a M.S. in Geological Sciences from the University of California at Santa Barbara.

Dave Gibson, Executive Officer, Elect, San Diego Regional Water Control Board

Dave Gibson graduated from San Diego State University in 1989 with a Bachelor of Science degree in Biology. At the Regional Board since 2000, Dave has worked in the Storm Water, Clean Water Act section 401 Certification, Grants, Non-Point Source, TMDLs and surface water quality monitoring and assessment. Prior to joining the Regional Board, he was an Entomologist and Watershed Biologist for the City of San Diego Water Department. He founded the San Diego Stream Team in 1998, a non-profit citizen monitoring organization that performs biological assessments of San Diego's rivers and streams. He has trained over 500 agency staff, tribal members, students, and members of the public on stream ecology, bioassessment, biocriteria, and wetlands protection in southern California. Dave Gibson is a fifth generation San Diegan.

Additional Speakers

Bruce Reznik, Executive Director, San Diego Coastkeeper

Bruce Reznik, a California-licensed attorney specializing in environmental law, joined San Diego Coastkeeper as executive director in August 1999. Under his direction, Coastkeeper has grown into the largest clean water advocacy organization in the region and has played a key role in helping reduce sewage spills and beach advisories and strengthen local water quality regulations to some of the best in the nation. Prior to joining Coastkeeper, Bruce worked to promote alternative fuels and clean air projects at a Los Angeles-based consulting firm. He earned his undergraduate degree from the UC Berkeley, his law degree from the University of San Diego, and completed environmental law coursework at George Washington University in Washington, D.C. He has served on numerous boards, including the United Way of San Diego, League of Conservation Voters San Diego, Vote the Coast, and the international Waterkeeper Alliance, and has been appointed to many local and state commissions on water quality. Bruce lives in North Park with his wife, Elizabeth, and their two dogs, Sasha and Bandit.

Linda Sheehan, Executive Director, California Coastkeeper Alliance

Ms. Sheehan brings 20 years of environmental law and policy experience to her work as Executive Director of the California Coastkeeper Alliance. Over the past 15 years, Ms. Sheehan has focused on protecting and enhancing the health of California's waterways and its world-renowned coast and ocean, implementing programs to ensure clean coastal waters with healthy flows and to safeguard marine ecosystems. She has achieved notable success in protecting the health of coastal waters by advancing legislation and policies to reduce polluted runoff, curtail sewage spills, increase coastal water quality monitoring, heighten enforcement of water laws, and make state water data readily available to all. For her efforts in "fight[ing] pollution of the Pacific and the streams and rivers that flow into it," Ms. Sheehan was recognized as a 2009 "California Coastal Hero" by Sunset magazine and the California Coastal Commission. Ms. Sheehan holds a B.S. in chemical engineering from the Massachusetts Institute of Technology; an M.P.P. from the University of California, Berkeley's Goldman School of Public Policy, where she was a Berkeley Policy Fellow; and a J.D. from the University of California's Boalt Hall School of Law.

San Diego Coastkeeper®

San Diego's water crisis is not a secret.

We import nearly 90 percent of our water from outside the region. In California, we use 19 percent of the state's energy to treat and transport it. Our main sources—the Colorado River and San Joaquin Delta—are drying up. And the *New York Times* recently detailed how cities such as San Diego are unable to closely monitor polluters.


The New York Times

Clean Water Laws Neglected, at a Cost


Board President David Field, Executive Director Bruce Reznik, Supervisor Pam Slater-Price, Mayor Jerry Sanders and Councilman Todd Gloria networking at San Diego Coastkeeper's 2009 Ocean Gala.

The good news is that San Diego's best defense is San Diego Coastkeeper—the region's leading environmental nonprofit protecting inland and coastal waters.

Coastkeeper employs legal, policy, education and advocacy efforts to lead San Diego's public and political debate on coastal stewardship, water quality and supply, pollution prevention and environmental education. It is part of Robert F. Kennedy, Jr.'s international Waterkeeper Alliance, one of the world's fastest growing environmental movements with nearly 200 independent member groups patrolling water on six continents.

Coastkeeper's hard work ensures that residents, businesses and our tourism-based economy can continue to depend on our pristine ocean for generations to come. In our fifteen-year history, Coastkeeper has played a pivotal role in helping to:

- Decrease sewage spills 90 percent in San Diego, including requirements for over $1 billion in sewage system upgrade
- Decrease beach closures 77 percent in the City of San Diego
- Elevate San Diego's urban runoff regulations to "best practices" in the state and nation, dramatically reducing pollution of our waters
- Engage 50,000 San Diegans to remove over one million pounds of trash from beaches and waterways
- Lead the region's largest and most comprehensive community-based water quality monitoring program
- Educate 160,000 local school children about water quality and pollution prevention through our hands-on, inquiry-based Project SWELL science curricula
- Secure San Diego's Marine Protected Areas—our "Yosemites under the sea," which are expected to be adopted in early 2011.

> ***"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."***
> —Margaret Mead

San Diego Coastkeeper is one organization protecting 100 percent of the coast.

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Securing San Diego's Water Future

We're in a water crisis. San Diego does not have enough local water to meet the county's demands, so we have to make important decisions on how to reduce our water needs and boost our supplies.

The popular mantra "reduce, reuse and recycle" belongs in San Diego's water supply planning just as much as it fits into our waste management philosophy. The reduction in demand, reuse and recycling of our resources helps keep our county cleaner and utilizes our assets to the very last drop. Prioritizing the "Three Rs" in developing San Diego County's integrated regional water plan will ensure smart decisions for our current water supply goals while establishing criteria for evaluation of future projects and programs.

One action is not the answer. To create a sustainable plan we need to act quickly on a thoughtful diversification of San Diego's water supply choices incorporating these options in a prioritized manner beginning with reducing the overall demand for water in our region.

REDUCE
It's basic math—the less water we use, the less water we need to supply. San Diego County is a semi-arid region, yet more than half of our residential water use goes to landscapes. Simple steps such as requiring new development to incorporate drought-resistant landscaping, incentives and pricing schemes that foster water-saving strategies among residential and business consumers, and conservation ordinances and education campaigns that encourage people to change their habits will dramatically reduce the region's water needs.

According to the California Energy Commission, transporting water throughout the state requires 19 percent of California's electricity, consumes 32 percent of the state's natural gas supplies and uses 88 million gallons of diesel. Water conservation is one measure that we can implement immediately to positively affect these numbers.

REUSE
Used water is an asset. Water that has been used still functions well in many applications. Our planet naturally reuses water in all stages of its cycle (rain becomes the ocean, which evaporates to become clouds, which then rain to become…), and so can we. In San Diego's desert climate, we have opportunities to capture our limited rainfall in rain barrels and utilize graywater (water from our bathroom sinks, showers, tubs, washing machines, etc.). These sources of water can fill essential needs for irrigation, plumbing systems and other uses.

Many, including the Environmental Protection Agency, view rainwater harvesting as a partial solution to the problems posed by water scarcity. Currently, the U.S. uses harvested rainwater and graywater mostly for irrigation; however, there is a growing interest in using rainwater for drinking and other indoor uses, though extra purification may be needed for these purposes.

RECYCLE
Water recycling can supplement water supplies by employing what's currently dumped into our ocean. Indirect Potable Reuse (IPR), where highly treated wastewater supplements local reservoirs, is recycled water so pure we can drink it.

IPR in San Diego means taking wastewater that would be discharged into the ocean through the Point Loma Wastewater Treatment Facility or other Publicly Owned Treatment Works (POTWs) and treating it to drinking water standards before it is used to recharge our local reservoirs. Most people aren't aware that we safely drink "toilet to tap" presently, as 400 million gallons of treated sewage are discharged into the Colorado River before it becomes our drinking water. And numerous cities already use similar projects, including Orange County, which currently produces 70 millions gallons of IPR water daily, enough for 500,000 residents.

The City of San Diego has a pilot project currently underway, and if successful, could ultimately provide up to 16 million gallons of advanced treated water per day from the city's existing reclamation facilities that currently provide water for non-drinking uses like irrigation. A second study is also underway exploring opportunities to build new plants that could reclaim 50 or 100 million gallons or more of water daily, which could potentially meet nearly half of the city's water needs.

OTHER OPTIONS

We need to support a comprehensive water policy - prioritizing how we get and use our water based on cost, environmental and energy impacts and reliability. First, we need to exhaust conservation and water efficiency, and then we should aggressively pursue water reuse and recycling. These options are cheaper, more energy efficient and more environmentally friendly than other options such as large-scale desalination, additional water transfers or even extensive purple-pipe (non-potable) projects.

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A Watershed Approach to Clean Water

We're all connected to the ocean.

San Diego's natural environmental makeup of eleven watersheds creates a unique drainage system directly to our ocean, bays, and beaches, carrying all of the pollutants, bacteria, pesticides, trash and other accidental remnants from our lives. To combat the flooding that can result from paving over natural surfaces, we compound environmental problems by channelizing streams and creating storm drain systems that allow our harmful left-behinds to bypass the organic filtering process.

Because we designed our stormwater infrastructure to empty directly into our waters, the rains act as a cleansing system for our roads, parking lots and buildings, which dump unfiltered, dirty runoff into our precious coastal and inland waters. Understanding San Diego's watersheds will help utilize low impact development to mimic nature in our built environment, which will allow the region to grow with our needs in a sustainable way.

LOW IMPACT DEVELOPMENT
Low impact development (LID) is a comprehensive land-use planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic system found in the local watersheds. LID's development techniques mimic nature without sacrificing quality in design.

LID is simple and effective. Instead of large investments in complex and costly engineering strategies for stormwater management, LID integrates green space, native landscaping, natural hydrologic functions and other techniques to generate less runoff from developed land.

SUPPORTING SMART DEVELOPMENT
LID is more than just site design. The approach and techniques can foster smart decisions about our development practices. LID does not replace local land use planning; rather, it is a complementary set of planning tools. LID works in concert with pedestrian- and transit-friendly, mixed-use communities with appropriate density, allowing us to maintain a significant portion of our landscape as natural systems.

PROMOTING INFILTRATION…
Not all pavement is bad, but covering San Diego County with non-porous roads, sidewalks and parking lots has severely damaged the region's ability to process rain and pollutants using its natural drainage systems. We've literally paved over it. One of the primary goals of LID is to reduce runoff volume by infiltrating rainwater to groundwater, evaporating rainwater back to the atmosphere after a storm and finding beneficial uses for water rather than dumping it down storm drains. The result is a landscape functionally equivalent to predevelopment watershed conditions, which means less runoff and less pollution entering our coastal waters.

Some common examples of LID techniques that incorporate infiltration are:

- porous pavement
- impervious surface reduction
- sidewalk storage

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…AND EVAPOTRANSPIRATION

This seven-syllable word describes the planet's evaporation and transpiration processes. Essentially it's a big word that denotes how water moves from land-based surfaces into the atmosphere and how water moves within plants, both of which are a natural part of the water cycle. Green spaces add aesthetic beauty to development, and they also can effectively remove nutrients, pathogens and metals from stormwater and reduce the volume and intensity of those flows.

We have been dealing with sewage and stormwater management for years, using conventional engineering and large-scale centralized facilities. LID offers a more natural approach, cleaning and managing the rainwater where it falls. Some examples of LID utilizing plants to help move and cleanse water include:

- native plant gardens
- rooftop gardens
- rain barrels
- tree preservation
- vegetated buffers

BENEFITS OF LID

The benefits of LID are numerous.

- It's effective—a simple, practical and universally applicable approach to reduce urban runoff and associated pollutants, while also offering opportunities to augment local water supplies through harvesting.
- It can also be cost-effective…and as LID becomes more universally implemented, the economical benefit will only continue to grow. Because many of the LID techniques accomplish multiple goals in one (reducing water and energy consumption, augmenting water supplies, controlling urban runoff, building aesthetics), it should be viewed as a smart investment in sustainable design rather than an additional cost.
- It's place-based. LID is also a flexible way to build a community because it utilizes small-scale water quality and volume control to be custom fit to the specific site.
- It's better for the environment, which means it's better for our communities and children.

Vision

Long-Term Water Resources Management Planning in San Diego:
Recommendations to Natural Resources and Culture Committee of the San Diego City Council
January 27, 2010

I. Introduction

San Diego, with over 1.3 million residents, still relies heavily on imported water to support its growing community.[1] Regionally, per capita use daily use of water was 164 gallons in 2009, a figure that is calculated based on residential, commercial and industrial consumption divided by the total number of residents in the County of San Diego.[2]

Recent state legislation[3] mandates a 20% reduction in regional per capita usage over the next ten years – a measure that is far more aggressive than accounted for in any of the current planning efforts that have been undertaken by the City. With the largest population of any of the water providers in the region, the City's actions and approaches will play a defining role in whether or not the region will be able to meet this mandate.

An opportunity exists to develop a vision and implementation plan that moves the City of San Diego in the direction of long-term sustainability.

United States per capita water consumption is remarkably greater than most other countries, including other developed nations with equal standards of living. Figure I shows 2002 water consumption data from the Organisation for Economic Co-operation and Development (OECD).[4] More recent data shows a greater disparity with an average of 169 gallons per capita per day (gcd) in the United States compared with 53 gcd in Australia.[5]

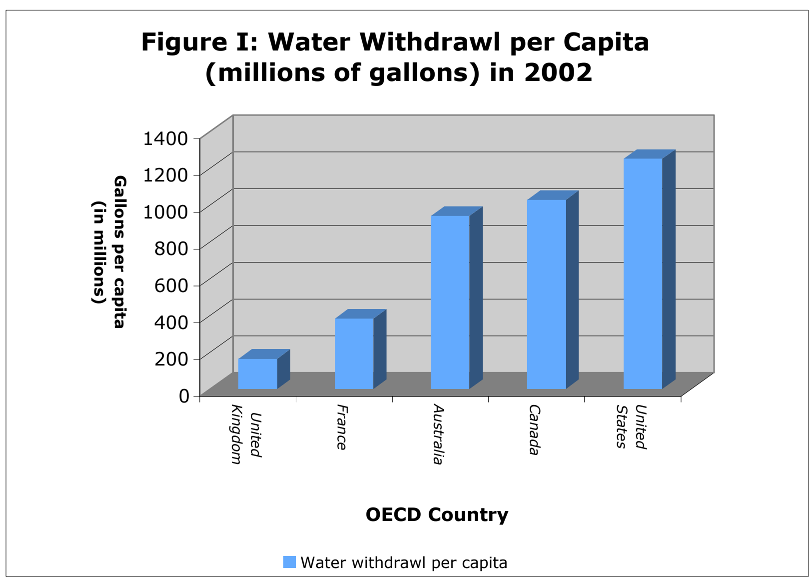


Figure I: Water Withdrawl per Capita (millions of gallons) in 2002

[1] The 2005 Urban Water Management Plan states that between 75% and 90% of all water is imported, relying 87% imported water in 2005 (p.35, available at http://www.sandiego.gov/water/pdf/uwmpfinal).

[2] Available at: http://www.equinoxcenter.org/regional-dashboard/water.html

[3] SBx7-7 legislative information available at: http://info.sen.ca.gov/cgi-bin/postquery?bill_number=sbx7_7&sess=CUR&house=B&site=sen

[4] Available at: http://www.oecd.org/dataoecd/42/27/34416097.pdf

[5] From presentation: *Australia and Water: Lessons for the US*, link to presentation available at: http://www.watersmartinnovations.com/2009/sessions-all.php?year=2009&SearchType=Speaker&search=59

II. Visioning and establishing a strategic framework for long term water management

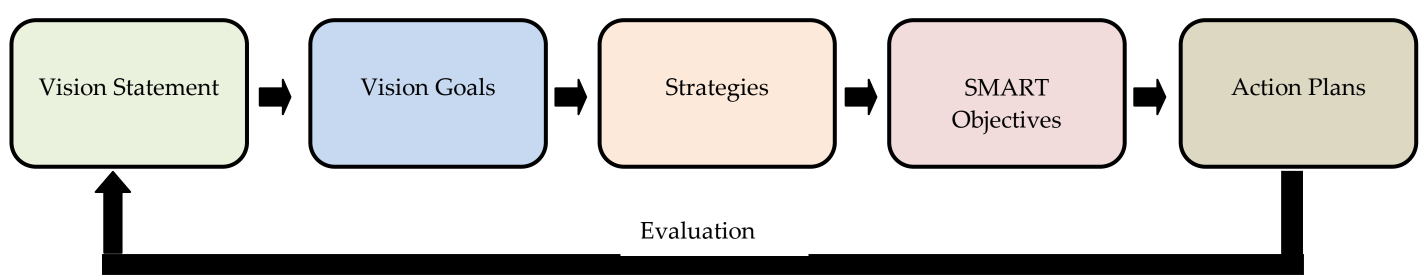
Through its *Long-Range Water Resources Plan (2002-2030)* developed in 2002, the City of San Diego took an important step in developing a strategic framework for water. As detailed in Section IV, however, this plan fell short in several areas and should be revisited and updated. Before addressing those details, however, it is important to take a step back and examine how a 'visioning process' should be undertaken.

Visioning is a process by which a specific group is tasked with identifying a long-term 'picture' of the future. This vision is then what sets the stage for identifying objectives and tactics to achieve these objectives. However, launching into identifying objectives without clearly envisioning what the end result is analogous to heading down a road without knowing where you are going.

A number of questions may be considered for driving the visioning process. For example, three critical guiding questions may be:[6]

1. If we allow San Diego's water supply to continue to evolve in the way it is now, what will our City look like in 50 years?
2. Is that what we want it to look like?
3. If not, what can and should we do about it?

Figure II: A Roadmap for Visioning



A basic visioning process, as illustrated in Figure, has six distinct elements:

Vision Statement

- A long-term 'picture' of the future; what the City should look like, feel like, be doing and be like at a point in the future

Vision Goals

- General statements of the direction in which the City wants to move; they are the "what" statements; they flow from the vision.

Strategies

- Key statements about the ways to enact goals from a broad, "best way to accomplish this" perspective
- Strategies must be prioritized (which means leaving things off the list, not simply reorganizing the list)

[6] These questions are loosely based on the State of Colorado's visioning process, as identified in the Colorado Water Conservation Board's June 2009 Study entitled "Strategies for Colorado's Water Supply Future".

SMART Objectives

- Measurable; who will do what when; they are "how" statements and are derived from and support the goals; objectives are also "SMART" (Specific, Measurable, Attainable/Actionable, Results-oriented, and Time-determinate)
- SMART objectives involve outside research to determine what is achievable (best practices)

Action Plans

- Support certain objectives; include tactics; last piece of plan to be developed; done only after a final budget and reviews have been completed.
- Within each strategy, there may be multiple tactics that will be more or less effective in helping achieve objectives.

Evaluation

- Allows a gauge of performance against pre-determined metrics; includes a 'feedback loop' and provides opportunities for adaptive management (so that plans become living documents).

An integrated planning process should consist of the following elements:

1. Active, meaningful stakeholder participation;
2. Rigorous examination of demand-side management as vigorously as supply options are explored;
3. The incorporation of multiple criteria in decision-making (reliability, cost, the environment, quality of life, recreation, climate, energy usage, etc);
4. Thorough exploration of risk and uncertainty;
5. Taking a long-term perspective.

The purpose of undertaking this sort of an exercise is to be able to move beyond a reactionary stance in terms of long-term water planning, towards a proactive approach where decision-makers and stakeholders set the course for how the City will function to secure long-term sustainable management of this resource.

III. A Possible Vision

While it would be premature to proclaim a final vision without undertaking the proper research and process, below is an example of what such a framework *could* look like.

Vision Statement

To ensure San Diego's long-term water security in an environmentally and economically sustainable way.

Vision Goals

To develop a comprehensive and forward-looking water portfolio that:

- *is Safe/protective of public health*
- *is Reliable & flexible*
- *is Affordable*
- *is Environmentally protective/beneficial*
- *is **Energy smart***
- *is **Municipally owned/controlled***

- ***Prioritizes most critical uses***

Most of these goals are included in the *Long-Range Water Resources Plan*; bolded items have been added.

Strategies

In choosing strategies, one often has to balance competing goals (cost-effective measures may not be environmentally friendly). However, when it comes to water supply strategies, most goals are not competing, and certain strategies achieve all or nearly all the goals far more effectively than other strategies. The City should not only prioritize these efforts, but invest most heavily in them.

San Diego's Water Supply strategies should include:

- *Conservation & efficiency*
- *IPR (decentralized)*
- *Rainwater harvesting*
- *Greywater*
- *Increased storage/more flexibility*
- *Small-scale/targeted purple pipe*
- *Small-scale/targeted desalination (subsurface intakes)*

- *Large scale purple pipe*
- *Large-scale or open-ocean intake desalination*
- *Additional transfers/peripheral canal*

Those strategies below the red line should not be pursued as they are the least effective at achieving goals established.

SMART Objectives

Examples of SMART Objectives for some strategies include:

- *Reduce per capita water usage by 20 gallons per day by 2012; 50 gpd by 2020*
- *Increase potable reuse by 16 mgd (daily average) by 2015; achieve 70mgd potable reuse by 2020*
- *Achieve 1 billion gallons of rainwater reuse annually (~3 mgd daily average) by 2020*

Action Plans

Action plans established to achieve the stated objectives could include some of the following tactics:

- *Conservation & efficiency*
    - *Permanent water restrictions (limits on watering lawns to 2 days a week, etc.)*
    - *Tiered pricing structures that promote conservation*
    - *Incentives/rebates to reduce usage (cash for lawns; low flow appliance rebates)*
    - *Education programs to change behaviors (publish reservoir levels weekly/daily in media outlets)*
- *IPR*
    - *Implement full-scale reclamation at North City (16 mgd additional reuse) by 2015*
    - *Build 2 addition reclamation facilities with a total capacity of 54 mgd to be operational by 2020*

Evaluation

- *Provide regular (e.g. monthly) progress reports to the City's Natural Resources & Culture Committee; regular (e.g. quarterly) updates to full Council.*
- *Engage outside stakeholders/peer reviewers in evaluation process.*
- *Develop adaptive management protocols to adjust for new information, changed circumstances.*

IV. 2002-2030 City of San Diego Long-Range Water Resources Plan

The City's stakeholder-driven process in developing the *Long-Range Water Resources Plan (2002-2030)* provided an excellent starting point for a comprehensive and forward-looking vision for San Diego's water portfolio. It is the perfect time for us to now to revisit and update the plan and ensure it is useful *to*, and used *by*, decision-makers and the public. The reasons this plan must be updated now are:

- The 2002 Plan was designed to be an adaptive management process. Phase I of the Plan has been executed through 2009 (as planned), providing an opportunity at this stage to revisit and revise the plan in order to account for additional information, and to reassess the situation for the next phase of San Diego's water management.
- This plan identifies planning objectives and performance measures, which may have been suitable for the political and technical climate of 2000-2002, but is not adequate given current circumstances. Specifically, the planning objectives do not consider the interconnected relationship between energy and water, the impacts of climate change on imported and local supplies, or watershed management and land-use considerations. A few of the areas that need to be updated and reassessed are:

Accurate financial calculations for all potential supply options. Some of the analyses conducted in the Long-Range Plan do not include financial costs associated with the development of distribution systems in order to move water from its treatment location to direct users. Such is particularly the case for ocean desalinated water and recycled water ("purple pipe"). Costs associated with distribution can be several million dollars to construct, particularly if the distribution systems are specifically for water of a lesser quality, as is the case for purple pipes transporting recycled water. Furthermore, the Long-Range Plan does not include Indirect Potable Reuse as a component of the future portfolio, although plans are underway in the City to proceed with IPR.

Incorporation of greywater and rainwater harvesting into the long-term water supply portfolio. Neither rainwater harvesting nor on-site greywater systems were considered in the Long-Range Plan. Residential greywater systems are allowed under SB 1258, and need to be factored into the Plan, with a particular emphasis on reducing landscape water needs. Rainwater harvesting employs a technology that has been around for centuries, and represents a shift from regarding stormwater as a nuisance that transports contaminants into waterbodies to a potential resource for regional sustainability.

Identification of Indirect Potable Reuse (IPR) Options. Similarly, IPR was not addressed at all in the 2002 Plan, likely a result of the Council's prohibition of allocating any resources towards IPR at that time. This needs to be corrected in the update, particularly in light of the ongoing pilot project at the North City Reclamation Facility and regional assessment of reuse options.

Acknowledgment of energy costs for water conveyance, treatment, and distribution. The 2002 Plan emphasizes importation as the key source for water. In 2005, the California Energy Commission authored an integrated energy policy report that examined the multi-faceted water and energy interlinkages. The report looks at the water used to generate various forms of electricity, as well as energy use to heat and transport water throughout the state of California. A number of conclusions have been identified, which have critical policy implications for any long-rage planning effort for water resources in the City.

Figure III below quantifies the energy used in both Southern and Northern California for the conveyance, distribution, and treatment of our water supply. Where it is commonly know that 19% of electricity and 32% of natural gas is used for water transport and treatment in California (Figure IV), understanding the discrepancy between Northern and Southern California emphasizes the necessity of a long-range planning effort that is inclusive of this data for long-term sustainability.

Figure III - Energy Embedded in Water: Northern and Southern California Comparison

	Northern California kWh/MG	Southern California kWh/MG
Supply & Conveyance	150	8,900
Water Treatment	100	100
Distribution	1,200	1,200
Wastewater Treatment	2,500	2,500
Regional Total	3,950	12,700

Source: California Energy Commission, 2005 Integrated Energy Policy Report

Figure IV: Water-Related Energy Use-CA 2001

	Electricity (GWh)	Natural Gas (Million Therms)	Diesel (Million Gallons)
Water Supply and Treatment			
Urban	7,554	19	?
Agricultural	3,188		
End Uses			
Agricultural	7,372	18	88
Residential / Commercial / Industrial	27,887	4,220	?
Wastewater Treatment	2,012	27	?
Totals	**48,012**	**4,284**	**88**
2001 Consumption	**250,494**	**13,571**	?
Percent of Energy Use	**19%**	**32%**	?
CO_2 e (Million Metric Tons)	**56**	**50**	

Source: California Energy Commission, 2005 Integrated Energy Policy Report

Inclusion of the impact of climate change on water resources. Climate impacts on water resources have been well researched, and the next iteration of the long-range plan must incorporate climate resiliency in into the strategy. Myriad impacts should be anticipated, including significant decrease in rainfall and the threat of a permanent drought in our region and in areas from which our water is imported. Additionally, climate change will reduce Sierra snowpack. The Sierras act as a natural reservoir of drinking water in the winter, releasing the supply in the spring as temperatures warm. As precipitation falls increasingly as rain instead of snow, this reservoir will be diminished. Additionally, warmer temperatures earlier in the year will cause snow melt at times when manmade reservoirs are unable to capture this water, further reducing available water supply throughout the year. Another impact is sea level rise. The resulting intrusion into freshwater supplies reduces the amount of available fresh water and increases the cost of purifying the water. This impact would be particularly detrimental to one of San Diego's main sources of water, the Sacramento/San Joaquin River Delta. Coupled with the increased agricultural demand for water resulting from warmer temperatures and the expected population increase in California, climate change impacts will exacerbate the already strained water supply situation in the state.

Incorporation of a watershed perspective and land-use considerations. The next iteration of the plan needs to pay special attention to the integrated watershed planning efforts that are underway in the City's nine watershed areas, and in particular the Low Impact Development strategies that are proposed for implementation. Low Impact Development attempts to tackle challenges of both water quality and water supply in an integrated manner.

Emphasis on conservation through tiered rate pricing structures. Water pricing needs to promote and reward conservation. The allocations-based method that has been successful from both a fiscal and water conservation standpoint in Irvine Ranch Water District (IRWD) can serve as a model for San Diego. However, tiered-rate structures in San Antonio, Texas may also serve as an example for San Diego in order to reach the goals that will be identified by Phase II of the Long-Range Plan.

V. San Diego Coastkeeper Recommendations – Moving Forward

While establishing a long-term vision and charting a course of action are critical for the region, the City does not have the luxury of waiting for a revised plan in order to make critical decisions now. Planning, however important, cannot be an excuse for delay or inaction. Therefore, City officials must move forward on dual tracks – (1) updating the 2002 plan (per above recommendations); while simultaneously (2) embarking on near-term actions using best evidence currently available.

The 2010 update of the Long-Range Plan needs to address the current context of water resources planning, include a visioning component, and be more aggressive in its conservation goals. Coastkeeper encourages the City to dedicate funds to hire a consultant to facilitate Phase II of this process. The time, attention, and funds dedicated to such a process now will pay dividends in future supply reliability, cost avoidance, and environmental stewardship. Our specific recommendations are below:

<u>Track 1: Updating the Long Range Plan</u>
Conduct a visioning process to create a working vision to help align water management efforts in the City of San Diego. Without a clear, agreed-upon vision, policies, planning efforts, and financial mechanisms will continue to be inconsistent, inadequate, and detrimental to the long-term sustainability of the region's water resources. The visioning process should include stakeholders representing all interests (fiscal / economic, environmental, etc.), and it should have a mechanism that allows for public comment and scrutiny.

Councilmember Lightner's memo of October 1, 2009 entitled "Updating the City Council's Water Policies" identifies the challenges that the current framework of water policies is facing. Stated concerns regarding purple pipe (nonpotable) and greywater systems should fold into the visioning process and set the stage for the revision of conflicting policies.

Convene a stakeholder conservation workgroup. We recommend this be developed under the auspices of the Natural Resources & Culture Committee in order to identify conservation goals and approaches for achieving those goals. Coastkeeper would encourage that the workgroup develop a standardized audit system for the region to help customers (both residential and commercial) achieve conservation targets. To date, the vision and strategies surrounding conservation have not been a true stakeholder process. Although input has been solicited during the public hearings prior to Stage 1 drought water restrictions, follow through on public input has been lacking. Although repeated assurances were made that Coastkeeper, or other members of the environmental community, would be included in the planning process for conservation, this has effectively been a closed process.

Develop an evaluation and adaptive management plan. The City should schedule a process for ongoing public review of this plan to ensure: (1) metrics are being achieved (2) adaptive management is undertaken if metrics are not being met or if circumstances change; (3) the long range plan update is integrated into other planning efforts (e.g. IRWMP); (4) the public and decision-makers are fully informed about the plan and progress to date.

Update the Lon-Range Plan in accordance with stated discrepancies identified in Section III above. The updated Plan should reflect recommendations outlined in this report.

Track 2: Near-term Actions

Develop and implement a pricing structure that rewards water conservation and financially penalizes water wasters. Steep tiers would ensure that demand on our water resources will be reduced, and that a steady stream of revenue will continue to flow to support the water department. Fixed service rates should not present a financial burden for low-income customers. Any additional funds received above and beyond the expected requirement for the operating budget should be channeled towards additional education and demand management technologies, and towards local supply enhancement – namely IPR, rainwater harvesting, and implementation of water efficiency solutions.

In October 2009, The Equinox Center[7] released a policy paper entitled *"A Primer on Water Pricing in the San Diego region,"*[8] which details the conservation, fiscal, and sustainability benefits of implementing a steep tiered rate structure for water pricing. This policy primer points out that a simple tiered structure is not sufficient to promote conservation behavior. Incremental rate increases that are substantial, such as those set out in the following examples detailed below for San Antonio Water System (SAWS) and IRWD, promote conservation in the long-term. IRWD, in particular, uses a allocations-based model which identifies a suitable rate of water consumption for each customer, and then levies a steep tiered rate structure for water users who consume in excess of that identified water budget for their property. IRWD has successfully achieved a 37%[9] rate of conservation since the implementation of the water allocations budget and steep tiered pricing structure in 1990.

The SAWS water rate structure was designed specifically to address severe demand fluctuations and ensure that conservation efforts were not undermined by seasonal or annual variation in precipitation. Rates were set to guarantee that conservation did not become a costly endeavor for San Antonio residents, and to minimize impacts on low income customers.[10] Before implementing the rates, SAWS analyzed its current water delivery challenges, and established numeric targets for conservation as goals it intended to achieve through the pricing measures.

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7 The Equinox Center exists to ensure a quality environment, vibrant communities and a healthy economy for the San Diego region, Equinox Center researches and advances best practices and innovative solutions to balance San Diego's regional growth with our finite natural resources. We produce and disseminate research papers, policy briefs, statistics, and maps and graphics all aimed at advancing balanced, integrated, regional approaches to San Diego's sustainability issues. From: www.equinoxcenter.org

8 Available at: www.equinoxcenter.org

9 Mayer, P. et al, May 2008 "Water Budgets and Rate Structures: Innovative Management Tools", American Water Works Association Journal.

10 Guz, Karen. Setting Rates, Conservation & Affordability. Presented at: Smart Water Innovations Conference, October, 2009.

San Antonio - MONTHLY VOLUME CHARGE[11]

	INSIDE CITY LIMITS RATE PER 100 GALLONS		OUTSIDE CITY LIMITS RATE PER 100 GALLONS	
Step in gallons	**Standard**	**Seasonal**	**Standard**	**Seasonal**
First 7,481	$0.0906	$0.0906	$0.1176	$0.1176
Next 5,236	0.1309	0.1423	0.1702	0.1850
Next 4,488	0.2058	0.2217	0.2674	0.2882
Over 17,205	0.3288	0.4246	0.4274	0.5519

The Volume Charge "Seasonal" Rate Per 100 Gallons shall be applied to all billings beginning July 1 and ending on or about October 31 of each year. At all other times the Volume Charge "Standard" Rate Per 100 Gallons shall be utilized.

Irvine Ranch Service Area / Potable Water[12]

Monthly water service charge		$7.75 (up to a 1" meter)	
	Tier	Percent of Allocation	Cost per ccf
	Low Volume	0 - 40%	$0.91
	Base Rate	41 - 100%	$1.15
Commodity charge	Inefficient	101 - 150%	$2.33
	Excessive	151 - 200%	$4.65
	Wasteful	201+%that promotes	$9.30

Additional pricing solutions must be researched in order to guarantee that pricing is consistent across all sectors, and working in a way to achieve identified water management goals. Analyses of commodity vs. fixed rates could also be included as a part of this research, as well as viable options to move towards tiered rates for businesses.

Implementation of Indirect Potable Reuse (IPR) Options. The City should continue with the Design, Build Operate component of the demonstration project at North City (vote likely in summer). Assuming results of that demonstration project are positive, a full-scale project to maximize reclamation at North City (~16 mgd to augment San Vicente Reservoir) should be implemented. Additionally, based on results of the regional assessment of water reuse options, the City should pursue water reclamation projects that best meet the goals of the 2002 Plan (or updated long range plan if available at that time). Finally, a review of the rate case and sewer and water cost of service should be conducted to ensure that the IPR analysis is included.

San Diego Coastkeeper looks forward to working with the City to implement these recommendations.

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11 Available at: http://www.saws.org/service/rates/resident.shtml

12 Available at: http://www.irwd.com/AboutIRWD/rates_residential.php ; note that one CCF is equal to 748 gallons

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San Diego's Water Sources: Assessing the Options

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

July 2010

Healthy Environment

Strong Economy

Vibrant Communities

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.

www.equinoxcenter.org
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LETTER TO THE READER

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	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

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.

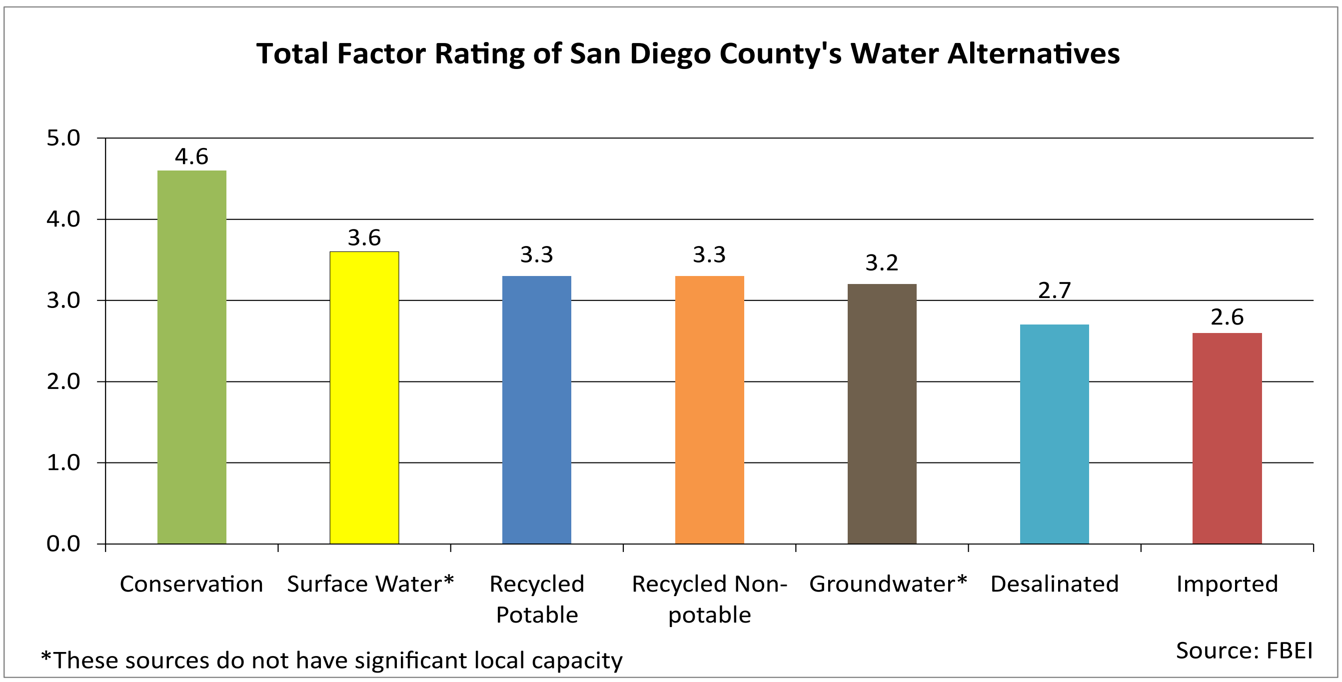
> Surface water and groundwater have relatively favorable scores of 3.6 and 3.2, respectively. However,

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 and Methodology Addendum 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

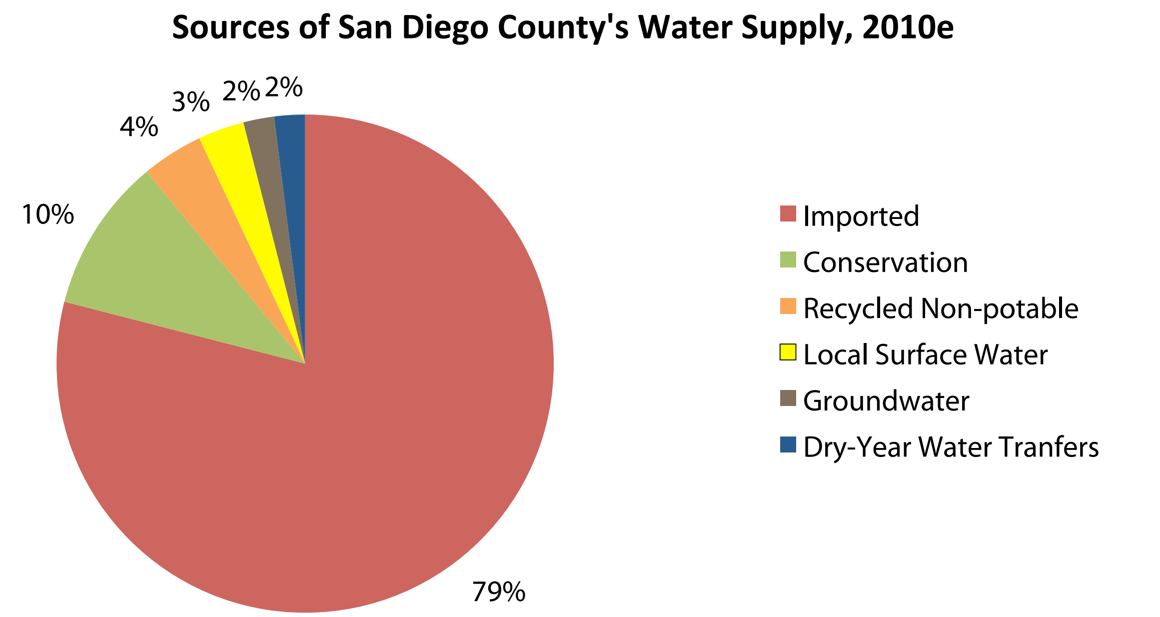
Seven solutions to meet the water demands of San Diego County are examined.

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.

Chart 1



e=estimate

Sources: San Diego County Water Authority; FBEI

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 not being 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

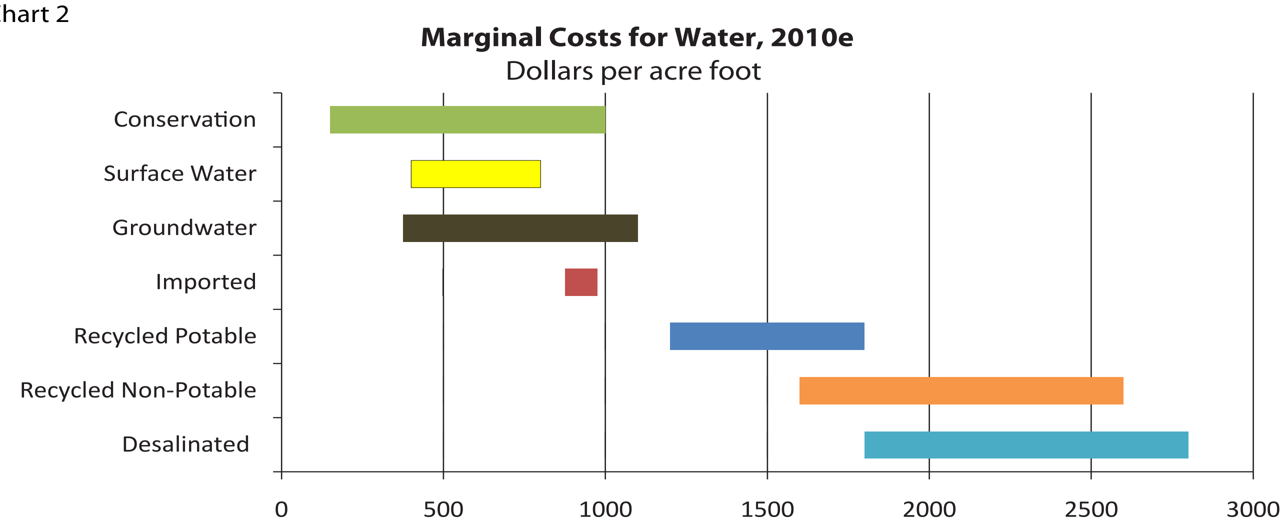
Surface Water: Surface water has a marginal cost estimated to range between $400 and $800 per acre foot. This represents treatment, pumping, distribution, and reservoir costs. Reservoir expenses encompass payments to the state for river usage rights and dam safety, brush clearance, habitat restoration, dikes to prevent contamination from diesel fuel and other elements, and dam improvements over time. The low and 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.

Chart 2



e=estimated range

Source: FBEI

Recycled Water, Non-Potable: 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.

Recycled Water, Potable: 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.)

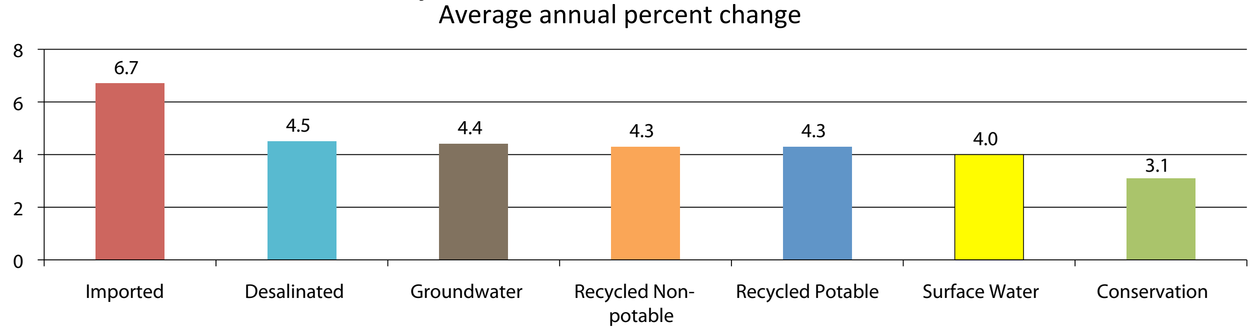
Although the relative cost rankings of the different sources do not change (with desalinated sea water still the most costly option and conservation the least expensive), there is some change in the relative dispersion of costs across the alternatives. In particular, by 2030, the marginal cost of recycled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

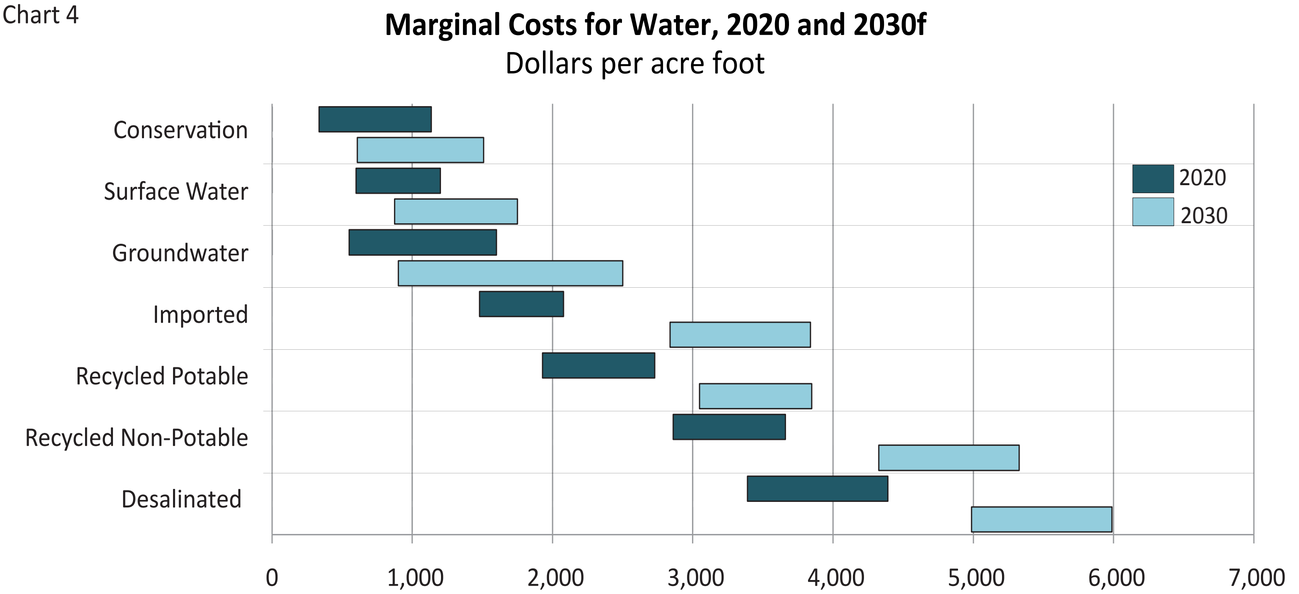
Projected Real Cost Increases, 2010-2030

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.

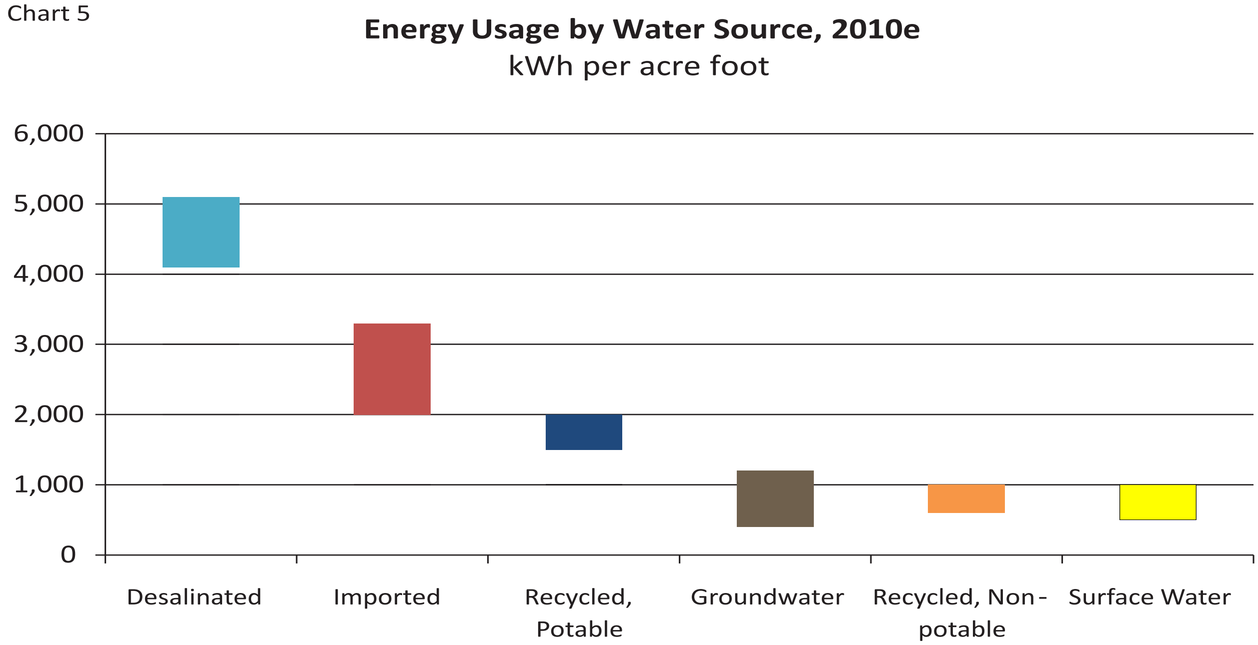
The marginal cost of conservation programs is projected to rise at a 3.1% real pace over the twenty-year period. Although new technologies could enhance water saving efforts, conservation programs could start to run into diminishing returns over the next two decades as the easiest and least costly options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

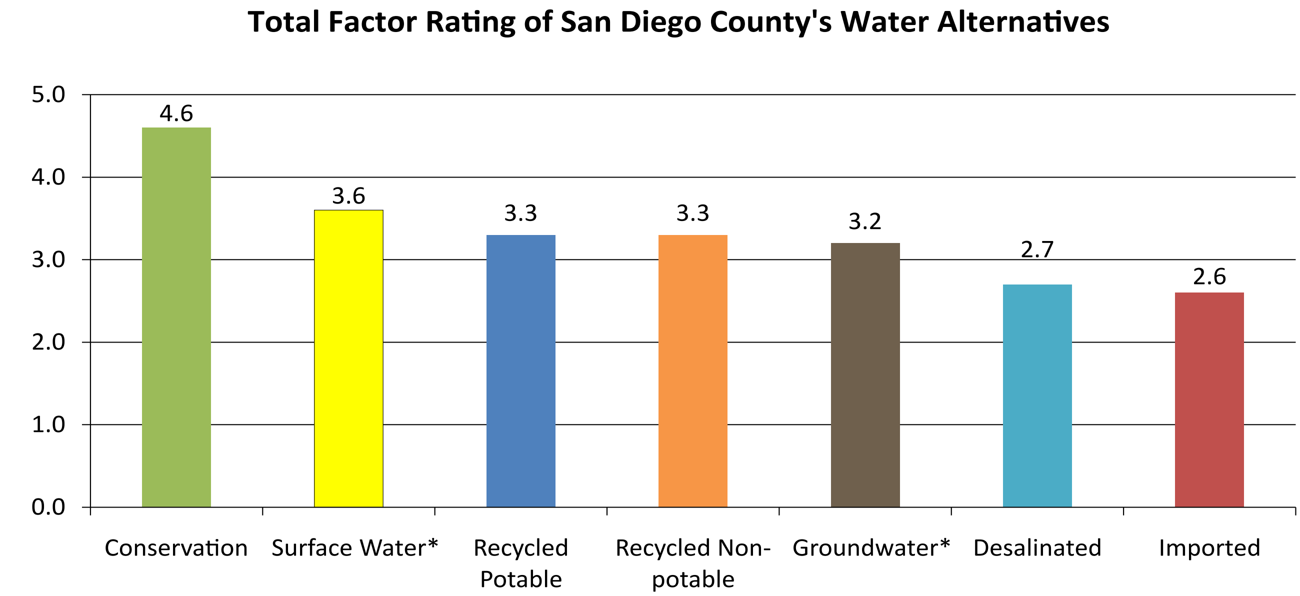
Availability: Availability refers to the amount of water that can be potentially supplied from each source. This factor measures the amount of the raw material resource assuming that the infrastructure to treat and convey it is in place. Availability is included in the scoring matrix because of the potential, 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 water demands.

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



*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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METHODOLOGY ADDENDUM

As discussed in the "Report Structure and Methodology" section, the estimates of marginal cost and energy intensity reflect the judgment and economic assessment of the author after consulting with various experts and studying a wide range of studies and reports. The ranges presented are intended to reflect what might be typically experienced in San Diego County, while allowing for geographically-specific conditions within the County, as well as the uncertainty over the actual results that might be experienced in the case of new facilities, technologies, or applications introduced into the region.

The following describes some of the specific sources consulted, methodology, and assumptions used in deriving marginal cost and energy intensity for each water alternative analyzed.

Imported Water: Marginal cost data was based primarily on data supplied by the San Diego County Water Authority (SDCWA), with the range reflecting differences in amortized costs of expanding conveyance capacity by the different utilities. Energy costs were based on data from the SDCWA as well as various studies, including GEI Consultants (2010), "Embedded Energy in Water Studies" and Wilkinson, R. (January 2000), "Methodology for Analysis of the Energy Intensity of California's Water Systems."

Surface Water: Marginal cost and energy estimates for surface water utilized data compiled in a study by the Sweetwater Authority (2006, April 26), "Cost of Free Water" and follow-up discussions with Sweetwater as well as consultations with the Orange County Water District (OCWD.) The ranges represent variations in environmental mitigation expenses that might be incurred as well as differences in pumping costs which can be affected by changes in reservoir levels from year to year.

Groundwater: Marginal cost and energy estimates for groundwater utilized data provided by the SDCWA, consultations with the Sweetwater Authority (where groundwater is a significant source), and the OCWD. Published research on the treatment and distribution, including that in the GEI study, was also assessed.

Desalinated Sea Water: Marginal cost and energy estimates for desalinated sea water were based on information provided by the SDCWA, review of documents prepared for the Carlsbad Sea Water Desalination Project, an assessment of desalination projects in California, including the proposed plant in Marin County (analyzed in Fryer, J. (2010), "An Investigation of the Marginal Cost of Seawater Desalination in California"), research into the experience of new facilities in Southern and Western Australia, consultation with the OCWD, and study of a number of reports on desalination, including Global Water Intelligence, (2009), "Water Desalination Report," Cooley, Gleick, and Wolff (June 2006), "Desalination," the GEI study, and the Wilkinson report.

Recycled Water, Non-Potable: Marginal cost and energy estimates for non-potable recycled water were based on discussions with the Irvine Ranch Water District (IRWD), where this alternative is a major source, review of the experience of the Olivenhain Water District, consultation with the OCWD, review of the "Water Reuse Study" (March 2006) by the City of San Diego, and information from a variety of different reports, including Navigant Consulting, Inc. (December 2006), "Refining Estimates of Water-Related Energy Use in California," the GEI report, and the California Energy Commission, (November 2005), "California's Water-Energy Relationship."

Recycled Water, Potable: Marginal cost and energy estimates for potable, recycled water were derived after reviewing the 2006 "Water Reuse Study" by the City of San Diego, analyzing various reports including those by Navigant Consulting and GEI, and consulting with cost and energy experts at the OCWD. The high end of the ranges reflect the pumping costs where, for example, the San Vicente Reservoir would be used as part of the water augmentation system versus the lower end where, for example, groundwater aquifers could be recharged.

Conservation: Marginal cost data for conservation (energy costs are deemed negligible) utilized information made available from the SDCWA, reflecting some of their conservation programs and cost assumptions, in addition to a variety of reports on conservation, including the California Department of Water Resources, (2009), "California Water Plan" and the U.S. Environmental Protection Agency (2010), "How to Conserve Water and Use It Effectively."

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Dieter Mauerman joined the staff of the Fermanian Business and Economic Institute (FBEI) as Research Assistant in January 2010. His role at the FBEI includes conducting field research and data acquisition as well as assisting Dr. Lynn Reaser with the economic analysis and reporting for FBEI's contracts.

Mauerman graduated from PLNU with a degree in Business Administration and studied in London at Kingston University. He is currently pursuing his MBA at PLNU.

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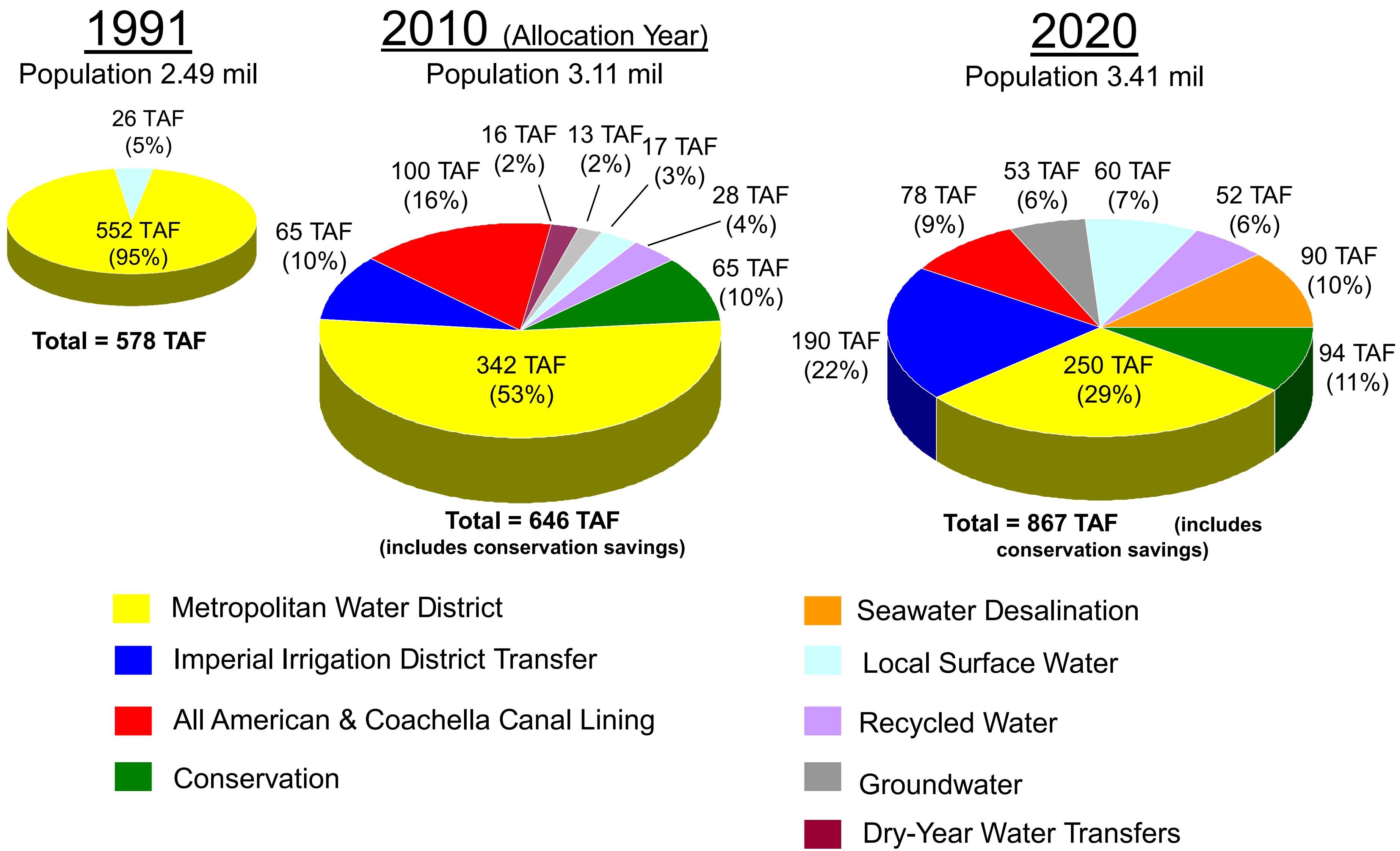
Diversifying San Diego County's Water Supply Portfolio

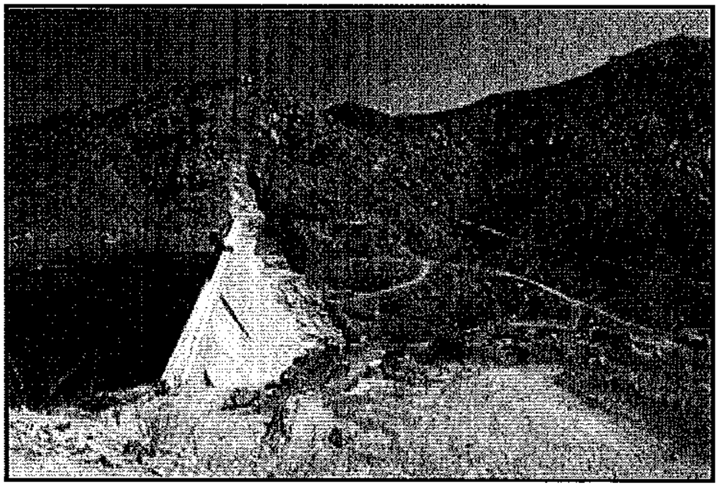


Water officials fear rising tide of rates

San Diego subsidizing rates for other areas, local agency says

By Mike Lee

Friday, September 17, 2010 at 8:09 p.m.



John Gibbins

Construction projects such as the raising of San Vicente Dam have led to water rate increases that are expected to continue under a 25-year reliability strategy crafted by the Metropolitan Water District.

Subsidy calculated

San Diego County water officials say these jurisdictions are getting a break on water because of the way the Metropolitan Water District calculates rates. Annual undercharge:

$7.6 million: Los Angeles

$4.3 million: MWD of Orange County

$2.2 million: West Basin MWD

$2 million: Calleguas MWD

$1.7 million: Eastern MWD

$1.4 million: Western MWD

$1.4 million: Inland Empire Utilities Agency

$1.2 million: Three Valleys MWD

$4.8 million: Other

Source: San Diego County Water Authority

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San Diego County water officials say residents here are subsidizing rates in the rest of Southern California — an inequity that could be made far worse under plans being devised in Los Angeles for the region's future.

The San Diego County Water Authority sued over the issue in June, saying the regional Metropolitan Water District's policies penalize county residents unfairly — an overcharge of $26.6 million this year and as much as $230 million by 2021.

Metropolitan is a mega-agency that is governed by local officials throughout the area. San Diego has only four representatives on the 37-member board, even though it contributes roughly a fourth of the agency's budget.

San Diego contends that Metropolitan charges more than the actual cost for transmission of water — and below the actual cost for the water itself. The arrangement affects San Diego County more than other areas, as it relies on Metropolitan's facilities to import water from the Colorado River.

The dispute arises against the backdrop of price hikes hitting homes and businesses across San Diego County. The increases will largely be in place by January. They are driven by several factors, including efforts to build new infrastructure, pay rising employee costs and make up for lower sales amid conservation.

County water authority officials said their 2011 price increase was about twice as high as it should have been because of the way Metropolitan charges for water transmission.

The disparity will cost San Diego County approximately $30 million in 2011, $34 million in 2012 and as much as $74 million in 2019, according water authority figures.

Unable to convince the Metropolitan board to adopt new accounting methods, the water authority in June took the unusual step of suing its largest supplier.

Metropolitan officials said they have followed the same procedures for years and contend they are squarely within their rights. In court papers, they said rate-setting is done at their discretion and is immune from challenge. They also said they are under no obligation to follow the rate structure preferred by San Diego.

"The courts will decide whether or not it's legal," said Brian Thomas, the chief financial officer at Metropolitan.

Now local leaders say Metropolitan's proposed 25-year strategy for stockpiling water for droughts and other emergencies would make the disparity more pronounced.

The Integrated Water Resources Plan calls for ambitious new strategies to build backup water supplies for dry times. The plan, which some see as a waste of money, is up for approval in October.

It is on track to pass, partly because many agencies with votes on the Metropolitan board purchase small amounts of water and won't pay nearly as much as San Diego.

"Many of them are not steady buyers of significant amounts of MWD's water and therefore don't shoulder much of the cost of such overdevelopment and the massive spending that goes along with it," said Dennis Cushman, assistant general manager at the San Diego County Water Authority. "They do, however, benefit from the spending if and when they need the water."

The regional water agency casts the blueprint as a "new course" designed to prepare for the uncertainties posed by climate change, the potential for prolonged droughts and future environmental constraints on pumping water. Metropolitan executives said the plan doesn't lock the region into spending but lays out alternatives.

"When the need arises, then we are going to call upon these resource options to develop specific projects," said Debra C. Man, an assistant general manager of Metropolitan.

The county water authority contends that the resources plan will create huge amounts of unused "buffer" water at an enormous expense. By 2035, they said it could top $1 billion a year beyond the cost of meeting projected needs — though scant financial details are provided in the draft document.

A letter Monday from 22 of Metropolitan's 26 member districts praised the 25-year supply plan, which they said will help develop new sources such as water recycling and desalination plants. Without mentioning San Diego by name, they said no agency should be able to opt out.

Despite Metropolitan's assurances that the strategy doesn't commit to specific projects, misgivings are widespread in San Diego County.

"MWD is setting itself up for a perfect storm of skyrocketing water rates and plummeting water sales," said Maureen Stapleton, general manager of the San Diego County Water Authority. "This course of action amounts to a fiscal death-spiral for MWD and it's financially unsustainable."

Patti Krebs, executive director of the Industrial Environmental Association, a business alliance in San Diego, said her members want to know what the plan will cost them.

"We don't want to see these water rates become a crisis like the energy rates were a few years back when they were driving businesses out of California," she said.

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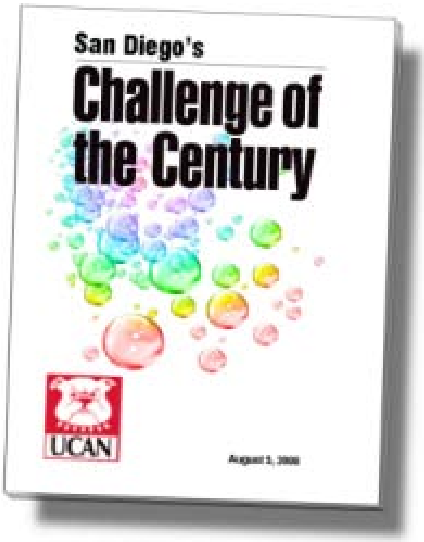
Reduce
(Conservation & Efficiency)

San Diego's Challenge of the Century Report:

Cutting edge strategies to make San Diego the world's most water-wise region



Published in August 2008, this report asks: **Is San Diego up to the challenge of the century?** San Diego faces a clear and present danger. The decisions we make about water today will be felt by our children for the next 100 years. Leadership, crisis management, and smart long-term solutions are urgently needed.

When it comes to infrastructure issues such as energy, communications, water and housing, San Diego, like so many other regions, has lots of controversies and precious few areas of regional consensus. However, water will prove to be the topic of this century. In the face of a recent drought and long-term predictions of reduced snow pack, San Diego policy makers have begun to slowly grapple with the realities of and the ramifications of a dwindling water supply. **And the convergence of this restricted supply along with the decades of unchecked growth has led the region to an inexorable coming-to-terms moment**.

UCAN recommends a set of measures that need to be considered by the region's policymakers that include:

- ***Pricing strategies***: San Diego water districts must provide customers with clearer economic signals through better rate design and rate incentive programs;
- ***Community involvement***: Local communities must be engaged to help with enforcement of water usage rules
- ***Linkage of resources***: Use the link between the region's energy and water resources to create an integrated approach to "harvesting" both energy and water resources in conjunction with SDG&E
- ***Prescriptive actions***: Some water uses must be severely restricted. New water users must adopt a zero net-usage principle
- ***Educate consumers***: Instilling an ethic in San Diego water customers that encourages water thriftiness and discourages water waste
- ***Water supply***: Water efficiency, reuse and creative water transfers represent the most promising sources of new water for the region
- ***Alter practices***: Given that landscape irrigation is the single largest use of water in California's urban areas, special attention needs to be given to altering irrigation practices in San Diego.

As noted by the County Water Authority, in 2007, Sierra snowpack supplying the State Water Project fell to 30 percent of its normal values and a federal court issued a ruling that will reduce pumping from the Bay-Delta to San Diego County. The Colorado River system is experiencing an eight-year drought and locally, San Diego received only 37 percent of its normal rainfall in 2007 and is in the driest two-year period since record keeping began in 1802.

UCAN *continued on the back…*

Most informed commentators and policymakers agree that **San Diegans must get serious about water conservation**. With water districts calling for voluntary water usage cutbacks, this has become an inarguably serious matter. However, there appears to be little agreement upon how to achieve those cutbacks.

The pressing challenge to this region is how to cost-effectively achieve an ethic of wiser water use amongst its citizenry. This report examines the **true constraints** placed on San Diego's water supply, what **best practices** are appropriate and **what we can learn** from other communities who are achieving measures of success with wiser water use.

San Diego County is particularly vulnerable as approximately 90% of the water consumed here is imported via pipelines and aqueducts from the Colorado River via the Colorado River Aqueduct and from Northern California via the Bay Delta and Central Valley Projects. The effects of increasing drought conditions, and loss of watershed-holding capacity due to the fire events of 2003 and 2007, are all contributing to increasing reliance on imported water.

UCAN offers a paper designed to further spark the local dialogue about how the San Diego County Water Authority, water districts and customers can implement innovative and effective measures to better manage this essential resource. UCAN has conducted a **survey of water efficiency measures** used throughout the world and has chosen some of the most successful conservation and reuse measures deployed elsewhere. We also offer some **original approaches** that warrant consideration by local policy makers. Most of the suggestions are focused upon water usage, rather than enhancing water supply. However, the differentiation between the two is largely illusory – **every gallon of water saved is a very low-cost gallon earned**.

UCAN views this matter as a challenge to San Diego. As the self-proclaimed "America's Finest City", San Diego and the surrounding region has an opportunity to demonstrate leadership in water conservation, in keeping with its claim to being among America's elite regions. **As our analysis shows, San Diego has not yet met that challenge.**

Calls for voluntary conservation are largely ineffectual. Rationing is inherently inequitable and could result in unintended consequences, as well as political and social backlash. UCAN suggests that neither of these tools should be relied upon.

Instead, UCAN offers a set of strategies and policy recommendations that need to be considered by the region's policymakers.

Read the full report online at www.ucan.org

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9/23/2008

California's Next Million Acre-Feet: *Saving Water, Energy, and Money*

Heather Cooley, Juliet Christian-Smith, Peter H. Gleick,
Michael J. Cohen, Matthew Heberger

September 2010

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PACIFIC INSTITUTE

About the Pacific Institute

The Pacific Institute is one of the world's leading non-profit research and policy organizations working to create a healthier planet and sustainable communities. Based in Oakland, California, we conduct interdisciplinary research and partner with stakeholders to produce solutions that advance environmental protection, economic development, and social equity – in California, nationally, and internationally. We work to change policy and find real-world solutions to problems like water shortages, habitat destruction, global warming, and environmental injustice. Since our founding in 1987, the Pacific Institute has become a locus for independent, innovative thinking that cuts across traditional areas of study, helping us make connections and bring opposing groups together. The result is effective, actionable solutions addressing issues in the fields of freshwater resources, climate change, environmental justice, and globalization. More information about the Institute and our staff, directors, funders, and programs can be found at www.pacinst.org.

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Acronyms and Abbreviations

AF – acre-feet

CEC – California Energy Commission

CIMIS – California Irrigation Management Information System

DWR – California Department of Water Resources

EPA – U.S. Environmental Protection Agency

GWh – gigawatt-hour

gpcd – gallons per capita per day

gpf – gallons per flush

gpm – gallons per minute

IID – Imperial Irrigation District

kWh – kilowatt-hour

MELASI – Mothers of East Los Angeles Santa Isabel

MWD – Metropolitan Water District of Southern California

RDI – regulated deficit irrigation

USBR – United States Bureau of Reclamation

Conversions

1 cubic meter (m^3) = 264 gallons = 0.0008 AF

1,000 gallons (kgal) = 3.79 cubic meters (m^3) = 0.003 acre-feet (AF)

1 million gallons = 3,785 cubic meters (m^3) = 3.1 acre-feet (AF)

1 acre-foot (AF) = 325,853 gallons = 1,233 cubic meters (m^3)

1 gigawatt-hour (GWh) = 1,000,000,000 watt-hours = 1,000,000 kilowatt-hours (kWh)

California's Next Million Acre-Feet: Saving Water, Energy, and Money

Introduction

Water is vital to the health of our economy and natural ecosystems. California's cities and agricultural communities depend upon reliable supplies of clean and adequate freshwater. As California's population and economy grow, there is mounting concern about our ability to meet future water demand amidst pressure on our complex water systems. In the 20th century, our approach to meeting this demand was to develop new supply by tapping our rivers, streams, and groundwater aquifers. While this approach brought tremendous benefits to the state, it also came at enormous environmental cost. We are reaching the economic, ecological, and social limits of traditional supply options: continuing to rely solely on building new infrastructure will fail to solve our impending crisis. We must expand our thinking about supply, away from costly new dams and toward other options for expanding supply (e.g., recycled water, stormwater capture, and integrated groundwater banking and management) and reducing statewide water demand. There is no "silver bullet" solution to our water problems, as all rational observers acknowledge. Instead, we need a diverse portfolio of solutions. But the need to do many things does not mean we must, or can afford, to do everything. We must do the most effective things first.

In particular, there are tremendous opportunities to improve the efficiency with which we use water at lower economic and ecological cost than developing new supply. There is vast potential to reduce our demand for water without affecting the services and benefits that water provides. Improving efficiency offers many benefits. Conserved water can be reallocated to other uses by the same user, such as growing more food on a farm. It can be left (or returned to) ecosystems to help restore natural water flow levels. It can be moved from one user to another as part of an economic arrangement or transfer. In addition, reducing the application of unnecessary water can save energy, reduce wastewater and associated treatment costs, and eliminate or delay the need for new water supply and treatment infrastructure. Water management efforts and programs should explicitly work to assure such co-benefits.

We have improved the efficiency of our water use substantially over the past 25 years. Without these past efforts, our current challenges would be much worse, demands on limited water supply would be much higher, and ecosystem destruction would be far more widespread. Despite these improvements, however, our current water use remains wasteful. The Pacific Institute has completed a series of independent reports on urban and agricultural water efficiency that provide a comprehensive statewide analysis of the conservation potential (Gleick et al. 2003, 2005; Cooley et al. 2006, 2008, 2009; Christian-Smith et al. 2010). Our findings have been confirmed by other independent assessments and adopted by the California Department of Water Resources in the California Water Plan (CALFED 2006; DWR 2005). These studies find that existing, cost-effective technologies and practices can reduce current state demand for water by six-to-eight million acre-feet per year, or around 20% statewide.

Widespread conservation and efficiency improvements are possible in every sector – in our homes, businesses, and farms. These water savings can be achieved for much less than the cost of building new, or expanding existing, supply. These savings represent a tremendous amount of untapped potential. Even today, after California's conservation efforts, millions of old inefficient toilets and household fixtures remain in use. California businesses are still relying on wasteful equipment and practices. Nearly 60% of all crop acreage in California still uses inefficient flood irrigation systems (Orang et al., 2005). Water savings are possible if farmers continue their efforts to shift to more efficient irrigation technologies and practices, such as drip systems, and improved management practices, such as better irrigation scheduling and soil-moisture monitoring, all of which can reduce water use while also improving agricultural yields and/or crop quality.

How much is an acre-foot?

-An acre-foot is a quantity of water that would flood an acre of land one foot deep, or 325,851 gallons.

A *million* acre-feet is:

- nearly 12 times the city of San Francisco's annual water use; 4.5 times the city of San Diego's annual water use; and 1.6 times the city of Los Angeles' annual water use.

- equivalent to a flow of 890 million gallons per day – 37% of the American River's annual discharge.

- approximately enough water to irrigate all the grain produced in California annually.

- enough water to satisfy the household needs of 6.7 million new Californians (more than the growth that demographers predict will occur within the next 10 years).

- almost three times the amount of water that would be yielded annually by the proposed Sites Reservoir and Temperance Flat Reservoir – combined.

- the amount of water that would be produced annually by 18 large desalination plants (the size of the proposed Carlsbad desalination plant, which would be the largest in the northern hemisphere).

In this report, we identify ways that Californians can capture a fraction of the potential water conservation and efficiency savings, and quantify these potential savings within the urban and agricultural sectors. Overall, we recommend technologies and strategies that will let California quickly save 1 million acre-feet of water at lower cost than current proposals to develop new supply, and with far fewer social and environmental impacts. All together, the efficiency improvements we identify require an upfront investment of $1.87 billion. The cost of the conserved water is $185 per acre-foot for the agricultural sector and a net *savings* of $99 per acre-foot for the urban sector, over the lifetime of the efficiency improvement.

These conservation and efficiency improvements are much cheaper than many proposed new surface storage projects. Sites Reservoir, for example, is estimated to require a capital investment of $3.0 billion while providing only 184,000 acre-feet of water per year; the cost of water from

Sites Reservoir is estimated at $520 per acre-foot[1] plus an additional $140 to $150 per acre-foot to pump that water over the Tehachapi Mountains (DWR 2007). The economic justification for Temperance Flat Reservoir, located on the San Joaquin River, is even weaker. In 2008 the US Bureau of Reclamation estimated that building a new dam at Temperance Flat would require a capital investment of $3.4 billion and yield only 158,000 acre-feet per year; the cost of water from Temperance Flat Reservoir is $720 per acre-foot.[2] And these costs are already rising. Additional cost would be required to actually deliver water to homes, farms, and businesses throughout California.

Unlike proposed new water storage projects, the efficiency improvements recommended here often pay for themselves as a result of the many co-benefits that water conservation and efficiency provides, including reductions in wastewater and energy bills and improvements in crop quality and yield. Reducing water demand also delays or eliminates the need to develop expensive water and wastewater treatment and energy infrastructure, thereby producing additional long-term financial savings for future generations. We note that these infrastructure savings are not included in this analysis, although they can be substantial.

Where will the water savings come from?

Water savings are available through a wide variety of water-efficient practices in the urban and agricultural sectors. In the urban sector this includes replacing old, inefficient devices with high-efficiency models, as well as lawn conversion, residential metering, and rate structures that better communicate the value of water. In the agricultural sector, best water management practices include weather-based irrigation scheduling, regulated deficit irrigation, and switching from gravity or flood irrigation to sprinkler or drip irrigation systems. Here, we focus on well-documented, cost-effective approaches that are already being used in California. We emphasize efficiency improvements rather than behavioral changes because the latter are less easily quantified. Nonetheless, experience in Australia, Colorado, and California in recent years shows that changing water use behavior can also provide very fast and inexpensive savings in emergencies, with long-term benefits.

This analysis explores how to capture one million acre-feet of potential water savings (only a fraction of the conservation potential statewide). We divide these savings between agriculture and urban uses, with approximately 70% of the savings derived from the agricultural sector and 30% from the urban sector. Our assessment could have identified one million acre-feet of water

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[1] Cost estimate based on the best alternative identified in USBR 2008a. Note that the Bureau of Reclamation annualizes the cost over a 100-year period at a 4 7/8% interest rate. These unusually generous assumptions deflate the cost of water from this project.

[2] Cost estimated based on alternatives identified in USBR 2008b. Note that the Bureau of Reclamation annualizes the cost over a 100-year period at a 4 7/8% interest rate. These unusually generous assumptions deflate the cost of water from this project.

savings in either the agricultural or urban sectors alone, but here we demonstrate how even small changes in cities and on farms can relatively quickly and inexpensively produce large water savings.

These water savings are a combination of "consumptive" and "non-consumptive" uses (see box below). Both kinds of savings are valuable, despite claims by some water analysts of the need to focus solely on reducing "consumptive" water uses. In particular, saving non-consumptive uses may be especially cost-effective and helpful for restoring instream flows for certain highly damaged aquatic ecosystems and for reducing energy use associated with on-farm or urban water systems.

Consumptive and non-consumptive water use

The water literature is rife with confusing and often misleading terminology to describe water use, e.g., water withdrawal, consumptive use, non-consumptive use, etc. It is important to clarify these terms, as different meanings can lead to different or conflicting conclusions about the water conservation potential. To be clear, water withdrawals refer to water taken from a source and used for human needs. These withdrawals can be divided into two water-use categories: consumptive and non-consumptive. Consumptive use is sometimes referred to as irretrievable or irrecoverable loss. According to Gleick (2003), "The term *consumptive use* or *consumption* typically refers to water withdrawn from a source and made unavailable for reuse in the same basin, such as through conversion to steam, losses to evaporation, seepage to a saline sink, or contamination." Additionally, water that is incorporated into products or plant and animal tissue is typically exported out of the basin of origin, and thus is also a consumptive use.

Confusion about consumptive and non-consumptive water use has led many planners to grossly underestimate the value of conserving non-consumptive water use and, consequently, overall water-conservation potential. Some water planners believe that conservation measures that produce savings in non-consumptive water uses are less important than that from consumptive water uses. They argue that water that is used non-consumptively is available for reuse by downstream users and thus conserving this water does not produce any new water. These planners, however, fail to realize that *any* demand reductions reduce the amount of water taken from ecosystems and the need for new infrastructure investments to capture, store, treat, and distribute water. It can also allow for greater flexibility in managing water deliveries. Furthermore, reductions in water withdrawals can improve the timing and maximize the amount of water left in the natural environment, providing benefits to downstream water quality, the environment, recreational uses, and even upstream use.

Urban water use: how much can we save?

In California's urban areas, water is used for residential, commercial, and industrial uses, outdoor landscaping, and other miscellaneous uses. Official estimates from California's Department of Water Resources indicate that urban water use was 9.3 million acre-feet in 2005, although significant uncertainties are associated with these numbers (DWR 2009). Some urban areas have been able to maintain or even reduce water demand while supporting population and economic growth: statewide per-capita demand between 1995 and 2005 remained fairly constant, averaging 192 gallons per person per day (DWR 2010). While many water agencies invested in water conservation and efficiency programs during this period, these savings were essentially cancelled out by urban growth in hot, inland areas where outdoor water demand is particularly high.

A wide variety of efficient devices and fixtures are available to reduce urban water demand. Our analysis shows that residents of California could reduce water use by more than 160,000 acre-feet each year by (1) replacing 3.5 million toilets with high-efficiency models, (2) installing faucet aerators and showerheads in 3.5 million homes, and (3) putting in 425,000 high-efficiency clothes washers. California businesses could save an additional 123,000 acre-feet each year by installing efficient devices in commercial and industrial kitchens, bathrooms, and laundries, and upgrading cooling towers. And nearly 35,000 acre-feet of water could be saved outdoors by using pressurized water brooms instead of hoses to wash sidewalks and by replacing just 2,000 acres of lawn with low-water-use plants in each of six counties: San Diego, Orange, Riverside, Ventura, Fresno, and Sacramento. In combination, these thirteen conservation measures alone would reduce urban demand by more than 320,000 acre-feet each year.

In addition to saving water, these water conservation and efficiency devices save energy. We estimate that these water-saving measures would reduce California's electricity use by 2,300 gigawatt-hours (GWh) and its natural gas use by 87 million therms each year. The annual electricity savings are equivalent to the electricity use of 309,000 average households in California.[3]

[3] According to EIA (2010), the average California household uses 7,440 kWh per year.

Table 1. Water and energy savings for selected water conservation and efficiency measures.

Efficiency Measure	Number Installed	Water Savings (AF)	Electricity Savings (GWh)	Natural Gas Savings (million therms)
Residential toilet (1.28 gpf)	3,500,000	93,500	306	-
Showerhead (1.5 gpm)	3,500,000	47,500	985	59.3
Residential front-loading clothes washer	425,000	13,300	188	8.86
Faucet aerator (1.5 gpm)	3,500,000	6,750	74.5	3.75
Pre-rinse spray valve (1.0 gpm)	20,000	3,070	76.9	3.70
Connectionless food steamer	7,000	3,440	24.9	1.31
Commercial dishwasher	8,500	1,300	56.4	2.90
Commercial front-loading clothes washer	90,000	10,500	148	6.98
Commercial urinal (0.5 gpf)	750,000	51,800	170	-
Commercial toilet (1.28 gpf)	750,000	31,300	103	-
Cooling tower pH controller	5,500	21,900	71.8	-
Pressurized water broom	50,000	7,670	20.3	-
Replace lawn with low-water-use plants	12,000 acres	28,400	75.4	-
Total		**320,000**	**2,300**	**86.8**

Notes: All numbers rounded to three significant figures. Energy savings include both end use and embedded energy savings. End use savings result from reductions in volume of water that must be heated prior to use. Embedded energy savings are due to reductions in the energy used to deliver drinking water to homes and businesses and treat wastewater before discharge into the environment. See Appendix A for a more detailed discussion of the assumptions and approach used in this analysis.

How do we capture the urban water savings?

Identifying potential savings is just the first step in tackling California's water problems. Equally, or even more, important is developing programs for achieving those savings. There are many tools available for this, including incentives, pricing policies, regulations, and education. In this section, we recommend strategies for moving forward quickly to reduce wasteful and inefficient uses of water.

Financial incentives

Even when energy or water savings are clearly cost-effective, up-front costs sometimes pose barriers to water users. Many approaches can help overcome these barriers. Rebate programs are among the most common ways to encourage customers to make investments in water conservation and efficiency improvements. Residents and business owners purchase new devices as the old devices wear out. While most new standard devices use less water than older models, there are many new high-efficiency devices available that use even less water. For example, an old clothes washer uses about 60 gallons per load. New, standard top-loading clothes washers use 30 gallons per load and cost $500. New, efficient front-loading clothes washers, however, use only 15 gallons per load, although the average cost is slightly higher, at about $750. While the efficient devices are cheaper over their lifetimes due to lower water, energy, and wastewater bills, users may be put off by the higher up-front costs. Many water agencies provide their customers with a rebate to defray the additional cost of the more efficient device. In the case of clothes washers, some water agencies partner with local energy utilities to provide rebates to their customers ranging from $200 to $300. Additionally, utilities may partner with retailers to offer rebates at the point of sale, giving customers an immediate incentive to purchase the more efficient device.

Another approach that may be effective is a "Cash for Water Wasters" program where old, inefficient devices would be replaced with more efficient models. Such a program would be similar to the Cash for Clunkers program implemented in the summer of 2009 to get old cars off the road and provide a boost to the automotive industry. A similar program focused on energy efficiency was launched by the federal government in 2010 with funding from the American Recovery and Reinvestment Act. Consumers across the country were provided a total of $300 million in rebates to purchase energy-efficient household appliances. To ensure the inefficient devices are taken off the market, the old appliances must be recycled. A "Cash for Water Wasters" program would operate in a similar matter but would target devices and fixtures that use water in residences and businesses. In addition to helping ensure the long-term sustainability of California's water resources, a "Cash for Water Wasters" Program would save money and reduce energy use and associated greenhouse gas emissions. It would also create jobs and promote a green economy benefiting product manufacturers, suppliers, plumbers, and contractors.

There are strong and successful precedents for such programs. In the mid-1990s, the New York City Department of Environmental Protection launched a massive toilet rebate program to replace one-third of all water-wasting toilets in New York City with low-flow models using no more than 1.6 gallons per flush. For this program, property owners contracted directly with private licensed plumbers for the installation of a low-flow toilet. After completion of the work, the City provided the property owner with a $240 rebate for the first toilet and $150 for the second toilet. Where possible, the plumber would also install low-flow showerheads and faucet aerators. The program was a huge success. Between 1994 and 1997, 1.3 million low-flow toilets were installed, saving 70 - 90 million gallons per day. Customers saw their water and wastewater bills drop 20 to 40% (EPA 2002). The City was able to defer the need to identify new supply sources and expand wastewater treatment capacity, thereby saving the community even more money.

Similarly, a successful toilet direct install program was implemented in Southern California in the 1990s. In 1992, a pilot partnership to install low-flow toilets was created between the community non-profit group Madres del Este de Los Angeles Santa Isabel (Mothers of East Los Angeles Santa Isabel - MELASI) and the Metropolitan Water District of Southern California, Los Angeles Department of Water and Power, Central Municipal Water District, and California Water Service Company. Toilets were installed in low-income households free of charge, and MELASI was paid $25 for every toilet replaced (Lerner 1997). The program provided employment opportunities to community residents, creating twenty-five full-time and three part-time jobs (Lerner 1997). The community-based approach was also a success in terms of water conservation, with one-in-three households contacted participating, and a total of 8,000 toilets replaced in the first year and 50,000 replaced by the end of 1997 (Hamilton 1992, Hamilton and Craft undated, Lerner 1997). Such a successful model could have been, but was not, expanded statewide. We recommend reinstituting and expanding this kind of community-based effort.

Regulations

In addition to financial incentives, regulations can facilitate water conservation and efficiency improvements. Recent standard state and federal regulations for appliance standards have greatly improved the efficiency of residential water-using fixtures. Other kinds of regulatory approaches are becoming increasingly common and can further reduce the burden on the water provider. In late 2009, for example, California enacted SB 407 (Padilla), which requires the replacement of all inefficient plumbing fixtures in commercial and residential properties with efficient models by 2017 for single-family homes and 2019 for multi-family homes and commercial properties.[4] While initial versions of the bill required these retrofits as a condition of sale or transfer of property, watered-down language of the final bill significantly reduced the enforceability and water conservation function of the law. Opposition from the California Association of Realtors and the California Business Properties Association, in particular, led to the elimination of the "replacement-on-resale" language and significant delays in the target compliance dates. The law makes compliance a condition for some – but not all – building permits after 2017, but otherwise, the law as written does not provide for any penalties or fines or any other mechanisms to ensure compliance. Strengthening this law by including some mechanism for ensuring compliance would result in even greater savings.

In addition, Governor Schwarzenegger recently signed SBx7-7, which requires urban water suppliers to reduce per-capita water use by 20% by 2020. Early versions of the bill set numeric water use reduction targets for agriculture, although this language was removed. The law still requires agricultural water suppliers to improve water use monitoring and reporting, establish

[4] Specifically, the law requires replacement of toilets using more than 1.6 gallons per flush; urinals using more than 1.0 gallons per flush; showerheads with a flow capacity of more than 2.5 gallons per minute; and faucets with a flow capacity of more than 2.2 gallons per minute.

pricing structures that reflect the volume of water used, and develops agricultural water management plans. This bill, if successfully implemented, is an important step to help California achieve more effective and efficient use of its water resources.

Pricing policies and metering

Pricing policies can also promote water conservation and efficiency improvements. Many water agencies are moving beyond simple volumetric pricing and are beginning to adopt inclining block rates. Through an increasing block rate design, the unit price for water increases as water use increases, with prices set for each block of water use. Customers who use low or moderate volumes of water are charged a modest unit price and rewarded for conservation; those using significantly higher volumes pay higher unit prices. When designed properly, this approach can provide a strong financial incentive to conserve while ensuring that lower-income consumers are able to meet their basic water needs at a reduced cost. A 2003 survey of water rate structures in the southwest United States found that per-capita water use is typically lower in cities with dramatically increasing block rates, such as Tucson and El Paso (WRA 2003).

Pricing policies that promote water conservation and efficiency are predicated on meters that measure actual water use. Water bills for unmetered residents are based on a flat fee that is independent of the volume of water that is actually used, eliminating information that could encourage residents to reduce their water use. Unfortunately, at a time of chronic water crises and calls for new water-supply expenditures, several major cities in California still do not measure water deliveries to residences. Although meters will be required on all water connections by 2025, many water utilities in the San Joaquin Valley and even much of Sacramento remain unmetered (Black and Veatch 2006). In addition, an estimated 96% of multi-family residents are not sub-metered nationwide (Mayer et al. 2004).

Studies show that metering customers and charging them for the water they use substantially reduces water use. The City of Davis, for example, installed meters on nearly 10,000 homes and began a metered billing rate, effectively reducing per-capita water use by 18% (Maddaus 2001). The City of Clovis, which uses water meters, has an average per-capita use nearly 40% lower than the neighboring city of Fresno, which does not use water meters (Hanak 2005, citing *Fresno Bee* 2004). In Denver, metering reduced water use by 28% (Bishop and Weber 1995). In addition to reducing household water use, meters are also critical for effective management of the water system. Water providers can use this information to target water conservation and efficiency programs to particular customer classes and determine the program's effectiveness. Meter data is also an extremely valuable audit tool that can help locate leaks within the distribution system and at the customer's homes. We recommend an accelerated effort to meter all water uses.

Education and outreach

Education programs can also be effective for promoting water conservation and efficiency. The U.S. Environmental Protection Agency (EPA), for example, launched the WaterSense labeling program in 2006 to promote water-conserving devices that are 20% more efficient than average products and meet rigorous performance criteria. Additionally, the State, in partnership with the Association of California Water Agencies, recently launched the "Save Our Water" program to develop a consistent statewide message on the importance of water conservation and efficiency and to disseminate consumer-oriented information and tools to help Californians reduce their water use.

Although not included in this analysis, behavioral changes can generate tremendous water savings very quickly and at very little cost. In South East Queensland, Australia, for example, residents responded to drought restrictions by decreasing water use from the already low 70 gallons per person per day (gpcd) to 34 gpcd. Even after restrictions were eased, water use rose only to 43 gpcd (Queensland Water Commission 2009). In Denver, water use dropped from 211 gpcd to 165 gpcd during drought restrictions imposed in 2002, then rose very slightly to 170 gpcd after those restrictions were removed (Denver Water 2009). Denver Water's public campaign expenditures in 2009 were only $735,000, yet the campaign contributed to the 6,000 acre-feet reduction in water use in the service area that year (A. Muniz, Denver Water, pers. comm. Dec. 2009). Consistent information on how to achieve efficiency improvements – and their benefits – should be prepared and disseminated throughout the state.

Agricultural water use: how much can we save?

Agriculture accounts for the vast majority of applied water use in California (DWR 2005). The agricultural sector uses 80% of California's developed water supply, or about 34 million acre-feet per year, thus even small improvements in irrigation efficiency can produce tremendous water savings. Yet, while recent legislation set a 20% water conservation target by 2020 for urban water suppliers, there are no quantitative savings required for agricultural water suppliers. Nonetheless, there is great potential for water savings in the agricultural sector. These savings are more cost-effective than most other water supply options and provide many co-benefits associated with improved agricultural water management, including increased crop quality and yield and water quality improvements (Cooley et al. 2009, Christian-Smith et al. 2010).

For this analysis, we chose among the simplest, proven agricultural water-use efficiency measures available, which include: (1) weather-based irrigation scheduling, (2) regulated deficit irrigation, and (3) efficient irrigation technologies, e.g., drip and sprinkler systems. First, weather-based irrigation scheduling uses data about local weather conditions to determine how much water a crop needs. The California Department of Water Resources maintains the California Irrigation Management Information System (CIMIS) to provide this information to growers. This service is free and available online to the public, but other kinds of weather-based systems are also available from irrigation consultants who may set up additional weather stations on-farm to provide even more precise local information.

Second, regulated deficit irrigation imposes water stress on certain crops that have drought-tolerant life stages, e.g., wine grapes and some nuts. This approach is widely practiced in many

Mediterranean and semi-arid climates around the world, including more and more efforts in California, providing improvements in crop quality and/or yield along with significant water savings (Cooley et al. 2009). Third, certain irrigation technologies, such as sprinkler and drip irrigation systems, tend to have higher distribution uniformities and water-use efficiencies than traditional flood, or gravity, irrigation systems. As we note elsewhere, however, realizing the full water savings from any irrigation technology requires proper management and maintenance (Cooley et al. 2008, 2009).

We applied these three measures to only a fraction of California's nearly 9.5 million acres of irrigated land. For instance, in our analysis, irrigation scheduling was applied to 20% of vegetable, orchard, and vineyard acreage in California, or about 811,000 acres. Regulated deficit irrigation was applied to 30% of almonds and pistachios in the state, or about 205,000 acres. We also calculated the water savings associated with converting a small portion of vegetable, orchard, and vineyard acreage from flood irrigation to sprinkler or drip irrigation systems in the Central Valley.[5] Altogether, these three measures were applied to only 15% of the irrigated agricultural acreage in California but produced nearly 700,000 acre-feet of water savings each year (Table 2).

Table 2. Agricultural water conservation and efficiency savings.

Measure	Annual Water Savings (AF)	Area Affected (acres)
Irrigation scheduling	291,000	811,000
Regulated deficit irrigation	170,000	205,000
Drip/sprinkler irrigation	238,000	424,000
Total	**699,000**	**1,440,000**

Notes: All numbers are rounded to three significant figures. Energy savings are not included as the embedded energy of agricultural water varies greatly based on the water source (e.g., groundwater vs. surface water, local supply vs. State Water Project). Adequate data are not available to estimate these savings but they make the recommended improvements even more attractive.

It is important to note that these savings are a combination of consumptive and non-consumptive water uses, and therefore they are not necessarily available for re-allocation or use elsewhere. However, as noted above, reductions in water demand often provide important co-benefits, including:

- **Improved Water Quality.** Runoff from agricultural lands often contains pesticides, fertilizers, salts, and fine sediments from surface erosion. These pollutants can contaminate surface and groundwater sources, increasing treatment costs for downstream users and degrading fish and wildlife habitat. Reducing excessive water use and withdrawals reduces these water-quality problems.

[5] We used the Analytica model described in Groves et al. (2005) to calculate the water savings from changing from flood to sprinkler and drip irrigation systems.

- **Increased Instream Flows.** The withdrawal of water directly reduces the amount of water left in the stream (also referred to as instream flows) between where the water is extracted and where it is returned. Reducing unproductive uses of water in selected locations permits less water to be taken from vulnerable stretches of natural systems. Instream flows serve many purposes (see, for example, Postel and Richter 2003, Maunder and Hindley 2005), including
  - removing fine sediments that cement river substrate and smother fish and invertebrate eggs and larvae;
  - maintaining suitable water temperatures, dissolved oxygen concentrations, and water chemistry;
  - establishing stream morphology, including the formation and maintenance of river bars and riffle-pool sequences;
  - preventing riparian vegetation from invading the channel and altering stream form and function;
  - flushing waste products and pollutants; and
  - allowing and supporting fish passages and migrations.

- **Improved Timing of Instream Flows.** While excessive water applications may lead to return flows that eventually flow back to a stream via surface runoff or groundwater percolation, there is a lag time between when the water is withdrawn and when it flows back into the river. This factor is important because the natural life cycles of many aquatic and riparian species are timed to either avoid or exploit flows of certain magnitudes. For example, high flows often signal, and support, anadramous fish migration (Maunder and Hindley 2005).

- **Benefits to Fish and Wildlife.** In addition to some of the indirect threats to wildlife described above, diversions from waterways can pose a direct threat to fish and wildlife populations. For example, the large pumps for the State Water Project and Central Valley Project kill fish on the intake screens and at the fish diversion facility, leading to expensive infrastructure retrofits, legal challenges, and controversial environmental restrictions on water withdrawals.

- **Delay or Elimination of Spending on Capital-Intensive Infrastructure.** Building and siting new reservoirs is time-consuming, extremely expensive, and politically controversial. Water savings achieved through efficiency improvements, however, are just as effective as new centralized water storage and infrastructure, assuming that such new infrastructure could even be sited, funded, approved, and built.

- **Improvements in Crop Quality and Yield.** More precise application of water to meet crop needs has been shown to improve crop quality and/or yield. In addition, slightly stressing drought-tolerant crops has been shown to increase solids (tomatoes), reduce hull split (almonds), increase shelf life (stone fruit), increase shell split (pistachios), and increase sugar content (wine grapes).

- **Reduced Energy Use.** Capturing and conveying water to agricultural users often requires an input of energy. For example, conveying surface water to farmers in the Tulare Lake hydrologic region requires up to 970 kWh per acre-foot.[6] Likewise, pumping groundwater requires between 175 kWh and 740 kWh per acre-foot or even more, depending on pumping depth (Wolff et al. 2004). As a result, reducing water withdrawals can save energy and reduce related greenhouse-gas emissions.[7]

- **Decreased Soil Salinity.** Irrigation water contains salts, and the application of this water increases soil salinity. Reducing the quantity of water applied to the field reduces salt accumulation, thereby reducing the risk of further loss of arable land. This works both ways, however, and at times, farmers may wish to increase water use to remove salts from soils. Careful soil and water management are required to balance these competing interests.

How do we capture the agricultural water savings?

Although financial incentives and regulations to promote water-use efficiency are less often applied to the agricultural sector, a transformation in agricultural water use could generate significant savings in water and energy and potentially create more and better rural jobs. There is an urgent need to modernize California's on-farm water infrastructure to become more efficient and resilient to drought and long-term climate changes by implementing water district upgrades (e.g., lining irrigation canals, implementing technologies to accurately measure water use, automating delivery structures, recycling drainage water, and providing pressurized water for farmers) and on-farm improvements (e.g., conversion to higher efficiency sprinkler and drip irrigation systems, shifting to conservation tillage practices, and other methods to conserve soil moisture). This would require substantial investment in new infrastructure and labor for up-front installation and ongoing maintenance. This work could potentially extend some seasonal farm jobs to year-round employment, increase wages for existing workers, and/or increase the number of jobs in the agricultural sector, though the employment opportunities have not yet been

[6] Based on State Water Project energy requirements from CEC 2005. We estimate the upper range on the energy intensity at Wheeler Ridge.

[7] In some cases, water-efficiency improvements may increase on-farm energy use, e.g., through conversion from flood to sprinkler irrigation. See the section on "Opportunities and Challenges for Achieving Water Conservation and Efficiency Improvements" in Cooley et al., 2008 for a more detailed discussion.

comprehensively analyzed. The costs for this transition could be defrayed by establishing new and expanding existing rebate programs,[8] low-interest loans (e.g., the state has provided low-interest loans to irrigation districts to finance district and on-farm water infrastructure improvements), and grant programs (e.g., the federal Farm Bill conservation programs). Additional revenue generated from tiered pricing could also be used to finance district-wide improvements.

Well-designed pricing policies have also been shown to be effective for reducing agricultural water use. For example, the Broadview Water District, a small district in the southern San Joaquin Valley, implemented increasing block rates in 1988 to reduce the volume of contaminated drainage water flowing into the San Joaquin River. The rate was set at $16 per acre-foot for the first 90% of the 1986 to 1988 average water use and $40 per acre-foot for any additional water. Careful monitoring ensured an accurate accounting of water use. By 1991, the district's average applied water declined by 19%, from 2.8 acre-feet per acre to less than 2.3 acre-feet per acre as a result of efficiency improvements and crop shifting (MacDougall et al. 1992). In addition to the rate changes, discussions and workshops with farmers facilitated the exchange of information and contributed to the program's success (Wichelns and Cone 1992).

Municipal water agencies may also provide another potential funding source for agricultural efficiency improvements. In1988, the Imperial Irrigation District (IID) entered into a 35-year agreement with the Metropolitan Water District of Southern California (MWD) in which MWD would pay for water conservation measures within the IID service area in exchange for more than 100,000 acre-feet of the conserved water each year. In 2003, IID entered into a similar agreement with the San Diego County Water Authority. These transfer offer examples of municipal water agencies funding system and on-farm efficiency projects in exchange for a portion of the water conserved. If the adverse environmental and social impacts of such efficiency projects are appropriately mitigated by the transfer parties, such projects can be clear examples of the "beneficiary pays" principle and provide irrigators with the capital they need to improve water delivery systems, without impairing agricultural productivity.

How much will conserving 1 million acre-feet cost?

When developing water conservation and efficiency programs, a key question is "how much will it cost?" Cost depends on how the program is structured and the assumptions about who pays and when. The program adopted in this analysis is modeled on a rebate program. For most devices, we assume that the customer was in the market for a new device, and thus the cost is the cost difference between a new standard and new efficient device. For some devices, including faucet aerators, cooling tower pH controllers, water brooms, replacing lawn with low-water-use plants, and all of the agricultural measures, however, we assume that the customer would not have made

[8] Pacific Gas and Electric offered a rebate program for installing drip irrigation systems in some areas of the state.

the investment otherwise, and thus the cost is the full cost of the device. We also include the administrative cost for running a rebate program, which typically varies from about 10% to 30% of the rebate cost, depending on the measure under consideration (Table 3).

Table 3. Cost data for selected urban water conservation and efficiency measures.

Conservation Measure	Device Cost ($/device)		Incremental Cost	Incremental Plus Administrative Cost
	Efficient	Standard		
Residential toilet (1.28 gpf)	$ 200	$ 150	$ 50	$ 63
Showerhead (1.5 gpm)	$ 40	$ 20	$ 20	$ 25
Residential front-loading clothes washer	$ 750	$ 492	$ 258	$ 323
Faucet aerator (1.5 gpm)	$ 8	$ -	$ 8	$ 10
Restaurant pre-rinse spray valve (1.0 gpm)	$ 70	$ 50	$ 20	$ 25
Connectionless food steamer	$ 6,000	$2,500 (elec.); $3,800 (natural gas)	$ 3,230	$ 4,040
Commercial dishwasher	$ 9,000	$ 6,950	$ 2,050	$ 2,560
Commercial front-loading clothes washer	$ 750	$ 492	$ 258	$ 323
Commercial urinal (0.5 gpf)	$ 550	$ 540	$ 10	$ 13
Commercial toilet (1.28 gpf)	$ 200	$ 150	$ 50	$ 63
Cooling tower pH controller	$ 2,250	$ -	$ 2,250	$ 2,810
Pressurized water broom	$ 250	$ -	$ 250	$ 313
Replace 1 acre of lawn with low-water-use plants	$ 43,600	$ -	$ 43,600	$ 54,500

Notes: gpf = gallons per flush; gpm = gallons per minute. All numbers rounded to three significant figures. See Appendix A for a more detailed discussion of the assumptions and approach used in this analysis. Cost of landscape conversion is based on a rebate level of $1 per square foot, which does not account for economies of scale with larger installations, which can have a unit cost of less than half this rate.

We estimate that, together, the urban water conservation and efficiency measures save more than 320,000 acre-feet per year and require an initial investment of $1.3 billion (Table 4). These measures save additional money over their lifetime through lower water, wastewater, and in some cases, energy bills. We estimate that these devices would have a "negative cost" over their lifetime,[9] saving an average of around $99 per acre-foot of water conserved. Although not included here, there are additional savings from the deferral or downsizing of capital-intensive

[9] A "negative cost" means that these technologies and approaches save more money over their lifetime than they cost to implement.

water supply and treatment facilities, which would further increase the financial savings from these measures. These additional savings accrue to the water distributors rather than the end users, though ultimately the end user saves by avoiding rate increases associated with capital programs.

Table 4. Initial investment and cost of conserved water for urban water conservation and efficiency measures.

	Number of Devices	Incremental Plus Administrative Cost	Initial Investment ($ millions)	Cost of Conserved Water ($/AF)
Residential toilet (1.28 gpf)	3,500,000	$ 63	$ 219	$ 1,580
Showerhead (1.5 gpm)	3,500,000	$25	$ 87.5	$ - 3,140
Residential front-loading clothes washer	425,000	$ 323	$ 137	$ - 1,510
Faucet aerator (1.5 gpm)	3,500,000	$ 10	$ 35.0	$ - 1,200
Restaurant pre-rinse spray valve (1.0 gpm)	20,000	$ 25	$ 0.500	$ - 5,550
Connectionless food steamer	7,000	$ 4,040	$ 28.2	$ - 523
Commercial dishwasher	8,500	$ 2,560	$ 21.8	$ - 7,060
Commercial front-loading clothes washer	90,000	$ 323	$ 29.0	$ - 231
Commercial urinal (0.5 gpf)	750,000	$ 13	$ 9.38	$ - 214
Commercial toilet (1.28 gpf)	750,000	$ 63	$ 46.9	$ - 229
Cooling tower pH controller	5,500	$ 2,810	$ 15.5	$ - 188
Pressurized water broom	50,000	$ 313	$ 15.6	$ 387
Replace lawn with low-water-use plants	12,000 acres	$ 54,500	$ 653	$ 1,680
Total			**$ 1,300**	**$ - 99.3**

Note: All numbers are rounded to three significant figures. Water savings from lawn replacements are based on replacing 2,000 acres of lawn with low-water-use plants in each of six California counties: San Diego, Orange, Riverside, Ventura, Fresno, or Sacramento Counties. Cost of landscape conversion is based on a rebate level of $1 per square foot, which does not account for economies of scale with larger installations and reduce the unit cost to less than half this rate.

We assume that the cost of installing precision irrigation systems is $1,200 per acre (Cooley et al. 2009; AWMC and CFWC 2010). The costs for improving irrigation management practices (regulated deficit irrigation and irrigation scheduling) vary depending on the equipment and amount of automation. A study coordinated by local Cooperative Extension agents in Nebraska found that costs to implement irrigation scheduling, including irrigation scheduling supplies, labor, and the cost for pumping plant adjustment, totaled around $15 per acre in 1990 U.S. dollars, or $25 per acre in 2010 U.S. dollars (Kranz et al. 1992). PureSense, and other private irrigation consultants, use probes, sensors, weather instruments, and meters to determine the soil moisture profile and water uptake. This information is collected by satellites, sent to a server, and processed by software that evaluates the amount of water needed. Based on this data, an irrigation schedule designed precisely to match crop water needs is sent directly to the farmer. Costs for these types of services average $20-30 per acre annually (Williamson, PureSense representative, pers. comm. 7/20/08).

In total, we estimate that these agricultural water efficiency measures require an initial investment of $575 million (Table 5), including $530 million in initial capital costs for installing efficient irrigation technologies and $45.7 million in weather and soil moisture monitoring equipment for irrigation scheduling and deficit irrigation. Annual operation and maintenance costs associated with these improved irrigation management practices would cost $47 million per year. The cost of conserved water would be of $185 per acre-foot over the lifetime of the measure, significantly cheaper than most sources of new water supply. Furthermore, these cost estimates do not include the many co-benefits of water-efficiency improvements, e.g., improvements in crop quality, water quality, and crop yield.

Table 5. Initial investment and cost of conserved water for agricultural water conservation and efficiency measures.

	Area Effected (acres)	Capital Cost ($/acre)	O&M Cost ($/acre)	Initial Investment ($ millions)	Annual O&M ($ millions)	Cost of Conserved Water ($/AF)
Irrigation scheduling	811,000	$ 45.0	$ 25.0	$ 36.5	$ 20.3	$ 100
Regulated deficit irrigation	205,000	$ 45.0	$ 25.0	$ 9.21	$ 5.12	$ 43.0
Drip/sprinkler irrigation	424,000	$ 1,250	$ 50.0	$ 530	$ 21.2	$ 391
Total	1,440,000			$ 575	$ 46.6	$ 185

How does the cost compare to other water supply options?

Applying the water conservation and efficiency measures described here to only a small fraction of the homes, businesses, and farmland in the state would deliver valuable water savings far below the cost of new infrastructure currently proposed. As in the earlier example of Sites Reservoir, a capital investment of $3.0 billion yields water at an estimated cost of $520 per acre-foot[10] plus an additional $140 to $150 per acre-foot to pump that water over the Tehachapi Mountains (DWR 2007), for an expected long-term annual yield of 184,000 acre-feet. And the

[10] Cost estimate based on the best alternative identified in USBR 2008a.

proposed dam at Temperance Flat requires a capital investment of $3.4 billion to yield water at an estimated cost of $720 per acre-foot, for an expected annual yield of 158,000 acre-feet per year.[11]

Like most projects, infrastructure project proponents minimize the actual costs and exaggerate the benefits. Project costs and benefits are spread out over an unusually long 100-year lifetime, making the annual costs lower and the project water yield higher than if the project lifetime were more realistic. Environmental benefits are included in the cost estimates, making the projects appear more economically favorable. Yet, the environmental cost of building these facilities, including riverine habitat losses, is ignored. Recreational benefits are typically included, although the cost of destroying existing recreational sites is ignored.

Furthermore, the costs for building Sites and Temperance Flat Reservoirs do not capture the cost of actually providing this water to Californians. Additional infrastructure would be required to deliver that water to communities throughout the state. In addition, local communities would need to build new or expand existing water and wastewater treatment plants. Furthermore, the customer would bear additional cost to use that water, e.g., heating and, in some cases, treating this water in their homes and businesses. By reducing the volume of water needed to take showers and clean clothes, water conservation and efficiency reduces the volume of water that must be moved, treated, heated, and treated again as wastewater, reducing the need and cost to develop additional water and wastewater treatment infrastructure.

How do we pay for it?

While the water savings we identified are far cheaper than most other supply options, they are not free. Capturing these savings requires an initial investment. These efficiency improvements, however, often pay for themselves as a result of the many co-benefits that water conservation and efficiency provides, including reductions in wastewater and energy bills and improvements in crop quality and yield. The distribution of benefits among the customer; general public; water, wastewater, and energy utilities; and irrigation districts suggest that the costs should be shared among these beneficiaries. Energy and wastewater utilities benefiting from these programs could partner with water agencies and irrigation districts to provide their customers with rebates and other financial incentives. Water agencies and irrigation districts could adopt pricing structures whereby revenue generated from higher charges on water wasters could fund conservation programs. The State could provide money through grants and low-interest loans to utilities and irrigation districts to increase customer incentives. Many of these programs are in use to some degree throughout California, but they can and must be expanded. In addition, the State could institute a public goods charge, as was done for energy in 2000, to provide a steady stream of

[11] Cost estimated based on alternatives identified in USBR 2008b. Note that the Bureau of Reclamation annualizes the cost over a 100-year period at a 4 7/8% interest. These unusually generous assumptions deflate the cost of water from this project.

funding for water conservation and efficiency programs. Depending on the fee schedule, a public goods charge could generate \$100 million to \$500 million annually (DWR 2010). These approaches have the added benefit of reducing pressure on the state's general fund by ensuring that the beneficiaries pay the costs.

Conclusions

Water conservation and efficiency must be a central component of a portfolio of solutions for California's water problems. Improved efficiency can help meet California's water needs for decades to come while still satisfying a growing population, maintaining a vibrant agricultural and industrial sector, and restoring the health of the Sacramento-San Joaquin Delta and other threatened ecosystems. This assessment identifies 1 million acre-feet per year of potential water savings, split between the agricultural and urban sectors, which can be achieved with existing technology, and we recommend strategies for moving forward quickly to capture these savings. All together, the efficiency improvements require an upfront investment of \$1.87 billion – far lower than many other water supply options. The cost of these efficiency improvements is \$185 per acre-foot for the agricultural sector and a net *savings* of \$99 per acre-foot for the urban sector. The net savings in the urban sector conservation measures means that the customer saves money over the lifetime of the device through lower energy and wastewater bills.

Water conservation and efficiency measures can be captured more quickly than traditional water supply options. In addition, savings from these measures are incremental. This is a key benefit of water conservation and efficiency measures. Conservation programs can be expanded when demand pressures are high and relaxed as demand pressures wane. With most water supply projects, however, the community is committed to maintain demand to ensure that the new supplies are fully utilized.

The cost for water conservation and efficiency measures can be defrayed through a combination of financial incentives, regulations, education, and pricing policies. Various financial incentives, including rebates, low-interest loans, and grants, can help reduce the upfront cost associated with these efficiency improvements. In addition, existing legislation requires that Californians install water meters, more efficient devices in their homes and businesses, and implement efficient water management practices on their farms. A combination of financial incentives, regulation, and education may mean that we can capture these savings at even lower costs and at a faster rate.

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SIGN ON SAN DIEGO

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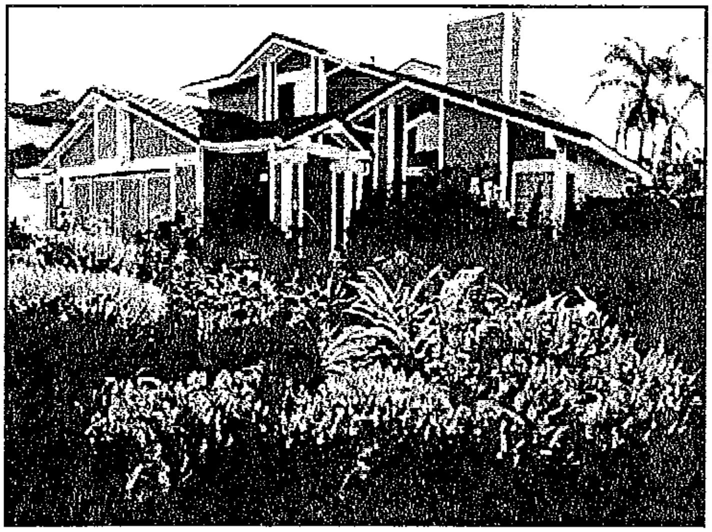
What should I do once the lawn is gone?

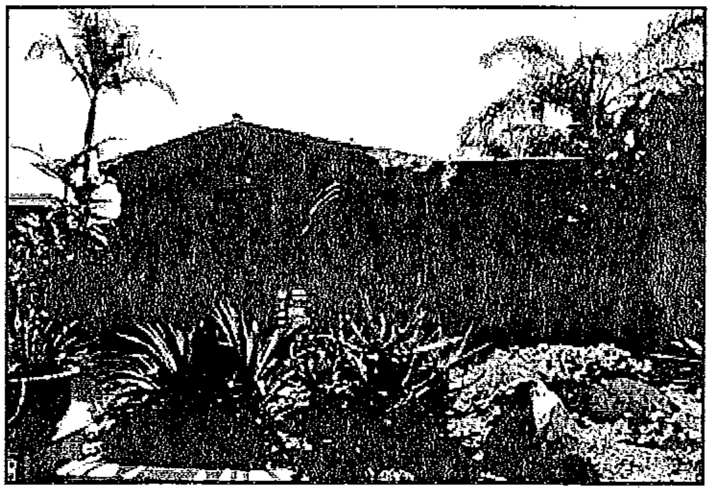
Unique gardens grow after their owners take a pass on grass

By Mary James • Special to the U-T,

Originally published September 10, 2010 at 5:33 p.m., updated September 10, 2010 at 5:33 p.m.



Eduardo Contreras • U-T



DAVID BROOKS • U-T

Earnie Grafton • U-T

Philip Diamond and his partner Kevin Tilden were fed up with the constant maintenance of their postage-stamp front lawn. Cathy and George Roswell covered their lawn with mulch in an effort to cut soaring water bills. Nan Sterman endured a lawn in her backyard only while her children were growing up.

Today, instead of swaths of traditional green grass, all three enjoy colorful new gardens that give them added pleasures while requiring less maintenance and water. In saying goodbye to lawns, these homeowners are among a growing number opting for landscapes better suited to San Diego's Mediterranean climate.

"It's not grass, it's lawn I don't like," says Sterman, a horticulturist and author who teaches classes on lawn removal and replacement. "It's too resource intensive. You water it a couple times a week and fertilize it regularly. You prune it weekly – that's what mowing is – and haul the clippings off to the dump, all with fossil fuel-using vehicles. It makes no sense."

Getting rid of lawn can be a simple as renting a sod cutter, stripping the turf about 2 inches down and hauling it away. Or it can be as time-consuming as spraying several times with an herbicide to destroy the stubborn roots of Bermuda grass. (To learn more, consult the how-to classes in the resource list below.)

Once the lawn is gone, landscape options abound. Diamond and Tilden collaborated with landscape designer Tom Mooney of Calavo Landscape to craft a garden of sculptural succulents outside their Mission Hills bungalow.

When the Bermuda grass lawn in the rear of her Olivenhain home was finally obliterated, Sterman installed a new patio with seating, a fire ring and stylish fountain, and planted meadow of low-growing ornamental grasses studded with bulbs and annuals.

The Roswells enjoy a mix of flowering Mediterranean plants, bulbs and succulents, along with the roses Cathy loves, in the makeover of her Oceanside front yard by landscape designer Ruth E. Wolfe.

Here are the details of each new landscape.

Oceanside: Beauty on a Budget

As their water bills climbed to more than $130 a month, the Roswells decided to "stop throwing money down the drain" and let their front lawn die. When a DIY-makeover proved too difficult, they covered the shriveled grass with compost. "We looked like a foreclosed home," said Cathy.

Months later, Roswell contacted Ruth E. Wolfe after seeing one of her waterwise garden designs that included roses. "I told her I wanted an English garden look but without high water bills," she recalled. "I didn't want just succulents because we can grow so much more here."

Today, fragrant 'Double Delight,' 'Chrysler Imperial,' 'Barbra Streisand' and other roses are clustered near a new decomposed granite path that curves to the entry of the Roswell home. A new drip irrigation system delivers the moisture roses need, while keeping the majority of the garden's plants on the dry side.

A trio of boulders at the peak of the contoured yard is backed by a strawberry tree (Arbutus unedo 'Marina') and circled by a deft mix of flowering plants with blue and yellow blooms – Cathy's favorite colors. Among them are Agapanthus 'Storm Cloud,' Salvias 'Savannah Blue' and 'Anthony Parker,' blue bearded iris, vanilla-scented heliotrope, fernleaf lavender and a sunny day lily called 'Move Over Moon.' Throughout the year, daffodils, Dutch iris, amaryllis, scilla, zephyranthes, species gladiolus, Urginea maritima and other bulbs pop seasonal color into the flower-filled scene.

Bordering the sidewalk are bold ribbons of golden Crassula 'Campfire,' lavender-pink Echeveria 'Afterglow' and gray-lavender Kalanchoe fedtschenkoi 'Aurora Borealis.' Behind them, wands of magenta-flowered Calandrinia grandiflora dance.

Foundation plantings designed for privacy and insulation include pale lavender Buddleja 'Sleeping Beauty,' variegated Plectranthus 'White Rhino,' white and blue-blossomed Duranta 'Sweet Memories' and the tall, winter-blooming Salvia karwinskii with its showy rose-pink flowers.

"Our water bill is much lower than when we had grass," Cathy said. "And now when we water, it's worth it. Neighbors see me out deadheading and they come by to say, 'Thank you for making something so beautiful.' "

Mission Hills: Award-winning succulent design

A colorful sign proclaiming their waterwise garden award stands proudly outside Philip Diamond and Kevin Tilden's front door. Tilden, an executive with California American Water in Coronado, entered the annual California Friendly Landscape contest sponsored by the county's water agencies and took home the 2010 prize for a garden in the city of San Diego.

Tilden and Diamond, a physician, took out their front lawn a few years after moving with their two dogs from downtown to Mission Hills." We were sick and tired of caring for it, and we weren't getting any enjoyment from it," Diamond recalled.

Instead of grass, the couple wanted a primarily succulent garden. "I love them," Diamond said. "They are architectural, so interesting to look at, and they flower."

With Tom Mooney, a landscape designer for more than three decades, Diamond and Tilden went succulent shopping at Daylily Hill Nursery in Bonsall and Walter Andersen Nursery in Point Loma. "They were looking for out-of-the-ordinary plants," Mooney said. "I suggested mixing in some softer plants and that they repeat some of their favorite succulents so that the front yard would look more like a garden and less like a collection."

Before planting started, Mooney flattened the sloped yard by constructing a new retaining wall a few feet back from the sidewalk, adding several boulders and installing a drip irrigation system and path lighting. Gravel mulch that complements the home's golden stucco completed the makeover.

Walking around the garden today, Diamond stops to admire a dramatic clump of Agave desmettiana with arching dark green leaves edged in cream, a silvery blue Agave parryi outlined with inky "teeth," and the spherical Dasylirion wheeleri with its long knitting needle-like leaves. Smaller succulents including yellow-flowered Euphorbia caput-medusea and ruby-tipped flapjack plants (Kalanchoe luciae) hug the ground while slender wands of Calandrinia grandiflora and the stout-stalks of aeoniums add some height.

Diamond and Tilden kept the palms in a walled bed that screens their front porch. Marching in front of the wall are a half-dozen multibranched Euphorbia trigona; below them is a row of Aloe striata, known as the ghost aloe for its foggy lavender leaves.

Since the landscape was completed, Diamond occasionally tucks new succulents that catch his eye into the garden. The couple also added a tall copper wind sculpture purchased in Santa Fe.

"We didn't set out to save water," said Diamond, "But the amazing thing is we did. Our water use dropped 70 percent."

Olivenhain: A gathering place

"I never wanted a lawn," said Nan Sterman, "but my husband thought we should have some grass for the kids to play on. But all they ever did was ride their Big Wheels around the DG path that circled it."

When her son and daughter entered high school, Sterman began the time-consuming process of eliminating the Bermuda grass lawn, a process that took two years. As the grass withered, she weighed options for the new garden space in her back yard, shaded by a tall flowering mulberry tree.

Brainstorming with her husband and other family members, as well as Fallbrook landscape designer Scott Spencer, led to plans for a new garden room and meadow rich with curves and the bold colors Sterman loves. "It was such a big space, we knew we needed structure for the plants to play off of," she said.

Chunks of concrete salvaged from a friend's demolished patio formed a new circular patio that includes a fire ring. Two stucco structures, one concave and the other convex, frame the patio's far edge while decomposed granite paths wend around its other edges and join a walkway to an upper patio and the entrance to the kitchen and dining room.

Bench seating spans the concave wall, painted a deep adobe. The convex wall, in creamy yellow, holds a three-tiered recirculating fountain created from oxblood glazed containers. Sconces made in South Africa — "purchased five years ago and stored in a closet" — turned out to be perfect lighting, Sterman said.

Peeking from behind the walls and echoing their colors are 10-foot-tall Pennisetum 'Prince,' a rare white pomegranate, a dusky lavender-leaved Arabian lilac (Vitex trifolia 'Purpurea') and Banksia speciosa with its cones of pale yellow flowers. In front of the convex wall are container plantings, a burgundy-leafed Crinum 'Splendens,' garnet-flowered Pelargonium sidoides and a weeping Agonis juniperina that casts dramatic evening shadows.

The yin to the patio's yang is an adjacent curving meadow ringed by low stone seating. Planted as 2-inch plugs, the native California field sedge Carex praegracilis will form a tousled dark green mat that is cut back once or twice a year. Sterman already has added some favorite South African bulbs and drought-tolerant perennials and annuals like yarrow, 'Big Rev' Dianella and breadseed poppies to the meadow for seasonal color and texture.

"We never used this part of the backyard very much before," Sterman said. "Now we are finding more reasons all the time to spend time here."

Find this article at:
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In Depth

What local agencies are saving the most water?

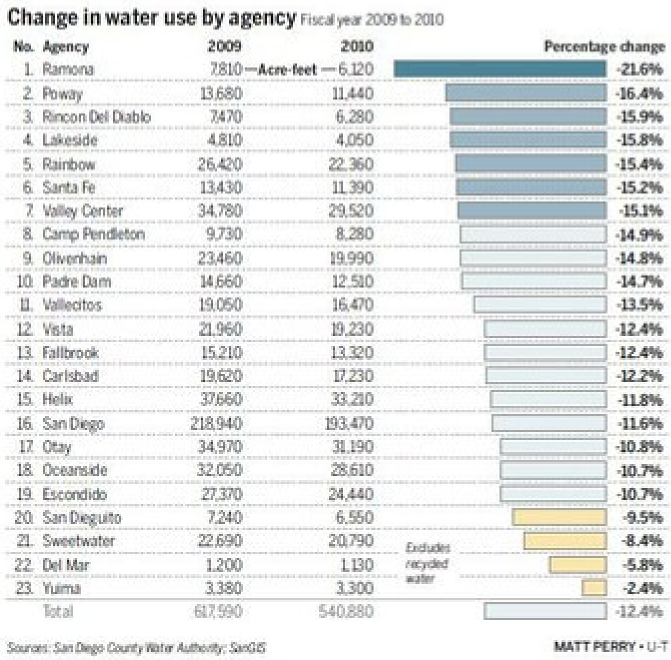
By Mike Lee, UNION-TRIBUNE

Tuesday, September 7, 2010 at 7:45 a.m.

Howard Lipin

A yard stick-like instrument called a staff gauge is used to measure the depth of the Sweetwater Reservoir.

Because of the drought, the San Diego County Water Authority ordered mandatory water conservation amounting to an 8 percent cut last year.


Change in water use by agency Fiscal year 2009 to 2010

No.	Agency	2009	2010	Percentage change
1.	Ramona	7,810 —Acre-feet—	6,120	-21.6%
2.	Poway	13,680	11,440	-16.4%
3.	Rincon Del Diablo	7,470	6,280	-15.9%
4.	Lakeside	4,810	4,050	-15.8%
5.	Rainbow	26,420	22,360	-15.4%
6.	Santa Fe	13,430	11,390	-15.2%
7.	Valley Center	34,780	29,520	-15.1%
8.	Camp Pendleton	9,730	8,280	-14.9%
9.	Olivenhain	23,460	19,990	-14.8%
10.	Padre Dam	14,660	12,510	-14.7%
11.	Vallecitos	19,050	16,470	-13.5%
12.	Vista	21,960	19,230	-12.4%
13.	Fallbrook	15,210	13,320	-12.4%
14.	Carlsbad	19,620	17,230	-12.2%
15.	Helix	37,660	33,210	-11.8%
16.	San Diego	218,940	193,470	-11.6%
17.	Otay	34,970	31,190	-10.8%
18.	Oceanside	32,050	28,610	-10.7%
19.	Escondido	27,370	24,440	-10.7%
20.	San Dieguito	7,240	6,550	-9.5%
21.	Sweetwater	22,690	20,790	-8.4%
22.	Del Mar	1,200	1,130	-5.8%
23.	Yuima	3,380	3,300	-2.4%
	Total	617,590	540,880	-12.4%

Excludes recycled water

Sources: San Diego County Water Authority; SanGIS

MATT PERRY • U-T

- Matt Perry • Union-Tribune

Graphic shows reductions in water use by district across the county. (Click to enlarge.)

Most districts exceeded the goal, with the Ramona Municipal Water District cutting the highest percentage — nearly 22 percent — while the tiny Yuima Municipal Water District near the Riverside County border cut back by just 2.4 percent.

Overall, San Diego County residents cut their water use by 12.4 percent during the first 12 months of mandatory conservation measures across the region, saving nearly 77,000 acre-feet of water. Only two reservoirs in San Diego County can store that much water, enough to serve roughly 150,000 families for a year.

About one-third of the volume saved was from cutbacks in the city of San Diego. It trimmed water use by 25,470 acre-feet, or 11.6 percent, in fiscal 2010 compared with 2009, according to the San Diego County Water Authority.

On a percentage basis, the city placed slightly below the regional mark.

Water conservation was ordered by most districts countywide because supplies have shriveled in recent years. Drought conditions and court-ordered protections for fish in the Sacramento-San Joaquin River Delta are major causes of the shortfalls. Delta safeguards limit pumping through the key conduit for water that flows from Northern to Southern California.

The regional numbers don't offer strong trends about which types of districts — urban or rural, large or small, north or south — were most successful in conserving water, said Dana Friehauf, a resource specialist with the water authority.

"What can be said, perhaps, is the makeup of the district and what the retail agency has done with their message, their restrictions and their rates plays more into it than size," Friehauf said.

The water authority buys wholesale water and distributes it to 24 members that service almost the entire metropolitan area. Starting in July 2009, the water authority told retail water districts to cut back by 8 percent compared to pre-cutback levels.

Most districts ordered customers to irrigate their yards only on certain days and many set rules for car washing, fountains and other water-intensive activities.

Friehauf said some farm-heavy districts made major cutbacks in water use two years ago so their 2010 numbers don't reflect the full scale of their conservation efforts. She said agriculture customers countywide have reduced their water use by more than half since 2007.

"That is huge," she said.

Conservation measures were so successful that some districts, including Ramona and Olivenhain, have backed off mandates.

But officials said that doesn't mean residents should revert to water-wasting ways. The water authority plans to maintain reduced deliveries at least through June 2011 and likely longer unless seemingly intractable problems with California's water delivery system are fixed.

"We expect everyone to be able to conserve as they have," Friehauf said.

Water savings around the county:

Ramona

Reduction in use, which was ordered by county districts, was highest in Ramona in fiscal 2010 — nearly a 22 percent cut. The weak economy played a major role in reducing water demand, said district manager Ralph McIntosh. "We have quite a few foreclosed houses up here and quite a few vacancies," he said. "There are a lot of dead yards."

The 21.6 percent decrease in water sales, combined with reductions in property tax revenue, put district finances in a tailspin and forced layoffs of five employees, McIntosh said.

Santa Fe

Compliance with district-mandated yard irrigation days was the key to conservation in a part of the county known for its lush residential landscapes.

"It doesn't matter if you are a quarter-acre lot or a three-acre lot," said district manager Michael Bardin. "If you followed the rules, you had a commensurate reduction in water use."

He said response was almost uniform. "We were really, truly amazed," he said. "It wasn't a painful year."

Del Mar

The tiny town by the sea started its "heavy lifting" on water conservation before the regional mandate was put into place, said Eric Minicilli, deputy public works director. He said since

2007, Del Mar residents have reduced water use by more than 21 percent using a variety of tools, including a water-waster reporting form on the city's main website.

San Diego

Mayor Jerry Sanders seemed to continually promote water conservation last year. The city also deputized a team of water cops, which processed 5,017 complaints about waste and referred 67 cases to code enforcement officials.

The combined measures lead to substantial cuts in every sector of the city: 10.7 percent for residential customers; 7.5 percent for industry; 20.4 percent for irrigators; and 10.9 percent for city facilities.

Sweetwater

Residents in the district had the lowest per capita consumption going into the drought, said general manager Mark Rogers, so the district took what he called "the adult approach" and didn't impose mandatory water-use restrictions.

In addition, "Sweetwater Authority customers already had paid for the things that allowed them to weather the drought better than most other agencies," Rogers said. Those facilities include two reservoirs, a groundwater desalination plant and freshwater wells.

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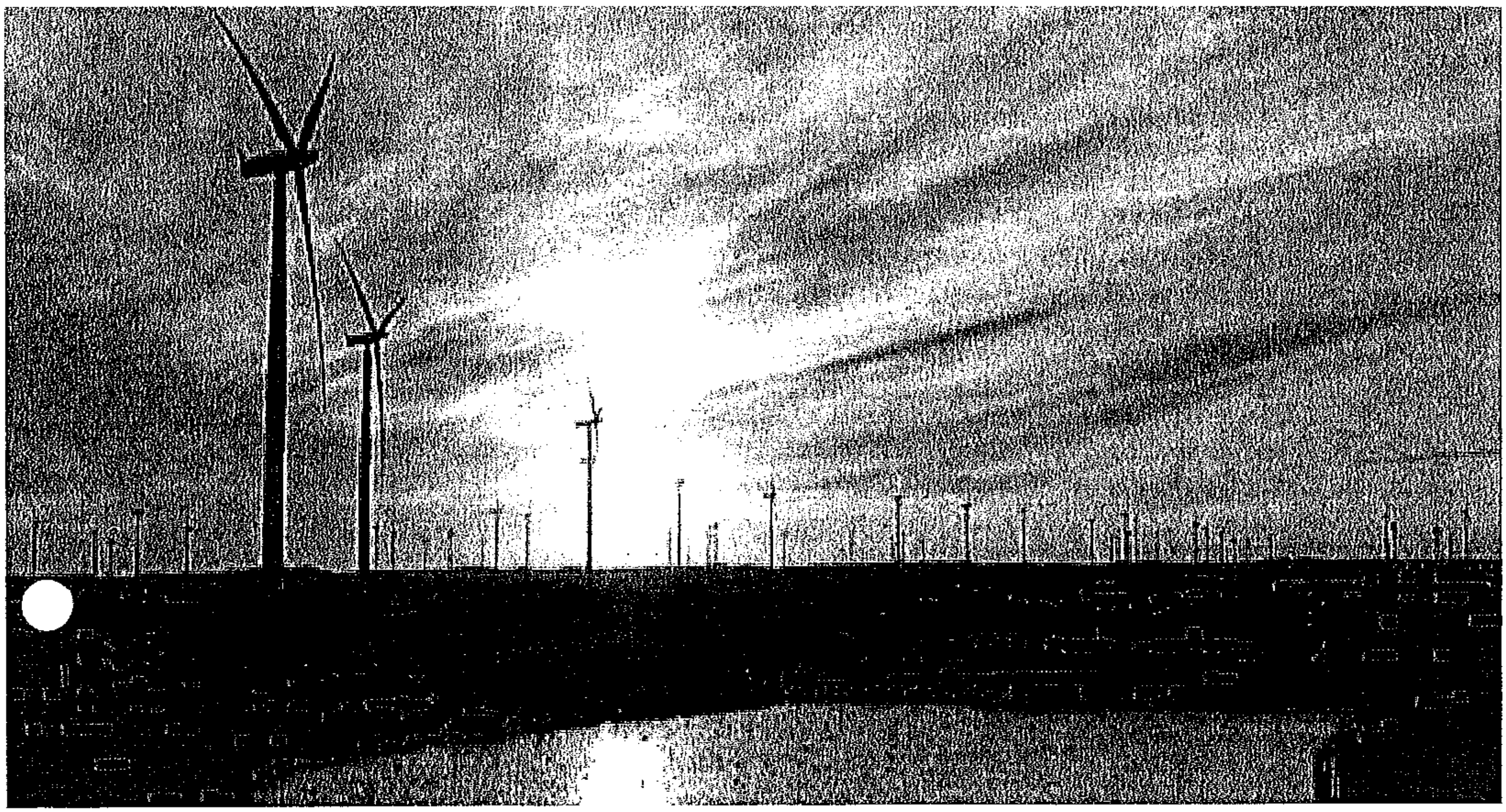
Implementing a Public Goods Charge for Water

by
Kasandra Griffin, Greg Leventis and Brian McDonald

July 12, 2010

U.C. Berkeley, Goldman School of Public Policy
Policy Analysis Project

On behalf of the
California Public Utilities Commission
And the
Water Energy Team of the Climate Action Team
(WetCat)



Executive Summary

Our client asked for recommendations on how to implement a public goods charge (PGC) on water, as per the "Water Energy" section of the Assembly Bill 32 (AB 32) Scoping Plan.

Before considering "how," we considered whether a public goods charge for water is the right tool. The problem we wanted to address is the negative externalities of high water consumption, including greenhouse gas emissions from the energy used to pump, transport, treat, and heat water. We gave serious consideration to two alternate strategies but ultimately decided the public goods charge for water is the best tool.

We recommend a public goods charge for water because:

- A public goods charge for water creates a price signal for water conservation.
- A public goods charge for water would provide a stable, sustainable funding mechanism to support the full list of conservation and efficiency activities specified in Assembly Bill 32.
- The dual energy and water conservation programs specified in AB 32, which could not be fully funded through the other mechanisms we considered, will be effective to both mitigate and adapt to climate change.
- Our proposed implementation strategy will help institutionalize regional water agencies, which are necessary for the state's long-term water-planning effectiveness.

We then make specific recommendations about the design of the public goods charge:

- We recommend passing state legislation requiring all water providers to assess volumetric surcharges on each water bill where metered, or by alternate means in the short-term for areas not metered.
- We recommend that the funds be managed by regional joint power authorities to implement Integrated Regional Water Management Plans (IRWMPs), which must institutionalize their operating structure before this can be put in place. This will provide the necessary regional organization for effective project choices, **and** will reduce the number of water agencies that need oversight from thousands to 50.
- We recommend that the Department of Water Resources (DWR), which already has jurisdiction over the IRWMPS, provide direction and oversight to ensure that specified state goals are met and that funds are well-managed, with assistance from the WETCAT members.
- We recommend that the fees initially be set to raise $680 Million per year. That level of funding can be used to meet the water supply targets of Senate Bill X7-7, and to exceed the greenhouse gas emissions goals of Assembly Bill 32. We recommend that the legislation be structured with maximum flexibility to allow for future rate changes.

Introduction

Public Goods Charges and Assembly Bill 32

A public goods charge is a fee applied to a utility bill to fund public-interest programs related to that utility service. A public goods charge for electricity was passed in California in 1996 as part of the energy sector deregulation, and has been very effective at funding conservation and efficiency programs for energy. State agencies in the field of water have been interested in the possibility of a similar charge on water bills for years. The current directive to look into it comes from the Scoping Plan of Assembly Bill 32 (AB 32), also known as "The Global Warming Solutions Act of 2006."

The overarching goal of AB 32 is to reduce greenhouse gas emissions in California to 1990 levels by the year 2020, which represents an approximately 25% reduction from "business as usual." For the purposes of this investigation, we assumed AB 32 will go into full effect on schedule, though in fact it is under continual threat of delay or repeal.

Assembly Bill 32 itself does not provide specific details about how the greenhouse gas emissions targets will be met. The AB 32 scoping plan, released by the California Air Resources Board in December of 2008, provides more direction, while still remaining quite vague. The items included in the scoping plan are **not** *law,* but rather administrative recommendations of how to achieve the law's goals. On the subject of water, the scoping plan recommends six specific measures, which are voluntary. The final one, the public goods charge, is intended as a financing mechanism for the others.

W-1 Water Use Efficiency
W-2 Water Recycling
W-3 Water System Energy Efficiency
W-4 Reuse Urban Runoff
W-5 Increase Renewable Energy Production
W-6 Public Goods Charge

Our direct clients are in the Policy Planning Division of the California Public Utilities Commission. Our indirect client is the Water Action Team of the Climate Action Team (WETCAT) that has been tasked with addressing this list of water issues included in the AB 32 scoping plan.

Our client asked us to make recommendations about how to implement a public goods charge for water.

Water, Energy, and the Environment

Water use and energy use are highly correlated in California, both in volume and in geography. Approximately 20% of all electricity consumed in the state is related to water delivery, treatment, and use. (CARB, 2008: p. 65) Shortages of water supply have a two-pronged impact on energy: they decrease the large amounts of water needed for hydroelectric generation while requiring higher-energy-intensity alternate sources of water. The focus of this report will be on the latter.

The underlying problem, as we defined it, is that water consumption has negative externalities on the environment.

The primary negative externalities are:

I. Greenhouse gas emissions from pumping, treating, and heating water.
II. Environmental externalities from removing water from its natural place in the ecosystem: decreased flows available for flora and fauna, concentrations of pollutants in remaining flows, and other ecosystem damage.

There are also two major economic externalities of water consumption:

I. Decreased supply, due to overdraft of groundwater, for future generations.
II. Increased costs of procuring less accessible new supply, through the consumption of "cheap" water.

Water Utilities and Regulation

According to consultations with professionals in the industry, there are 3,000 to 6,000 water providers in the state of California. Those provider agencies are regulated by several state agencies, including the Department of Water Resources (DWR), State Water Resources Control Board (SWRCB), California Public Utilities Commission (CPUC), and Department of Public Health (DPH). Several federal agencies are also involved. The division of roles in regulating water supply and water quality is not always clear.

The majority of water providers are publicly owned utilities with locally elected boards of directors, and there is no additional oversight of their rates. Because they are publicly owned, they are presumed to act in the best interests of their member/owners.

However, investor-owned water utilities (IOUs) *are* regulated and carefully counted. There are fewer than 150 such providers in California, and most of them are small. Only a handful serves significant numbers of customers, but that handful supplies water to approximately 20% of California's residential users. The investor-owned water providers, like investor-owned electricity providers, are regulated by the California Public Utilities Commission in matters of rate-se ting and customer protection.

Three Alternatives, Two Recommendations

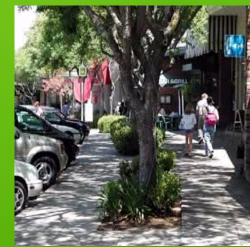
After gathering information about the state of the water industry (thousands of providers, limited regulation), we considered three alternatives for how to address the negative externalities:

1. No new funding mechanism: Create/expand programs to educate water providers about laws that require water and/or energy conservation, and about funding sources or pricing mechanisms already available to them. This alternative does **not** include a new regulatory component; only outreach tools (brochure, website,

Reuse
(Harvesting, Graywater)








Managing Wet Weather with Green Infrastructure

Municipal Handbook

Rainwater Harvesting Policies

Managing Wet Weather with Green Infrastructure

Municipal Handbook

Rainwater Harvesting Policies

prepared by

Christopher Kloss
Low Impact Development Center

The Municipal Handbook is a series of documents
to help local officials implement green infrastructure in their communities.

December 2008

EPA-833-F-08-010

Front Cover Photos
Top: rain garden; permeable pavers; rain barrel; planter; tree boxes.
Large photo: cisterns in the Wissahickon Charter School's Harmony Garden in Philadelphia

Rainwater Harvesting Policies

Introduction

From the last half of the 20th century, the U.S. has enjoyed nearly universal access to abundant supplies of potable water. But as witnessed by the recent serious and sustained droughts in the Southeast and Southwest, this past luxury is not something that can be expected for the long term. Future population growth will exert more demand on water systems while climate change is predicted to decrease available supplies because of decreased snow pack and drier regional climatic patterns. The U.S. has been identified as a country that faces imminent water shortages and a Government Accountability Office (GAO) survey found that water managers in 36 states anticipate water shortages during the first two decades of this century.[1] These challenges will require a more sustainable approach to using water resources, looking at not only how much water is used, but also the quality of water needed for each use.

The overwhelming majority of the water used in the U.S. comes from freshwater supplies of surface and groundwater. Water extracted for public systems is treated to potable standards as defined by the Safe Drinking Water Act. Access to high quality water has greatly benefited public health, but it has also resulted in our current system that utilizes potable water for virtually every end use, even when lesser quality water would be sufficient. In addition to conservation methods, using alternative sources of water will be necessary for more efficient use of water resources.

Rainwater harvesting, collecting rainwater from impervious surfaces and storing it for later use, is a technique that has been used for millennia. It has not been widely employed in industrialized societies that rely primarily on centralized water distribution systems, but with limited water resources and stormwater pollution recognized as serious problems and the emergence of green building, the role that rainwater harvesting can play for water supply is being reassessed. Rainwater reuse offers a number of benefits.[2]

- Provides inexpensive supply of water;
- Augments drinking water supplies;
- Reduces stormwater runoff and pollution;
- Reduces erosion in urban environments;
- Provides water that needs little treatment for irrigation or non-potable indoor uses;
- Helps reduce peak summer demands; and
- Helps introduce demand management for drinking water systems.

Rainwater harvesting has significant potential to provide environmental and economic benefits by reducing stormwater runoff and conserving potable water, though several barriers exist that limit its application. The U.S. uses more water per capita than any other country, with potable water delivered for the majority of domestic and commercial applications. Typical domestic indoor per capita water use, shown in Table 1, is 70 gallons per day (gpd); however outdoor water use can constitute 25% to 58% of overall domestic demand, increasing per capita domestic use up to 165 gpd.

Table 1. Typical Domestic Daily per Capita Water Use.[3]

Use	Gallons per Capita	% of Daily Total
Potable indoor uses		
• Showers	11.6	7.0%
• Dishwashers	1.0	0.6%
• Baths	1.2	0.8%
• Faucets	10.9	6.6%
• Other uses, leaks	11.1	6.7%
Subtotal	**35.8**	**21.7%**
Non-potable indoor uses		
• Clothes washers	15.0	9.1%
• Toilets	18.5	11.2%
Subtotal	**33.5**	**20.3%**
Outdoor uses	**95.7**	**58.0%**

While potable water is used almost exclusively for domestic uses, almost 80% of demand does not require drinkable water. Similar trends exist for commercial water use. Table 2 provides examples of daily commercial water usage.

Table 2. Typical Daily Water Use for Office Buildings and Hotels.[4]

Use	Office Buildings % of Daily Total	Hotels % of Daily Total
Potable indoor uses		
Showers	---	27%
• Faucets	1%	1%
• Kitchen	3%	10%
• Other uses	10%	19%
Subtotal	**14%**	**57%**
Non-potable indoor uses		
• Toilets/urinals	25%	9%
• Laundry	---	14%
• Cooling	23%	10%
Subtotal	**48%**	**33%**
Outdoor uses	**38%**	**10%**

Both the domestic and commercial water use statistics show that potable water is often being utilized for end uses that could be satisfied with lesser quality water. The statistics also indicate that nearly all water is used in a one-time pass through manner, with little attempt at reuse. Rainwater harvesting offers an alternative water supply that can more appropriately match water use to the quality of water supplied.

Rainwater harvesting systems typically divert and store runoff from residential and commercial roofs. Often referred to as 'clean' runoff, roof runoff does contain pollutants (metals or hydrocarbons from roofing materials, nutrients from atmospheric deposition, bacteria from bird droppings), but they are generally in lower concentrations and absent many of the toxics present in runoff from other impervious surfaces. Installing a rainwater collection system requires diverting roof downspouts to cisterns or rain barrels to capture and store the runoff. Collection containers are constructed of dark materials or buried to prevent light penetration and the growth of algae.[5] From the storage container, a dual plumbing system is needed for indoor uses and/or a connection to the outdoor irrigation system.

Regulations

Although a few states and local jurisdictions have developed standards or guidelines for rainwater harvesting, it is largely unaddressed by regulations and codes. Neither the Uniform Plumbing Code

(UPC) nor International Plumbing Code (IPC) directly address rainwater harvesting in their potable or stormwater sections. Other reuse waters are covered by codes. The UPC's Appendix J addresses reclaimed water use for water closets and urinals and the IPC's Appendix C addresses graywater use for water closets and urinals along with subsurface irrigation.[6] Both sections focus on treatment requirements, measures necessary to prevent cross-contamination with potable water, and appropriate signage and system labeling. However, because of a general lack of specific rainwater harvesting guidance some jurisdictions have regulated harvested rainwater as reclaimed water, resulting in more stringent requirements than necessary. These issues have led to confusion as to what constitutes harvested rainwater, graywater, or reclaimed water.[7]

The confusion among waters for reuse and the lack of uniform national guidance has resulted in differing use and treatment guidelines among state and local governments and presents an impediment to rainwater reuse. Texas promotes harvested rainwater for any use including potable uses provided appropriate treatment is installed; Portland, like many other jurisdictions, generally recommends rainwater use to the non-potable applications of irrigation, hose bibbs, water closets, and urinals.

UPC Definitions – Waters for Reuse[8]

- *Graywater* – untreated wastewater that has not come in to contact with black water (sewage). Graywater includes used water from bathtubs, showers, lavatories, and water from clothes washing machines.
- *Reclaimed water* – water treated to domestic wastewater tertiary standards by a public agency suitable for a controlled use, including supply to water closets, urinals, and trap seal primers for floor drains and floor sinks. Reclaimed water is conveyed in purple pipes (California's purple pipe system is one of the better known water reclamation systems).
- *Harvested rainwater* – stormwater that is conveyed from a building roof, stored in a cistern and disinfected and filtered before being used for toilet flushing. It can also be used for landscape irrigation.

To develop general or national guidance for rainwater harvesting, several factors must be considered. While potable use is possible for harvested rainwater, necessary on-site treatment and perceived public health concerns will likely limit the quantity of rainwater used for potable demands. Irrigation and the non-potable uses of water closets, urinals and HVAC make-up are the end uses that are generally the best match for harvested rainwater. A lesser amount of on-site treatment is required for these uses and, as seen from the use statistics presented above, these uses constitute a significant portion of residential and commercial demand. Focusing harvested rainwater on irrigation and selected non-potable indoor uses can significantly lower demand while allowing a balance and public comfort level between municipal potable water and reused rainwater.

Guidance for the reuse of harvested stormwater will be similar to reclaimed water and graywater but will differ because of lower levels of initial contamination and targeted end uses. The primary concerns of indoor rainwater reuse are cross-contamination of the potable supply and human contact with bacteria or pathogens that may be present in the collected rainwater. Portland's Rainwater Harvesting One and Two Family Dwelling Specialty Code provides a good example of specific rainwater reuse stipulations. Although the code doesn't address multi-family residential or non-residential applications, rainwater reuse is permitted for these facilities, but due to the unique design of each system, commercial reuse systems are considered on a case by case basis. In addition, multi-family residential units and sleeping portions of hotels are allowed to use rainwater for irrigation only; non-residential buildings are permitted to use rainwater for irrigation, water features, water closets and urinals. In these applications, water provided for water closets and urinals must be treated with filters and UV and/or chlorinating.[9]

Tucson Rainwater Harvesting Requirements

Tucson, Arizona became the first city in the country to require rainwater harvesting for landscaping use. Beginning June 1, 2010, 50% of a commercial property's irrigation water must be supplied from rainwater. In addition to cisterns, the regulations allow berms and contoured slopes to be used to direct rainwater to trees and landscaped areas.

Portland's code permits rainwater reuse for potable uses at family dwellings only through an appeals process. In addition, rainwater used only for outdoor irrigation is not covered by the code and needs no treatment prior to use. Acceptable indoor non-potable uses are hose bibbs, water closets, and urinals. The code illuminates several important issues that need to be considered when developing rainwater harvesting code.

Excerpts of General Requirements
Portland Rainwater Harvesting Code Guide

General

- Harvested rainwater may only be used for water closets, urinals, hose bibbs, and irrigation.
- Rainwater can only be harvested from roof surfaces.
- The first 10 gallons of roof runoff during any rain event needs to be diverted away from the cistern to an Office of Planning & Development Review (OPDR) approved location.

Rainwater Harvesting System Components

- Gutters – All gutters leading to the cistern require leaf screens with openings no larger than 0.5 inches across their entire length including the downspout opening.
- Roof washers – Rainwater harvesting systems collecting water from impervious roofs are required to have a roof washer for each cistern. Roof washers are not required for water collected from green roofs or other pervious surfaces. The roof washer is required to divert at least the first 10 gallons of rainfall away from the cistern and contain 18 inches of sand, filter fabric, and 6 inches of pea gravel to ensure proper filtration.
- Cisterns – Material of construction shall be rated for potable water use. Cisterns shall be able to be filled with rainwater and the municipal water system. Cross-contamination of the municipal water system shall be prevented by the use of (1) a reduced pressure backflow assembly or (2) an air gap. Cisterns shall be protected from direct sunlight.
- Piping – Piping for rainwater harvesting systems shall be separate from and shall not include any direct connection to any potable water piping. Rainwater harvesting pipe shall be purple in color and labeled "CAUTION: RECLAIMED WATER, DO NOT DRINK" every four feet in length and not less than once per room.
- Labeling – Every water closet or urinal supply, hose bibb or irrigation outlet shall be permanently identified with an indelibly marked placard stating: "CAUTION: RECLAIMED WATER, DO NOT DRINK."
- Inspections – Inspections are required of all elements prior to being covered.
- Maintenance – Property owner is responsible for all maintenance.

- *Water quality* – Water quality and its impact on human health is a primary concern with rainwater harvesting. This issue is comprised of two components: end use of the rainwater and treatment provided. Rainwater used for residential irrigation (on the scale of rain barrel collection) does not typically require treatment. Commercial applications and non-potable indoor uses require treatment but the type of use will determine the extent of treatment. Each jurisdiction will need to assess the level of treatment with which it is comfortable, but limiting rainwater reuse to water closets, urinals and hose bibbs presents little human health risk. Each system will require some level of screening and filtration to prevent particles and debris from traveling through the plumbing system, and most jurisdictions require disinfection with UV or chlorination because of bacterial concerns. Table 3 provides an example of minimum water quality guidelines and suggested treatment methods for collected rainwater.

  A review of treatment standards among various jurisdictions shows a wide range of requirements from minimal treatment to reclaimed water standards. A recent memorandum of understanding from the City and County of San Francisco allows rainwater to be used for toilet flushing without being treated to potable standards. Texas requires filtration and disinfection for non-potable indoor uses, and Portland requires filtration for residential non-potable indoor uses, but requires filtration and disinfection for multi-family and commercial applications. Treatment requirements ultimately come down to risk exposure with risk of bacterial exposure determining the most stringent levels of treatment. However, San Francisco's Memorandum or Understanding indicates a belief in a low exposure risk with rainwater when used for toilet flushing. Likewise, testing conducted in Germany demonstrated that the risk of *E. coli* contact with the human mouth from toilet flushing was virtually non-existent, resulting in the recommendation that special disinfection measures were unnecessary for rainwater dedicated to non-potable uses.[10]

The level of treatment required by each municipality can influence the number of harvesting systems installed. Filtration and disinfection are not expensive treatment requirements but each treatment requirement adds a cost to the system. Simplifying the treatment requirements when there is not a threat to public health lowers the cost for private entities to install systems and encourages broader adoption of the practice.

- *Cross-contamination* – Cross-contamination of the potable water system is a critical concern for any water reuse system. Cross-contamination measures for rainwater reuse systems will be similar to those for reclaimed and graywater systems. When rainwater is integrated as a significant supply source for a non-potable indoor use, a potable make-up supply line is needed for dry periods and when the collected rainwater supply is unable to meet water demands. The make-up supply to the cistern is the point of greatest risk for cross-contamination of the potable supply. Codes will require a backflow prevention assembly on the potable water supply line, an air gap, or both. In addition to backflow prevention, the use of a designated, dual piping system is also necessary. Purple pipes, indicating reused water, are most often used to convey rainwater and are accompanied by pipe stenciling and point-of-contact signage that indicates the water is non-potable and not for consumption.
- *Maintenance and inspection* – The operation and maintenance of rainwater harvesting systems is the responsibility of the property owner. Municipal inspections occur during installation and inspections of backflow prevention systems are recommended on an annual basis. For the property owner, the operation of a rainwater harvesting system is similar to a private well. Especially for indoor uses annual water testing to verify water quality is recommended as well as regular interval maintenance to replace treatment system components such as filters or UV lights. The adoption and use of rainwater harvesting systems will add to the inspection responsibilities of the municipal public works department, but the type of inspection, level of effort, and documentation required will be similar to those of private potable water systems and should be readily integrated into the routine of the inspection department.

Table 3. Minimum Water Quality Guidelines and Treatment Options for Stormwater Reuse.[11]

Use	Minimum Water Quality Guidelines	Suggested Treatment Options
Potable indoor uses	• Total coliforms – 0 • Fecal coliforms – 0 • Protozoan cysts – 0 • Viruses – 0 • Turbidity < 1 NTU	• Pre-filtration – first flush diverter • Cartridge filtration – 3 micron sediment filter followed by 3 micron activated carbon filter • Disinfection – chlorine residual of 0.2 ppm or UV disinfection
Non-potable indoor uses	• Total coliforms < 500 cfu per 100 mL • Fecal coliforms < 100 cfu per 100 mL	• Pre-filtration – first flush diverter • Cartridge filtration – 5 micron sediment filter • Disinfection – chlorination with household bleach or UV disinfection
Outdoor uses	N/A	Pre-filtration – first flush diverter

*cfu – colony forming units
*NTU – nephelometric turbidity units

Institution Issues and Barriers

Although stormwater reuse offers environmental and economic benefits, its use has remained relatively limited. This is caused by a number of perceived and actual barriers. The high rate of water consumption in the U.S. is coupled with water cost rates that are among the lowest. For example, U.S. water use is approximately twice that of Europe, but the annual cost of household water bills are roughly equal. The cost of water in the U.S. ranges from $0.70 to $4 per thousand gallons, with the national average cost slightly more than $2 for a thousand gallons. Price, therefore, creates little incentive for conservation or the use of alternative sources.[12]

Residential rain barrels are an inexpensive and easy retrofit that reduces stormwater runoff and provides irrigation water. *Photo at left: District of Columbia Water & Sewer Authority; Photo at right: Ann English.*

San Francisco Rainwater Harvesting MOU

In 2008, San Francisco's Public Utilities Commission (SFPUC), Department of Building Inspection (DBI), and Department of Public Health (DPH) signed a Memorandum of Understanding for the permitting requirements for rainwater harvesting systems located within the City and County of San Francisco. The MOU encourages rainwater harvesting and its reuse for non-potable applications without requiring treatment to potable water standards. It also defines the roles of the participating agencies. From the MOU:

- The SFPUC will create and distribute guidance and material on rainwater harvesting. The material will cover system design, system components, allowable uses, owner responsibilities, and permitting requirements. The SFPUC will encourage all rainwater harvesters to notify the SFPUC with the design specifications of their systems for research purposes.
- DBI will issue permits for construction of properly designed rainwater harvesting systems for non-potable uses that meet the minimum criteria described in the MOU and in guidance materials prepared by the SFPUC. DBI will be responsible for review of permit applications and inspection of rainwater harvesting systems that require permits.
- DPH will review rainwater harvesting projects that propose any residential indoor uses of rainwater other than toilet flushing to assure the protection of public health.

It also stipulates that system design, maintenance, and use are the responsibility of the system owner.

The MOU classifies rain barrels and cisterns and defines the allowable uses of harvested rainwater. Water from rain barrels may be used for irrigation and vehicle washing; it is prohibited to connect rain barrels to indoor or outdoor plumbing. Water from cisterns connected to indoor plumbing may be used for irrigation, vehicle washing, heating and cooling, and toilet flushing. If a cistern is not connected to indoor plumbing it cannot be used for toilet flushing.

The MOU also includes safety and maintenance requirements, required system components, labeling requirements, and DBI permit requirements.

To better manage natural resources and water infrastructure, EPA has advocated four pillars of sustainable infrastructure, one of which is full cost pricing of water. Full cost pricing would result in water rates that reflect the entire suite of costs associated with water delivery: past, present, and future capital costs and operations and maintenance. Full cost pricing would ideally also include the external costs associated with the environmental damage and resource depletion created by water use.[13, 14] However, user fees and other funding sources are insufficient in 29% of water utilities to cover the cost of providing service, let alone including external costs.[15] Insufficient pricing is a significant barrier to collection and reuse.

Water needed for sanitation, cleaning, and cooking is less responsive to price than discretionary uses such as landscaping, but overall, water generally displays inelastic demand. A 10% increase in domestic prices decreases demand 2 to 4%; a 10% increase in commercial prices decreases demand 5 to 8%.[16] While studies show that price has limited effect on demand, they also do not consider the option of a low-cost alternative source of water. Increased prices may not significantly diminish water use, but may be sufficient to encourage the use of lower cost alternatives. When faced with sufficiently priced potable water, the investment in a low cost alternative that provides continued savings becomes increasingly favorable.

Albuquerque-Bernalillo County Building Standards

In 2008, the Water Utility Authority of Albuquerque-Bernalillo County instituted new standards that require rainwater harvesting systems for new homes. Buildings larger than 2,500 square feet are required to have a cistern and pump, while smaller buildings can use cisterns, rain barrels, or catchment basins. All rainwater harvesting systems need to capture the runoff from at least 85% of the roof area.

The standards also include a requirement for high efficiency toilets and prohibitions against installing turf on slopes steeper than 5:1 and sprinkler irrigating areas smaller than 10 feet in any dimension.

Regulations and codes also inhibit rainwater collection. Plumbing codes have been identified as a common barrier. Whether they make no provisions for rainwater reuse or require downspouts to be connected to the stormwater collection system, thereby eliminating the possibility of intervening to intercept roof runoff, code changes are often a necessary first step to enabling rainwater harvesting. Other regulations complicate the implementation of rainwater harvesting. Western water rights and the doctrine of "first in time, first in line" access to water can present a barrier to rainwater harvesting. Colorado interprets its Western water rights laws as prohibiting rainwater harvesting. The state's interpretation that cisterns and rain barrels prevent runoff from reaching rivers and thereby decrease a downstream user's allotted water right has been questioned, but it currently prohibits rainwater capture and reuse.

Rainwater Harvesting in the West

Western water rights can be an impediment to rainwater harvesting efforts because the doctrine of prior appropriation has created ambiguity about the legality of intercepting and storing rainwater. In the strictest interpretation, diverting rainwater to a collection system is a taking of a water previously appropriated.

This issue has been overlooked for many community rain barrel initiatives, because the individual storage units are relatively small. The City of Seattle, however, obtained a citywide water-right permit to ensure the legality of water harvesting efforts.

State legislation may ultimately be necessary to ensure the legality of rainwater harvesting and establish the upper capacity limit for rainwater systems. Any efforts should fully assess the watershed impacts of rainwater harvesting efforts. Colorado law, for instance has assumed that all rainfall eventually reaches groundwater or surface waters and is therefore appropriated. In the dry regions of the state, however, a study has found that the majority of rainfall on undeveloped lands is lost to evaporation and transpiration and only a small fraction actually reaches surface waters.

Likewise, rainwater harvesting is a water conservation practice which will reduce the overall withdrawal and use of water, making a greater quantity of water available for downstream users. Harvested rainwater used for irrigation or other outdoor uses reapplies the water in a manner similar to normal precipitation. Rainwater used for non-potable indoor uses is collected in the sanitary system and eventually returned to receiving streams and available for downstream use.

Energy and Climate

In addition to the natural resources impacts that water use imparts, water collection, treatment, and distribution has energy and climate consequences. The connection between water and energy is often overlooked but the process of extracting water from surface or groundwater supplies, bringing it to treatment facilities, treating it to drinking water standards, and delivering it to residential and commercial customers expends energy primarily because of pumping and treatment costs. The water sector consumes 3% of the electricity generated in the U.S. and electricity accounts for approximately one-third of utilities' operating costs.[17] Reducing potable water demand by 10% could save approximately 300 billion kilowatt-hours of energy each year.[18] Water reuse systems, like rainwater harvesting, supplant potable water and reduce demand. The reduced water demand provided by rainwater harvesting systems translates directly to energy savings. Table 4 presents estimates of the energy required to deliver potable water to consumers.

Table 4. Estimated Energy Consumption for Water Treatment and Distribution.[19]

Activity	Energy Consumption kWh/MG
Supply and conveyance	150
Water Treatment	100
Distribution	1,200
Total	**1,450**

Decreasing potable water demand by 1 million gallons can reduce electricity use by nearly 1,500 kWh. An inch of rainfall produces 600 gallons of runoff per 1,000 square feet of roof. Coordinated residential applications and large-scale non-residential rainwater harvesting systems offer an alternative method of reducing energy use.

Limiting energy demand is significant but the impact that decreased energy demand has on carbon dioxide emissions is critical. Carbon dioxide emissions associated with electricity generation vary according to the fossil fuel source. Rough estimates suggest that reducing potable water demand by 1 million gallons can reduce carbon dioxide emissions 1 to 1½ tons when fossil fuels are used for power generation (Table 5).

Table 5. Carbon Dioxide Emissions from Electric Power Generation.[20]

Fuel Type	CO_2 Output Rate Pounds CO_2/kWh	CO_2 Output per MG Water Delivered (x 1,450 kWh)
Coal	2.117	3,070 lbs
Petroleum	1.915	2,775 lbs
Natural gas	1.314	1,905 lbs

The carbon reductions associated with rainwater harvesting are admittedly not on the order of magnitude required to significantly impact climate change. However, the connection between potable water use and energy demand is important to recognize in the broader context of sustainable water management. It is critical to assess water use not only from a resource availability and protection standpoint, but also with the aim of improving overall sustainability of which energy is a critical component. As municipalities are faced with the anticipated CO_2 reductions that will be required over the coming decades, decreased potable water demand (along with other measures such as increased energy efficiency and conservation) represent the "low hanging fruit" that may provide the quickest and easiest reductions. Rainwater harvesting along with graywater and reclaimed water reuse represent an integrated water management approach that can not only limit contributions to climate change, but also protect and conserve limited water resources developing resiliency to the uncertain effects of climate change.

Conclusions and Recommendations

Encouraging rainwater harvesting and reuse requires enabling the practice through codes and regulations and providing incentives. State or municipal codes need to address public health concerns by stipulating water quality and cross-contamination requirements. Similar to reclaimed and graywater, specific rainwater harvesting codes need to be developed. Codes should establish acceptable uses for rainwater and corresponding treatment requirements. Disinfection of rainwater for reuse has been the standard, but recent research and policies should encourage jurisdictions to evaluate lesser requirements for non-potable uses in water closets and urinals. The simplification of the on-site treatment process and associated cost savings could broaden the use of rainwater harvesting without increasing exposure risks.

In addition to code development, incentives for rainwater harvesting should be instituted. The incentives should recognize that rainwater is a resource and that the use of potable water carries and environmental and economic cost. Current water policies and rates do not promote sustainability, with a structure that inadequately accounts for the value of water and does not promote conservation. Municipalities should review their water rates to see if they appropriately account for the full cost of water. Pricing alternatives such as increasing block rates, which increase the price of water with increased use, create an incentive to conserve potable water. An increased price of potable water would encourage investment in rainwater harvesting systems because they offer a long-term inexpensive supply of water after the initial capital investment. The combined actions of establishing certain requirements for rainwater harvesting systems and increasing the currently underpriced cost of water creates a complementary system that can encourage the use of alternative water sources.

Commercially sized cistern at the Chicago Center for Green Technology. *Photo: Abby Hall, EPA.*

Considerations when Establishing a Municipal Rainwater Harvesting Program

1. Establish specific codes or regulations for rainwater harvesting
   - Building and plumbing codes are largely silent on rainwater harvesting. Consequently, graywater requirements are often used to govern rainwater harvesting systems, resulting in requirements that are more stringent than necessary. Codes should define rainwater harvesting and establish its position as an acceptable stormwater management/water conservation practice.
2. Identify acceptable end uses and treatment standards
   - Each municipality will need to consider and identify acceptable uses for harvested rainwater and the required treatment for specified uses. Rainwater is most commonly used for non-potable applications and segregated by indoor and outdoor uses.
     - Typical outdoor uses:
       1. Irrigation; and
       2. Vehicle washing.
     - Typical indoor uses:
       1. Toilet flushing;
       2. Heating and cooling; and
       3. Equipment washing.
   - Non-potable uses typically require minimal treatment. Outdoor uses normally need only prescreening to limit fouling of the collection system. Indoor non-potable uses do not necessarily require treatment beyond screening, although some municipalities have adopted a conservative approach and require filtration and disinfection prior to reuse.
   - Harvested rainwater can be used for potable applications although a special permitting process should be established to ensure that proper treatment (e.g., filtration and disinfection) is provided and maintained.
3. Detail required system components
   - Jurisdictions often delineate between rain barrels and cisterns because of the size and potential complexity of the systems. Rain barrels collect relatively small quantities of water and generally only require mosquito prevention, proper overflow, and an outlet for outdoor uses. Cisterns can be 100 to several thousand gallons in size and may be connected to various indoor plumbing and mechanical systems. Needed system requirements include:
     - Pre-filtration – Filtration prior to the rain barrel or cistern should be provided to remove solids and debris.
     - Storage containers – Rain barrels and cisterns should be constructed of a National Sanitation Foundation approved storage container listed for potable water use.
     - Back-flow prevention – For cisterns that require a potable water make-up for operation, back flow prevention in the form of an air gap or backflow assembly must be provided.
     - Duel piping system – a separate piping system must be provided for harvested rainwater distribution. The pipe should be labeled and color coded to indicate non-potable water. Purple piping indicating reclaimed water is often used for rainwater harvesting systems. Cross connections with the potable water supply system are prohibited.
     - Signage – permanent signage should be provided at every outlet and point of contact indicating non-potable water not for consumption. In addition, biodegradable dyes can be injected to indicate non-potable water.
4. Permitting
   - Rain barrels should not need to be permitted provided that they are installed correctly and direct overflow to a proper location. A permit application process should be instituted for cistern systems used for non-potable uses. If harvested rainwater is used for potable water, the collection and treatment system should be inspected and approved by the public health department.
5. Maintenance
   - Adequate design and maintenance of the cistern and piping system is the responsibility of the cistern owner.
6. Rates of reuse
   - For harvesting systems to be efficient stormwater retention systems, the collected rainwater needs to be used in a timely matter to ensure maximum storage capacity for subsequent rain events. Cistern systems generally supply uses with significant demands, ensuring timely usage of the collected water. Outreach and education is a critical component of rain barrel programs, however, because of the more episodic and less structured use of this collected water. Municipalities should inform homeowners of the steps needed to maximize the effectiveness of their rain barrels. Harvesting programs targeting susceptible combined sewer areas have used slow draw down of the rain barrels to delay stormwater release to the sewer system, yet ensure maximum storage capacity for subsequent rain events.

Case Studies

King Street Center, Seattle

The King Street Center in Seattle uses rainwater for toilet flushing and irrigation. Rainwater from the building's roof is collected in three 5,400 gallon cisterns. Collected rainwater passes through each tank and is filtered prior to being pumped to the building's toilets or irrigation system through a separate piping system. When needed, potable makeup water is added to the cisterns. The collection and reuse system is able to provide 60% of the annual water needed for toilet flushing, conserving approximately 1.4 million gallons of potable water each year.[21]

The Solaire, Battery Park City, New York

The 357,000 square foot, 27 floor building was the first high-rise residential structure to receive LEED® Gold certification. The Solaire was designed to comply with Battery Park City's progressive water and stormwater standards; more than 2 inches of stormwater must be treated on site to meet the standards. Rainwater is collected in a 10,000 gallon cistern located in the building's basement. Collected water is treated with a sand filter and chlorinated according to New York City Standards prior to being reused for irrigating two green roofs on the building. Treated and recycled blackwater is used for toilet flushing and make-up water. Water efficient appliances and the rainwater and blackwater reuse system have decreased potable water use in the building by 50%.[22] Because of its innovative environmental features, the Solaire earned New York State's first-ever tax credit for sustainable construction.[23, 24]

Philip Merrill Building, Annapolis, MD

The Chesapeake Bay Foundation's headquarters is a LEED® Version 1 Platinum certified building. Rainwater from the roof is collected in three exposed cisterns located above the entrance.[25] Roof runoff passes through roof washers before entering the cisterns; following the cisterns the water is treated with a sand filter, chlorination, static mixer, and carbon filter prior to reuse. The building uses composting toilets, so the reused water is used for bathroom and mop sinks, gear washing, irrigation, fire suppression, and laundry. The building's design allows for a 90% reduction in potable water use with 73% of the water used within the building supplied by the cistern collection system.[26, 27, 28]

Cisterns at CBF headquarters. Photo: *Chesapeake Bay Foundation.*

Alberici Corporate Headquarters, Overland, Missouri

Alberici Corporation, a construction company, chose to relocate its corporate headquarters to a 14-acre site in the St. Louis suburbs in 2004. The site renovation included refurbishing a 150,000 square foot former metal fabrication facility into a LEED® platinum certified office building. The building design includes a rainwater collection and reuse system. Rainwater is collected from 60% of the garage roof area and stored in a 38,000 gallon cistern. The collected water is filtered and chlorinated and used for toilet flushing and the building's cooling tower. The stormwater reuse system saves 500,000 gallons of water each year, reducing potable water demand by 70%.[29, 30]

Lazarus Building, Columbus, Ohio

After Federated Department Stores closed the 750,000 square foot retail store in 2002, it donated the building to the Columbus Downtown Development Corporation. The building renovation completed in 2007 achieved LEED® Gold certification and the building's largest tenant is Ohio EPA. The renovated building includes a rainwater collection and reuse system. The system makes use of an existing 40,000 gallon tank on the building's roof and a new 50,000 gallon tank installed in the basement. The collected rainwater is used for toilet flushing, irrigation, and HVAC makeup. A biodegradable blue dye is added to the water used for toilet flushing to visually identify it as non-potable water. The system reduces potable water use in the building by several million gallons a year.[31, 32]

Stephen Epler Hall, Portland State University

PSU's 62,500 square foot mixed-use student housing facility (classrooms and academic office space are located on the first floor) was completed in 2003 and is LEED® Silver Certified. The stormwater management system was designed to be engaging to the public; rain from the roofs of Epler Hall and neighboring King Albert Hall is diverted to several river rock "splash boxes" in the public plaza.[33] The water then travels through channels in the plaza's brick pavers to planter boxes where it infiltrates and is filtered before being collected in an underground cistern. UV light is used to treat the water prior to its reuse for toilet flushing in the first floor restroom and irrigation. Placards located in the water closets indicate that the non-potable toilet flushing water is not for consumption. The stormwater collection and reuse system conserves approximately 110,000 gallons of potable water annually, providing a savings of $1,000 each year.[34, 35]

Natural Resources Defense Council's Robert Redford Building, Santa Monica

NRDC's renovation of a 1920s-era structure in downtown Santa Monica achieved LEED® New Construction, Version 2 Platinum certification. The innovative water systems in the 15,000 square foot building are a key component of the project's sustainability. The plumbing system delivers potable water only to locations where drinking water is needed, such as faucets and showers. Water from the showers and sinks is collected in graywater collection tanks and treated on-site. The treated graywater is reused for toilet flushing and landscaping. Rainwater from the building is collected in outdoor cisterns, which were installed beneath planters adjacent to the building. The collected rainwater is filtered prior to being added to the graywater collection tank as part of the water reuse system. The graywater/rainwater reuse system and high-efficiency features such as duel-flush toilets, waterless urinals, and drought-tolerant plants reduce potable water demand by 60%. Each waterless urinal, for instance, saves 40,000 gallons of water each year.[36]

Rainwater cistern at NRDC's Santa Monica Office (inset photo after planter planting). *Photo: NRDC.*

The City's plumbing code complicated the installation of many of the building's water features. The plumbing code prohibited waterless toilets or urinals, requiring a resolution that allowed the waterless urinals to be installed with water supply stubbed out behind the wall if needed for future use. The City is now seeking a change to City Code to allow for waterless urinals to be installed without an available water supply. Similarly, California's graywater ordinance did not contain a provision for rainwater collection; an agreement was negotiated with the County Health Department after which the City's Building and Safety Division agreed to sign off on the plans.[37, 38]

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Recycle (IPR)

EQUINOX CENTER

Healthy Environment   Strong Economy   Vibrant Communities

H2Overview Project: The Potential of Purified Recycled Water reveals:

- Recycled potable water, as produced by **indirect potable reuse (IPR)*, would be a strong, viable addition to the region's diversified water portfolio**.
- **IPR** provides a local, reliable water supply that is **less vulnerable to interruptions** such as earthquakes, wildfires or legal challenges to water rights **that could restrict San Diego's access to imported water.**

COST ADVANTAGES:

- **IPR on average costs less per unit than desalination or non-potable recycled water.**
- **After advanced treatment, recycled water can be added to the existing drinking water infrastructure, making it a less expensive option than recycled non-potable water** (for most districts)**.** Currently, the cost to construct a second pipe system to distribute non-potable recycled water is $2 million per mile.

SAFETY:

- **Recycled water has been safely used for human consumption for a number of years** in Long Beach, Los Angeles, Orange County, Virginia, Scottsdale, Las Vegas and Singapore.
- Testing on populations where IPR is in use has **not determined any significant health risks.**
- Studies show that **IPR's advanced treatment creates purified water with fewer contaminants** than San Diego County's existing imported water supply.

OTHER FACTORS:

- Energy is used to treat and distribute all water sources, so the availability and cost of energy make energy use an important factor. **IPR uses significantly less energy than desalinated sea water or imported water,** although the energy use is somewhat higher than non-potable recycled water.
- **Business sectors, such as life sciences and clean tech, can confidently expand** based on a reliable, high quality water source.
- IPR **reduces the amount of potentially harmful pollutants being released into rivers, bays and the ocean** by diverting wastewater from treatment plants and further purifying it for reuse.

** IPR is **Indirect Potable Reuse (IPR)**, also known as **advanced treated water, purified water** or **recycled water.** The process purifies treated water to be potable, and then diverts it to either a groundwater source or a surface water reservoir. The water is treated again before it is added to the existing drinking water infrastructure.*

More drinking water for San Diego

By David Schubert
September 12, 2008

Like many communities throughout the world, San Diego has a drinking problem. However, rather than intoxicating alcohol, the problem is toxic pharmaceuticals and consumer goods such as cosmetics that make their way into our drinking water supply from homes, hospitals, businesses and farms.

They primarily pass through sewage (wastewater) systems with only partial removal. The treated wastewater is released into rivers and lakes and ends up in downstream water supplies, like San Diego's. While the concentrations of individual toxins in drinking water is often quite low, there is growing evidence that the amounts are sufficient to cause reproductive problems in aquatic animals and to lead to antibiotic resistance in pathogenic bacteria.

Although scientists and government health agencies have known about this problem for nearly 20 years, little has been done in the United States to stem the flow of these toxins into the environment. It seems to have taken a recent, widely publicized investigation by the Associated Press to raise public concern.

The appearance of pharmaceuticals in rivers, lakes and streams was first reported in Europe in the early 1990s. It was initially believed that these chemicals came exclusively from manufacturing facilities, and indeed some of them did. However, further investigation showed that the majority came from the effluents of community wastewater treatment plants.

Using standard treatment regimes, most of the toxins entering treatment plants are released into the environment in the treated wastewater. The geology of Europe makes the water circulation there more of a closed system than in most other parts of the world.

In some cases, half of the volume of a river is from treated wastewater. Since it is difficult to remove toxins during the subsequent preparation of municipal drinking water, there has been an intense effort in Europe to improve the sewage treatment facilities such that most of the toxins are removed before discharge.

This has not happened in the United States. With a growing population, greater water reuse along the rivers that supply our drinking water, and an overall decrease in the volume of our water supplies, there has been a significant increase in concentrations of toxins in many of our waterways, ground waters and in the drinking water of San Diego.

How can this trend be reversed to eliminate a very real threat to public health? San Diego receives most of its water from the Sacramento River Delta area near San Francisco and from the Colorado River.

Water flowing through the Delta includes agricultural runoff (chemicals and pesticides) and municipal wastewater discharges from cities such as Sacramento. Colorado River water has passed through multiple cities, including Las Vegas, which draws its water from Lake Mead and then discharges reclaimed water back into the lake, which flows into the Colorado River for our downstream consumption.

The best way to reduce the toxin problem along these waterways, as well as at the national level, is to follow the example of Europe and try to remove 80 percent to 90 percent of the toxins at the wastewater treatment facilities. This approach requires a longer retention time in the biological treatment step used by wastewater treatment plants to allow for the degradation of toxins by microbes and oxidation. It also places an additional cost on the operation of these plants, but this is a cost that society should be willing to pay.

However, the only truly effective way of removing the vast majority of the these toxins from our drinking water supply is via the technology currently being proposed for San Diego's poorly named "toilet-to-tap" program. The toilet-to-tap program was created because it is imperative that San Diego find other sources of water besides the Sacramento River Delta and the Colorado River.

The Delta water supply is subject to elimination by an earthquake or a judicial cutback due to a threatened species such as the Delta smelt. Some have estimated that at the current rate of consumption Lake Mead will be dry by 2021, and the water transport system from the Colorado River to San Diego is also subject to earthquake damage.

Since local groundwater supplies are few and of limited volume, alternative water sources for San Diego are very limited. These include seawater desalination, planned for Carlsbad, and reclaimed water, which is taken from treated wastewater.

Reclaimed water is already used in San Diego for landscape watering. This water is heavily chlorinated, so if the reclamation plant is functioning properly, there is minimal risk of infection. But it does contain significant levels of toxins and other contaminants.

For the toilet-to-tap project, this reclaimed water would be taken through three additional purification steps: micro-filtration and reverse osmosis, followed by exposure to a strong oxidant or high intensity ultraviolet light. These extra steps reduce the toxins to undetectable levels, creating essentially pure water. It is so pure that it cannot be used for agriculture unless minerals are added back into it, for example by diluting it into imported water in the San Vicente reservoir.

The purification procedures for the proposed San Diego drinking water program are already being used to recharge the drinking water aquifers under Orange County with advanced treated reclaimed sewage water. Singapore has installed a similar recycling system, called NEWater, so that it is not dependent upon Malaysia for its water supply.

For San Diego to become less dependent upon imported water, it is mandatory that it creates other sources. The production of ultrapure water from our wastewater facilities is a step in this direction, and it should be supported along with conservation and seawater desalination. Perhaps only through these measures will we be able to continue to enjoy a healthy life in a coastal desert.

▪ Schubert is a professor at the Salk Institute for Biological Studies in La Jolla.

»Next Story»

Coalition has hand in water recycling plan

Council advances recycling project

By Mike Lee, UNION-TRIBUNE

Wednesday, January 27, 2010 at 12:01 a.m.

SAN DIEGO — An unusually diverse coalition of community groups last night helped persuade the San Diego City Council to keep moving ahead on a landmark water recycling plan.

Environmentalists, labor leaders, business officials, taxpayer advocates, building managers and engineering professionals lent their combined support to an $11.8 million pilot project to turn wastewater into drinking water.

"Early on, someone suggested that we call ourselves the Unprecedented Coalition because of the diverse membership," said Lani Lutar, head of the San Diego County Taxpayers Association and a member of the Indirect Potable Reuse Coalition.

The alliance officially formed last summer when Lutar was talking with Bruce Reznik at San Diego Coastkeeper about how to swing council votes and public opinion on what has been a touchy subject. It now boasts 13 member organizations, including high-profile groups such as the Surfrider Foundation and the San Diego Regional Chamber of Commerce.

INDIRECT POTABLE REUSE COALITION

BIOCOM

Building Office Managers Association, San Diego chapter

Citizens Coordinate for Century 3

Coastal Environmental Rights Foundation

Friends of Infrastructure

Industrial Environmental Association

National Association of Industrial and Office Properties, San Diego chapter

San Diego and Imperial Counties Labor Council

San Diego Audubon Society

San Diego Coastkeeper

San Diego County Taxpayers Association

San Diego Regional Chamber of Commerce

Surfrider Foundation, San Diego chapter

In recent weeks, coalition members have visited council offices, given community presentations, researched ways to address council concerns and written a joint letter supporting the $3.28 million contract approved last night as part of the overall demonstration program.

The money will pay for a private company, RMC of Walnut Creek, to manage the project and educate residents about water recycling.

Reznik and other backers viewed the 5-3 vote as a referendum on indirect potable reuse, the formal name for putting highly treated sewage back into the drinking-water system. It's also called reservoir augmentation.

The pilot project is designed to show whether modern water-cleaning technologies pass muster with state health officials. It doesn't include injecting recycled water into a reservoir, which would happen if the city moves forward with a full-blown system.

Every council vote on the issue is important because water reuse has proved a tough sell in San Diego since the late 1990s, when it was dubbed "toilet to tap" and killed by the City Council. In December 2007, the council reversed course and overrode Mayor Jerry Sanders' veto with a 5-3 vote in favor of the pilot project.

The council later approved a water-rate increase to cover the estimated $11.8 million expense. It still must sign off on each major contract related to the project.

Council members' comments last night showed that deep divisions remain about the proposal.

"I don't necessarily support the concept, but I do support adequate outreach and adequate management," said Councilman Tony Young, whose vote for the contract was considered pivotal.

Sanders has said reservoir augmentation is expensive and unnecessary given the city's other water supplies and new technologies such as desalination. On Monday, a mayoral spokesman said Sanders hasn't changed his stance even though the coalition's members have urged him to join their side.

"I think it's just a matter of time before the mayor eventually comes onboard," Lutar said.

Others have been easier to convince.

"This is an important issue for the San Diego work force," said Evan McLaughlin, political director for the San Diego and Imperial Counties Labor Council.

"People make too much of this issue of ideological differences," he said, noting that the labor council has worked with diverse stakeholders in the past.

Lutar said she isn't aware of any formal opposition to the demonstration project. Another key vote will come this summer, when the City Council is expected to consider a $7.4 million bill for installation of the water-treatment system.

Other
(Desal, Transfers)

EXECUTIVE SUMMARY

LONG CONSIDERED THE Holy Grail of water supply, desalination offers the potential of an unlimited source of fresh water purified from the vast oceans of salt water that surround us. The public, politicians, and water managers continue to hope that cost-effective and environmentally safe ocean desalination will come to the rescue of water-short regions. While seawater desalination plants are already vital for economic development in many arid and water-short areas of the world, many plants are overly expensive, inaccurately promoted, poorly designed, inappropriately sited, and ultimately useless. To avoid new, expensive errors, policymakers and the public need to take a careful look at the advantages and disadvantages of desalination and develop clear guidance on how to evaluate and judge proposals for new facilities.

In this report, the Pacific Institute provides a comprehensive overview of the history, benefits, and risks of ocean desalination, and the barriers that hinder more widespread use of this technology, especially in the context of recent proposals for a massive increase in desalination development in California.

The potential benefits of ocean desalination are great, but the economic, cultural, and environmental costs of wide commercialization remain high. In many parts of the world, alternatives can provide the same freshwater benefits of ocean desalination at far lower economic and environmental costs. These alternatives include treating low-quality local water sources, encouraging regional water transfers, improving conservation and efficiency, accelerating wastewater recycling and reuse, and implementing

The potential benefits of ocean desalination are great, but the economic, cultural, and environmental costs of wide commercialization remain high.

smart land-use planning. At present, the only significant seawater desalination capacity is in the Persian Gulf, on islands with limited local supplies, and at selected other locations where water options are limited and the public is willing to pay high prices.

In the United States, almost all seawater desalination facilities are small systems used for high-valued industrial and commercial needs. This may be changing. Despite the major barriers to desalination, interest has recently mushroomed as technology has improved, demands for water have grown, and prices have dropped.

Interest in desalination has been especially high in California, where rapidly growing populations, inadequate regulation of the water supply/land-use nexus, and ecosystem degradation from existing water supply sources have forced a rethinking of water policies and management. In the past five years, public and private entities have put forward more than 20 proposals for large desalination facilities along the California coast (Figure ES1; Table ES1). If all of the proposed facilities were built, the state's seawater desalination capacity would increase by a factor of 70, and seawater desalination would supply 6% of California's year 2000 urban water demand. Project proponents point to statewide water-supply constraints, the reliability advantages of "drought-proof" supply, the water-quality improvements offered by desalinated water, and the benefits of local control. Along with the proposals, however, has come a growing public debate about high economic and energy costs, environmental and social impacts, and consequences for coastal development policies. We review and analyze these factors here.

Figure ES1
Map of Proposed Desalination Plants in California, Spring 2006

- ● > 20 MGD (76,000 m^3/d)
- ○ 5 – 20 MGD (19,000 – 76,000 m^3/d)
- ● < 5 MGD (19,000 m^3/d)

Operator	Location	Max Capacity MGD	Max Capacity m^3/d
Marin Municipal Water District	San Rafael	10-15	38,000-57,000
East Bay Municipal Utility District/ San Francisco Public Utilities Commission/ Contra Costa Water District/ Santa Clara Valley Water District	Pittsburg/Oakland/ Oceanside	20-80	76,000-300,000
East Bay Municipal Utility District	Crockett	1.5	5,700
Montara Water and Sanitary District	Montara	N/A	N/A
City of Santa Cruz	Santa Cruz	2.5, possible expansion to 4.5	9,500, possible expansion to 17,000
California American Water Company	Moss Landing	11-12	42,000-45,000
Pajaro-Sunny Mesa/Poseidon	Moss Landing	20-25	76,000-95,000
City of Sand City	Sand City	0.3	1,100
Monterey Peninsula Water Management District	Sand City	7.5	28,000
Marina Coast Water District	Marina	1.3	4,900
Ocean View Plaza	Cannery Row	0.05	190
Cambria Community Services District/ Department of the Army	Cambria	0.4	1,500
Arroyo Grande/Grover Beach/ Oceano Community Services District	Oceano	1.9	7,100
Los Angeles Department of Water and Power	Playa Del Rey	12-25	45,000-95,000
West Basin Municipal Water District	El Segundo	20	76,000
Long Beach Water Department	Long Beach	8.9	34,000
Poseidon Resources	Huntington Beach	50	190,000
Municipal Water District of Orange County	Dana Point	25	95,000
San Diego County Water Authority/ Municipal Water District of Orange County	Camp Pendleton	50, expanding to 100	190,000, expanding to 380,000
Poseidon Resources	Carlsbad	50, possible expansion to 80	190,000, possible expansion to 300,000
San Diego County Water Authority	Carlsbad	50, possible expansion to 80	190,000, possible expansion to 300,000

Table ES1
Proposed Plants in California as of Spring 2006

Based on this assessment, we conclude that most of the recent seawater desalination proposals in California appear to be premature. Among the exceptions may be desalination proposals where alternative water-management options have been substantially developed, explicit ecosystem benefits are guaranteed, environmental and siting problems have been identified and mitigated, the construction and development impacts are minimized, and customers are willing to pay the high costs to cover a properly designed and managed plant.

When the barriers to desalination are overcome, carefully regulated and monitored construction of desalination facilities should be permitted. We urge regulators to develop comprehensive, consistent, and clear rules for desalination proposals, so that inappropriate proposals can be swiftly rejected and appropriate ones identified and facilitated. And we urge private companies, local communities, and public water districts that push for desalination facilities to do so in an open and transparent way, encouraging and soliciting public participation and input in decision making.

Is desalination the ultimate solution to our water problems? No. Is it likely to be a piece of our water management puzzle? Yes.

Is desalination the ultimate solution to our water problems? No. Is it likely to be a piece of our water management puzzle? Yes. In the end, decisions about desalination developments will revolve around complex evaluations of local circumstances and needs, economics, financing, environmental and social impacts, and available alternatives. We urge that such decisions be transparent, open, public, and systematic. To that end, we offer a set of **Conclusions and Recommendations** that will help water users and planners interested in making desalination a more significant part of international, national, and local water policy. Our intention is to provide information to help the public and policymakers understand and evaluate the arguments being put forward by both proponents and opponents of the current proposals.

Desalination Conclusions and Recommendations

Economic Costs of Desalination

The cost of desalination has fallen in recent years, but it remains an expensive water-supply option. Desalination facilities are being proposed in locations where considerable cost-effective conservation and efficiency improvements are still possible.

The cost of desalination has fallen in recent years, but it remains an expensive water-supply option.

- Water planners, agencies, and managers must comprehensively analyze all options, including conservation and efficiency, and pursue less costly, less environmentally damaging alternatives first.
- Desalination facilities should be approved only where water agencies have implemented all cost-effective water conservation and efficiency measures.

Desalination costs are influenced by many factors, making comparisons difficult and estimates uncertain.

- All cost estimates should explicitly state the underlying assumptions.
- Cost comparisons must be made on a comparable basis.

The assumption that desalination costs will continue to fall may be false. Further cost reductions may be limited, and future costs may actually increase.

- Projected costs must be justified over the lifetime of the facility, taking into account possible changes in the cost of energy and construction materials, limits to membrane performance, and other factors.

More energy is required to produce water from desalination than from any other water-supply or demand-management option in California. The future cost of desalinated water will be more sensitive to changes in energy prices than will other sources of water.

- Project proponents should estimate and publicly disclose the full energy requirements of each proposed project and provide details of energy contracts.

- Project proponents should explicitly evaluate energy price risk, including year-to-year variation and trends over time, in the revenue requirement of water utilities that invest in or purchase water from ocean desalination.

More energy is required to produce water from desalination than from any other water-supply or demand-management option in California.

Public subsidies for desalination plants are inappropriate unless explicit public benefits are guaranteed.

- Decisionmakers should offer public subsidies to desalination facilities only when the facilities come with a guarantee of public benefits, such as restoration of ecosystem flows.

More research is needed to fill gaps in our understanding, but the technological state of desalination is sufficiently mature and commercial to require the private sector to bear most additional research costs.

- Public research funds should be restricted to analyzing the public aspects of desalination projects, including environmental impacts, mitigation, and protection.

Reliability and Water-Quality Considerations

Desalination plants offer both system-reliability and water-quality advantages, but other options may provide these advantages at lower cost.

- Water agencies should estimate the value of reliability or water-quality advantages in general, regardless of how that reliability or water-quality improvement is achieved.

- Water agencies should compare the cost of providing reliable or high-quality water from various sources, including ocean desalination. Water managers must still apply the standard principles of least-cost planning.

Desalination can produce high-quality water but may also introduce biological or chemical contaminants into our water supply.

- In order to ensure public health, all water from desalination plants must be monitored and regulated.

- When new or unregulated contaminants are introduced, new legislation, regulatory oversight, or standards may be needed.

Impingement and entrainment of marine organisms are among the most significant environmental threats associated with seawater desalination.

Desalination can produce water that is corrosive and damaging to water-distribution systems.

- Additional research is needed to determine the impacts of desalinated product water on the distribution system.
- Water-service providers must ensure that distribution systems are not adversely affected.

Environmental Considerations

Desalination produces highly concentrated salt brines that may also contain other chemical pollutants. Safe disposal of this effluent is a challenge.

- More comprehensive studies are needed to adequately identify all contaminants in desalination brines and to mitigate the impacts of brine discharge.
- Water managers should carefully monitor, report, and minimize the concentrations of chemicals in brine discharges.
- Federal or state regulators should evaluate whether new water-quality regulations are needed to protect local environments or human health.
- Under all circumstances, water managers must minimize brine disposal in close proximity to sensitive habitats, such as wetlands.
- Disposal of brine in underground aquifers should be prohibited unless comprehensive and competent groundwater surveys are done and there is no reasonable risk of brine plumes appearing in freshwater wells.

Impingement and entrainment of marine organisms are among the most significant environmental threats associated with seawater desalination.

- The effects of impingement and entrainment require detailed baseline ecological assessments, impact studies, and careful monitoring.
- Intake pipes should be located outside of areas with high biological productivity and designed to minimize impingement and entrainment.

Subsurface and beach intake wells may mitigate some of the environmental impacts of open ocean intakes. The advantages and disadvantages of subsurface and beach intake wells are site-specific.

- For all desalination projects, proponents should evaluate the advantages and disadvantages of these options, including a review of impacts on freshwater aquifers and the local environment.

Desalination may reduce the need to take additional water from the environment and, in some cases, offers the opportunity to return water to the environment.

- Desalination proposals that claim environmental benefits must come with binding mechanisms to ensure that these benefits are delivered and maintained in the form, degree, and consistency promised.

Climate Change

Desalination offers both advantages and disadvantages in the face of climatic extremes and human-induced climate changes. Desalination facilities may help reduce the dependence of local water agencies on climate-sensitive sources of supply.

- Desalination proposals should evaluate the long-term climatic risks and benefits.

Extensive development of desalination can lead to greater dependence on fossil fuels, an increase in greenhouse gas emissions, and a worsening of climate change.

- Plans for desalination must explicitly describe the energy implications of the facility and how these impacts fit into regional efforts or requirements to reduce greenhouse gas emissions or meet regional, state, or federal clean air requirements.

- Regulatory agencies should consider requiring desalination plants to offset their greenhouse gas emissions.

Coastal desalination facilities will be vulnerable to the effects of climate change, including rising sea levels, storm surges, and extreme weather events.

- Planners should design and construct all desalination facilities using estimates of future, not present, climate and ocean conditions.

- Regulatory agencies should permit desalination facilities only when consideration of climate change factors and other hazards has been integrated into plant design.

Siting and Operation of Desalination Plants

Ocean desalination facilities, and the water they produce, will affect coastal development and land use.

- Project proponents must evaluate the growth-inducing impacts of desalination facilities on a case-by-case basis and not assume these impacts to be incidental, minimal, or secondary.

- Desalination proponents must identify to the public and appropriate regulatory agencies all buyers and potential buyers of project water.

- California coastal development permits should be denied to desalination plants that will induce growth beyond levels projected in certified Local Coastal Programs.

There are unresolved controversies over private ownership and operation of desalination facilities.

- Negotiations over project contracts should be open, transparent, and include all affected stakeholders.

Desalination offers both advantages and disadvantages in the face of climatic extremes and human-induced climate changes.

- Contracts that lay out the responsibilities of each partner are a prerequisite for the success of any project. These contracts must include explicit dispute resolution mechanisms and provisions addressing financial risks in the event of project failure.
- Independent technical and contract review should be standard.

Co-location of desalination facilities at existing power plants offers both economic and environmental advantages and disadvantages.

- Proponents should not use desalination to keep once-through cooling systems in operation longer than would otherwise be permitted under current or proposed regulations.
- Regulators should not issue exemptions to permit once-through cooling systems to remain in operation solely to service desalination plants.
- Project proponents must assess the effects of desalination independently of the power plant due to uncertainty associated with once-through cooling system systems.
- Additional research is needed to determine whether there are synergistic effects caused by combining desalination's high salinity discharge with the high temperatures and dead biomass in power plant discharge.

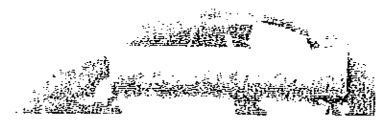
Siting, building, and operation of desalination facilities are likely to be delayed or halted if local conditions and sentiments and the public interest are not adequately acknowledged and addressed.

- The process of designing, permitting, and developing desalination facilities must be transparent and open.
- Draft contracts, engineering designs, and management agreements should be widely available for public review beginning in the early stages of project development.
- Project developers and local water agencies should commission and make publicly available independent review of the social and economic impacts of desalination facilities on local communities.
- Affected community members should be invited to participate in desalination project planning, implementation, and management during the early stages of the process.

The regulatory and oversight process for desalination is sometimes unclear and contradictory.

The regulatory and oversight process for desalination is sometimes unclear and contradictory.

- Federal, state, and local policies should standardize and clarify the regulation of desalination.
- Desalination should not be hindered by inappropriate regulation nor accelerated by regulatory exemptions.



St. Petersburg Times
tampabay

March 18, 2010

Tampa Bay Water wants to increase rates 8 percent

By Craig Pittman, Times Staff Writer

One reason for the proposed hike: customer conservation.

Tampa Bay Water wants to boost rates by $1.20 a month for an average household that uses 8,000 gallons of water, according to budget figures released Thursday.

The 8 percent rate increase proposal comes amid declining water usage in the region. The wholesale utility serving Pinellas, Pasco and Hillsborough counties has seen demand for its product drop 13 million gallons a day over the past year, due to lawn-sprinkling restrictions, heavy rainfall and the tanking Florida economy.

Tampa Bay Water general manager Gerald Seeber said he doesn't expect anyone to be happy about seeing a rate hike right now. "Nobody wants to have to pay more for less," he said.

Pinellas County Commissioner Susan Latvala, who sits on the regional utility's board, said last month that she knew such an increase is likely to be extremely unpopular with people who have been doing their best to reduce their water usage. She predicted customers will say, "You told us to cut back and we cut back, and now you're raising our rates?"

More than 80 percent of the utility's expenses go for electricity, chemicals and paying off the money it borrowed to build the state's largest reservoir and the nation's biggest desalination plant. As a result, utility spokeswoman Michelle Biddle Rapp said in an e-mail to the *Times*, "We have little ability to control these costs."

The new budget does cut three staff positions, reducing the size of the utility's payroll to 125 people, and cuts expenditures by $10.8 million, or 6 percent, from last year, Rapp said.

Also, to save money, the utility expects to operate its desal plant - which has a capacity of 25 million gallons a day - at an average of just 8 million gallons a day. Water from the desal plant is the most expensive that the utility produces because of the cost of power and treatment chemicals.

It can do that because the 15-billion-gallon reservoir is full now. However, in the next few years the utility plans to drain the reservoir and spend millions of dollars fixing recurring cracks in the reservoir's wall. Paying for the repairs may require another rate hike then, utility officials have said.

Tampa Bay Water's current rate is $2.398 per 1,000 gallons, and the utility is proposing to raise the rate to $2.5892 per 1,000 gallons starting July 1. That charge on the water it sells to the local utilities is then partially passed along to their residential and business customers. Tampa Bay Water's total budget is $163 million, a decrease from the current budget of $176 million.

The budget and rate hike proposal will be discussed at the next meeting of Tampa Bay Water's board on April 19, with the budget scheduled for adoption at a meeting June 21.

Although Latvala said water conservation was a major factor in the rate increase, Southwest Florida Water Management District executive director Dave Moore contended that wasn't the biggest reason for the drop in water usage in the region. "A lot of it is related to the economic downturn," he said Thursday. "When a house goes into foreclosure, they stop paying those water bills."

The more water that homeowners conserve, he said, the longer utilities can hold off building expensive new facilities such as the ones driving Tampa Bay Water's rates now.

Craig Pittman can be reached at (727) 893-8530 or craig@sptimes.com.

St. Petersburg Times

The New York Times

July 10 2010

Arid Australia Sips Seawater, but at a Cost

By NORIMITSU ONISHI

BRISBANE, Australia – In Australia, the world's driest inhabited continent, early British explorers searching for a source of drinking water scoured the bone-dry interior for a fabled inland sea. One overeager believer even carted a whaleboat hundreds of miles from the coast, but found mostly desert inside. Today, Australians are turning in the opposite direction: the sea.

In one of the country's biggest infrastructure projects in its history, Australia's five largest cities are spending $13.2 billion on desalination plants capable of sucking millions of gallons of seawater from the surrounding oceans every day, removing the salt and yielding potable water. In two years, when the last plant is scheduled to be up and running, Australia's major cities will draw up to 30 percent of their water from the sea.

The country is still recovering from its worst drought ever, a decade-long parching that the government says was deepened by climate change. With water shortages looming, other countries, including the United States and China, are also looking to the sea.

"We consider ourselves the canary in the coal mine for climate change-induced changes to water supply systems," said Ross Young, executive director of the Water Services Association of Australia, an umbrella group of the country's urban water utilities. He described the $13.2 billion as "the cost of adapting to climate change."

But desalination is also drawing fierce criticism and civic protests. Many homeowners, angry about rising water bills, and environmentalists, wary of the plants' effect on the climate, call the projects energy-hungry white elephants. Stricter conservation measures, like mandating more efficient washing machines, would easily wring more water from existing supplies, critics say.

Desalination has also helped dampen the enthusiasm for a "big Australia," the previous, immigration-friendly government's projection that the country's population will rise to 36 million in 2050, from 22 million now.

"Big waste of money," said Helen Meyer, 65, a retired midwife in Tugun, the town where the northeastern state of Queensland opened a $1 billion desalination plant last year. "It cost a lot of money to build, and it uses a lot of power. Australia is a dry country. I think we just have enough water for 22 million people. What are we going to do when we're up to 36 million?"

The plant, sprawling across 15 acres next to an airport and near residential neighborhoods, provides water to Brisbane, the capital of Queensland, and other areas of southeastern Queensland, the nation's fastest-growing region. Despite technical problems that temporarily shut down the plant recently, it has been supplying 6 percent of the region's water needs and has the capacity to deliver 20 percent, said Barry Dennien, chief executive of the SEQ Water Grid Manager, the utility that oversees this region's water supply.

The drought in this region lasted from 2000 to 2009, as the reservoir behind the largest dam, Wivenhoe, dropped to only 16 percent of capacity at one point. (On a recent visit, it was at 98 percent.) While it took the state authorities until 2005 to grasp the magnitude of the crisis, Mr. Dennien said, they moved quickly after that.

Besides restricting water use and subsidizing the purchase of home water tanks to capture rainwater, the state spent nearly $8 billion to create the country's most sophisticated water supply network. It fashioned dams and a web of pipelines to connect 18 independent water utilities in a single grid. To "drought proof" the region, it built facilities for manufacturing water, by recycling wastewater, to use for industrial purposes, and by desalinating seawater. Production of desalinated water can be adjusted according to rain levels.

"When the last of the assets were coming online, it rained, as it always does," Mr. Dennien said, adding that the region now has enough water for the next 20 years.

"We've got a method of operating the grid that the next time any sign of drought occurs, we can just," he snapped his fingers, "build something else or turn something else on, and we've got enough water supply."

Other cities are making the same bet. Perth, which opened the nation's first desalination plant in 2006, is building a second one. Sydney's plant started operating early this year, and plants near Melbourne and Adelaide are under construction.

Until a few years ago, most of the world's large-scale desalination plants were in the Middle East, particularly in Saudi Arabia, though water scarcity is changing that. In the United States, where only one major plant is running, in Tampa Bay, officials are moving forward on proposed facilities in California and Texas, said Tom Pankratz, a director of the International Desalination Association, based in Topsfield, Mass. China, which recently opened its biggest desalination plant, in Tianjin, could eventually overtake Saudi Arabia as the world leader, he said.

Many environmentalists and economists oppose any further expansion of desalination because of its price and contribution to global warming. The power needed to remove the salt from seawater accounts for up to 50 percent of the cost of desalination, and Australia relies on coal, a major emitter of greenhouse gases, to generate most of its electricity.

Critics say desalination will add to the very climate change that is aggravating the country's water shortage. To make desalination politically palatable, Australia's plants are using power from newly built wind farms or higher-priced energy classified as clean. For households in cities with the new plants, water bills are expected to double over the next four years, according to the Water Services Association.

But critics say there are cheaper alternatives. They advocate conservation measures, as well as better management of groundwater reserves and water catchments. "Almost every city which has implemented a desalination plant has nowhere near maxed out or used up their conservation potential," said Stuart White, director of the Institute for Sustainable Futures at the University of Technology, Sydney. Even without restrictions, cities could easily save 20 percent of their water, Mr. White said.

He said cities should practice "desalination readiness" by drawing plans to build a plant, but should carry them out only as a last resort in the event of a severe drought.

Mr. Young of the Water Services Association said desalination in Australia costs $1.75 to $2 per cubic meter, including the costs of construction, clean energy and production. The prices are probably the world's highest, said Mr. Pankratz of the International Desalination Association, adding that desalination was cheaper in countries with less strict environmental standards. He said the cost at a typical new plant in the world today would be about $1 per cubic meter.

Opponents of desalination say that a cheaper and environmentally friendlier alternative is recycling wastewater, though persuading people to drink it remains difficult and politically delicate. The SEQ Water Grid Manager, for instance, retreated from its initial plan to introduce recycled wastewater into its drinking reservoirs after it began raining.

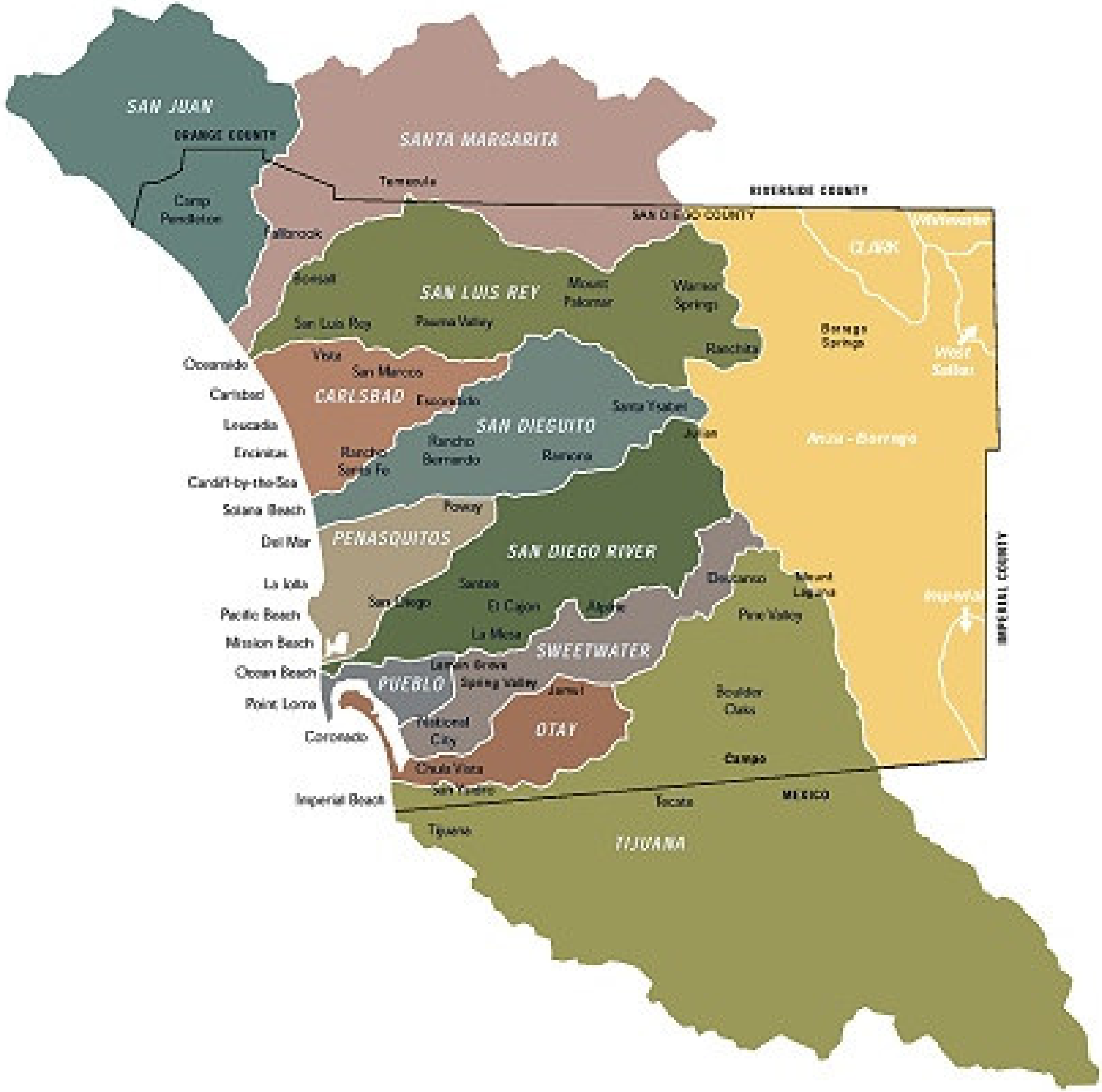
"There's a stigma against recycled water," said David Mason, 40, a resident of Tugun.

"But since there's only so much water in the world, and it's been through somebody's body or some other place over the past 250 million years, maybe it's not that bad. At least, it might be better than desalination."

SD Watersheds

San Diego's Watersheds

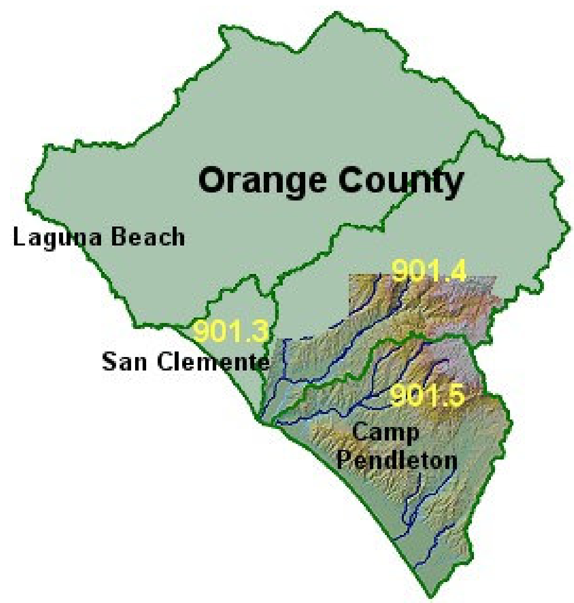
A watershed is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. San Diego has 11 major watersheds as detailed below (all information from Project Clean Water at www.projectcleanwater.org).



San Juan

Major Water Bodies:	Orange County: Aliso Creek, San Juan Creek, Dana Point Harbor San Diego County: San Mateo Creek, San Onofre Creek, Las Flores Creek
Major Impacts:	Surface and groundwater quality degradation, habitat loss, channel bed erosion, and invasive species
Constituents of Concern:	coliform bacteria, nutrients, TDS, solvents, trace metals, and petroleum
Sources / Activities:	urban runoff, agricultural runoff, and military operations

The San Juan Hydrologic Unit (SJHU) covers 496 square miles in San Diego, Orange, and Riverside counties. Approximately 150 square miles (30%) of this area is located in northwest San Diego County, almost entirely within the Camp Pendleton Marine Corps Base. The topography of the watershed is varied, ranging from coastal plains in the western portion to the Santa Margarita Mountains, which rise over 2,000 feet above mean sea level.



The San Diego portion of this watershed is largely undeveloped and includes coastal sage scrub, oak woodlands, chaparral, grasslands, coastal dunes, salt marshes, and riparian woodlands. This series of habitats supports 18 threatened or endangered plant and animal species. Past water quality monitoring has indicated that the region's surface waters are high in total dissolved solids. Local wells are the sole water source for Camp Pendleton and several elevated constituents have been noted including nitrates, TDS, iron, sodium, and E. Coli, although there appear to be no long-term trends.

Santa Margarita

Major Water Bodies:	Santa Margarita River, Temecula Creek, Murrieta Creek, Santa Margarita Lagoon, Vail Lake, Skinner Reservoir, and Diamond Valley Lake Reservoir
Major Impacts:	Surface and groundwater quality degradation, habitat loss, invasive species, and channel bed erosion
Constituents of Concern:	Nitrate (surface and groundwater), sediment, indicator bacteria, and TDS in groundwater
Sources / Activities:	Agricultural, orchards, livestock, domestic animals, septic systems, use of recycled water, and urban runoff

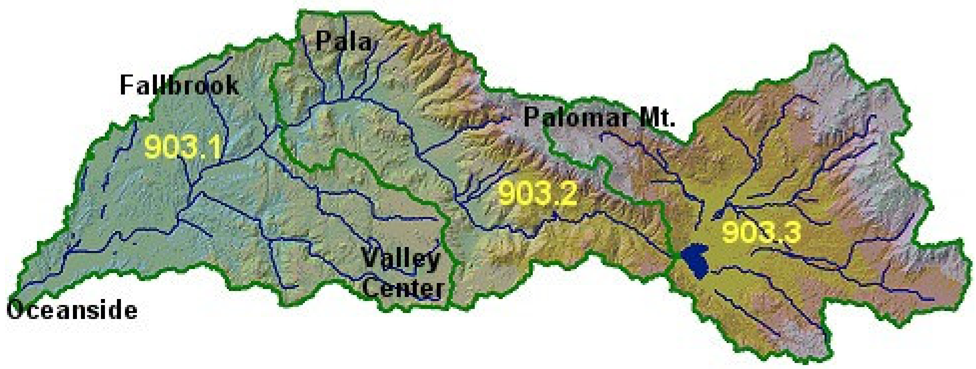
The Santa Margarita River watershed encompasses approximately 750 square miles in northern San Diego and southwestern Riverside counties. The watershed contains a variety of nearly intact habitats including chaparral-covered hillsides, riparian woodlands, and coastal marshes. Of the total watershed area, approximately 27% is within San Diego County. The lower Santa Margarita River and estuary have largely escaped the development typical of other regions of coastal Southern California, and are therefore able to support a relative abundance of functional habitats and wildlife.

The upper watershed basin lies in Riverside County, one of the fastest growing areas in California. In the absence of effective planning measures, this rapid development will likely exasperate surface water quality problems. Presently, several waterbodies are listed on the Clean Water Act section 303(d) list due to excessive nutrients from a variety of sources including agriculture, nursery operations, municipal wastewater discharges, urban runoff, septic systems, and golf course operations. Other serious water quality and environmental concerns in the watershed include excessive sedimentation from development and agricultural areas, groundwater degradation and contamination with nitrates and other salts, habitat loss, channelization, flooding, and scour.

San Luis Rey

Major Water Bodies:	San Luis Rey River and Lake Henshaw
Major Impacts:	Surface water quality degradation, habitat loss, invasive species, channel bed erosion
Constituents of Concern:	Indicator bacteria and nutrients
Sources / Activities:	Agriculture, orchards, livestock, domestic animals, urban runoff, and septic systems

The San Luis Rey River Watershed is located in northern San Diego County. The San Luis Rey River originates in the Palomar and Hot Springs Mountains, both over 6,000 feet above mean sea level, as well as several other mountain ranges along the western border of the Anza Borrego Desert Park. The river extends over 55 miles across northern San Diego County forming a watershed with an area of approximately 360,000 acres or 562 square miles. The river ultimately discharges to the Pacific Ocean near the City of Oceanside.

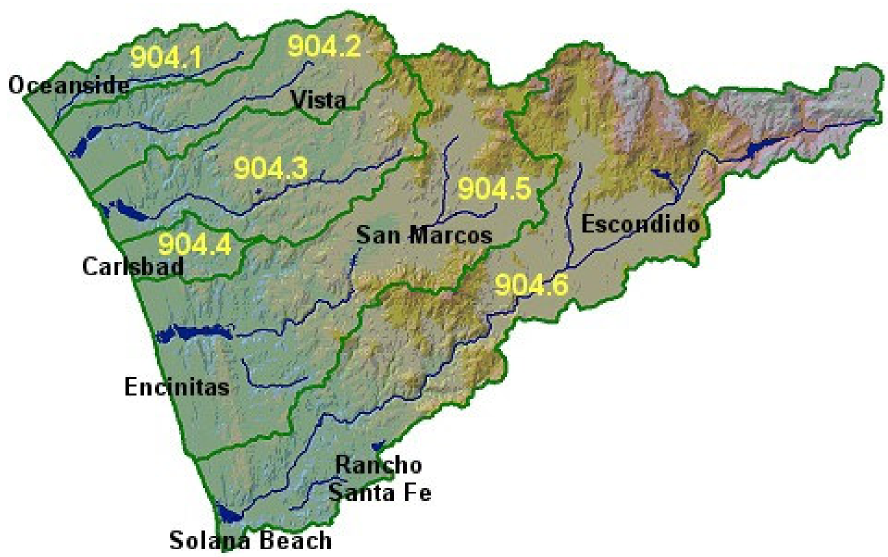


About half (49%) of the land in the watershed is privately owned, 37% is publicly owned, and the remaining 14% consists of six federally recognized Tribal Indian Reservations. Over 54% of the land in the watershed is vacant or undeveloped. The next largest land uses in the watershed are residential (15%) and agriculture (14%). Principal agricultural uses include cattle grazing, nurseries, citrus groves, and avocado groves. Water from the San Luis Rey River is diverted approximately ten miles downstream of Henshaw Dam to serve the municipal drinking water needs of customers in Escondido and Vista.

Carlsbad

Major Water Bodies:	Loma Alta Creek, Buena Vista Creek, Buena Vista Lagoon, Agua Hedionda Creek, Agua Hedionda Lagoon, San Marcos Creek, Batiquitos Lagoon, Escondido Creek, San Elijo Lagoon, and Lake Wolhford
Major Impacts:	Surface water quality degradation, beach closures, sedimentation, habitat degradation and loss, invasive species, eutrophication
Constituents of Concern:	Indicator bacteria, nutrients, and sediment
Sources / Activities:	Urban runoff, agricultural runoff, sewage spills, livestock, and domestic animals

The Carlsbad watershed is approximately 210 square miles in area extending from the headwaters above Lake Wolhford in the east to the Pacific Ocean in the west, and from Vista and Oceanside in the north to Solana Beach, Escondido, and the community of Rancho Santa Fe to the south. Approximately 48% of the Carlsbad watershed is urbanized. The dominant land uses are residential (29%), commercial/industrial (6%), freeways and roads (12%), agriculture (12%), and vacant/undeveloped (32%).



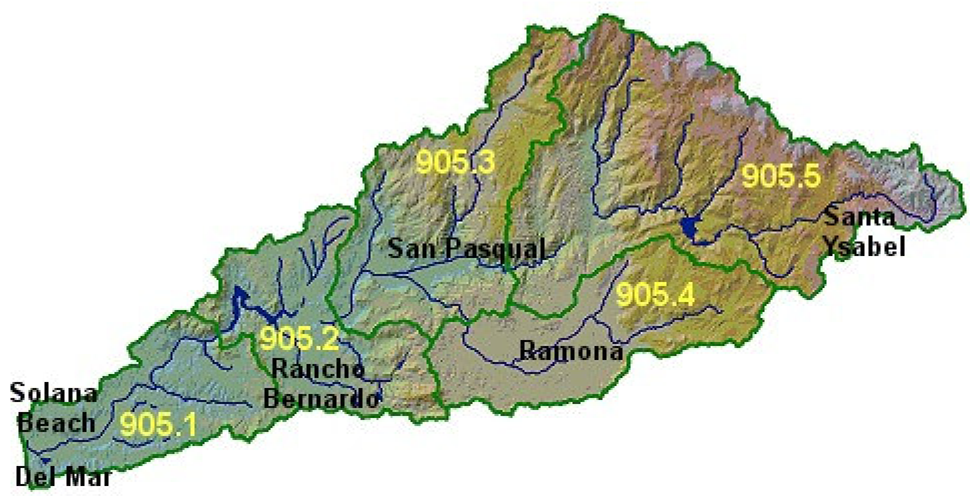
The Agua Hedionda, Buena Vista, and San Elijo lagoons are experiencing impairments to beneficial uses due to excessive coliform bacteria and sediment loading from upstream sources. These coastal lagoons represent critical regional resources that provide freshwater and estuarine habitats for numerous plant and animal species.

San Dieguito

Major Water Bodies:	San Dieguito River, San Dieguito Lagoon, and Lake Hodges
Major Impacts:	Surface water quality degradation, habitat degradation and loss, invasive species, and increased imperviousness
Constituents of Concern:	Coliform bacteria, nutrients, sediment, and trace metals
Sources / Activities:	urban runoff, agricultural runoff, and domestic animals

The San Dieguito River watershed is a drainage area of approximately 346 square miles in west-central San Diego County. The watershed includes portions of the cities of Del Mar, Escondido, Poway, San Diego, and Solana Beach, and unincorporated San Diego County. In terms of land area, the majority of the watershed (79.8%) is within the unincorporated jurisdiction. The San Dieguito River watershed is presently divided into vacant/undeveloped (54%), parks/open space (29 %), and urban (18%) land uses. Population levels are projected to rise to over 210,000 residents by 2015.

The watershed extends through a diverse array of habitats from its eastern headwaters in the Volcan Mountains to the outlet at the San Dieguito Lagoon and the Pacific Ocean. Natural areas within the watershed include the 55-mile long, 80,000 acre San Dieguito River Park, the 150 acre San Dieguito Lagoon, and five water storage reservoirs.

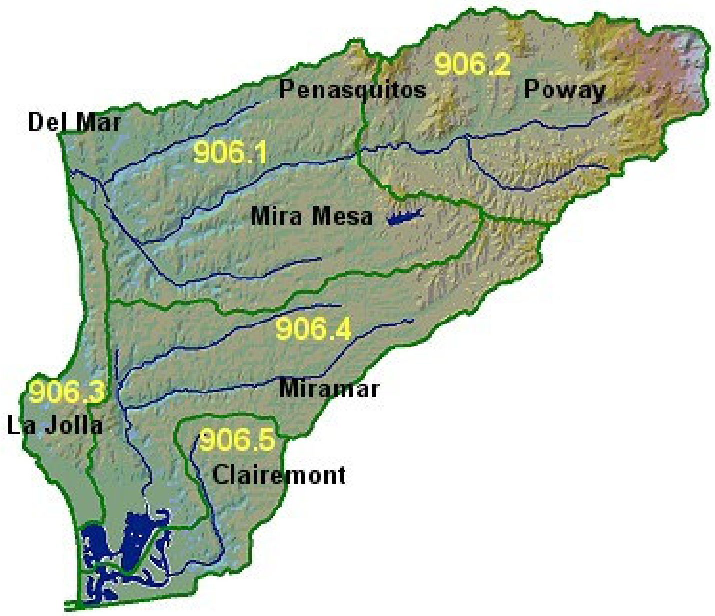


In the absence of a comprehensive watershed planning effort, large-scale future development may exasperate current water quality problems and create additional beneficial use impairments. The San Dieguito Lagoon is especially sensitive to the effects of pollutants and oxygen depletion due to restricted or intermittent tidal flushing.

Los Peñasquitos

Major Water Bodies:	Los Peñasquitos Creek, Los Peñasquitos Lagoon, Rose Creek, Tecolote Creek, Mission Bay, Miramar Reservoir
Major Impacts:	Surface water quality degradation, beach closures, sedimentation, habitat degradation and loss, invasive species, eutrophication
Constituents of Concern:	Indicator bacteria, nutrients, trace metals, toxics, and sediment
Sources / Activities:	Urban runoff, sewage spills, dredging, and landfill leachate

The Los Peñasquitos watershed drains a highly urbanized region located almost entirely west of Interstate 15 in coastal San Diego County. The major receiving waters, Los Peñasquitos Lagoon and Mission Bay, are both fragile systems that support diverse native fauna and flora.

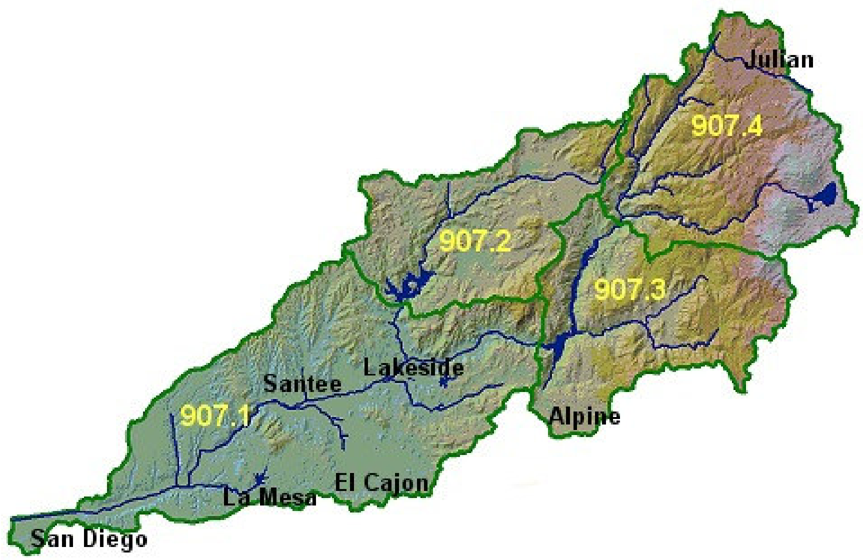


The watershed encompasses a land area of approximately 180 square miles. Los Penasquitos Creek discharges to a 0.6 square mile lagoon while Rose Creek and Tecolote Creek are the main tributaries to Mission Bay, which was converted from a coastal marshland in the 1940s after the completion of a large dredging project. Much of Mission Bay is adversely affected by coliform bacteria inputted by urban runoff and sewage spills, which are discharged by the main tributaries and smaller conveyances draining the watershed.

San Diego River

Major Water Bodies:	San Diego River, El Capitan Reservoir, San Vincente Reservoir, Lake Murray, Boulder Creek, Santee Lakes
Major Impacts:	Surface water quality degradation, habitat degradation and loss, sediment, invasive species, eutrophication, and flooding
Constituents of Concern:	Coliform bacteria, TDS, nutrients, petroleum chemicals, toxics, and trash
Sources / Activities:	Urban runoff, agricultural runoff, mining operations, sewage spills, and sand mining

The San Diego River watershed has a land area of approximately 440 square miles and the highest population (~475,000) of the County's watersheds. Important hydrologic resources in the watershed include five water storage reservoirs, a large groundwater aquifer, extensive riparian habitat, coastal wetlands, and tidepools. Approximately 58.4% of the San Diego River watershed is currently undeveloped.



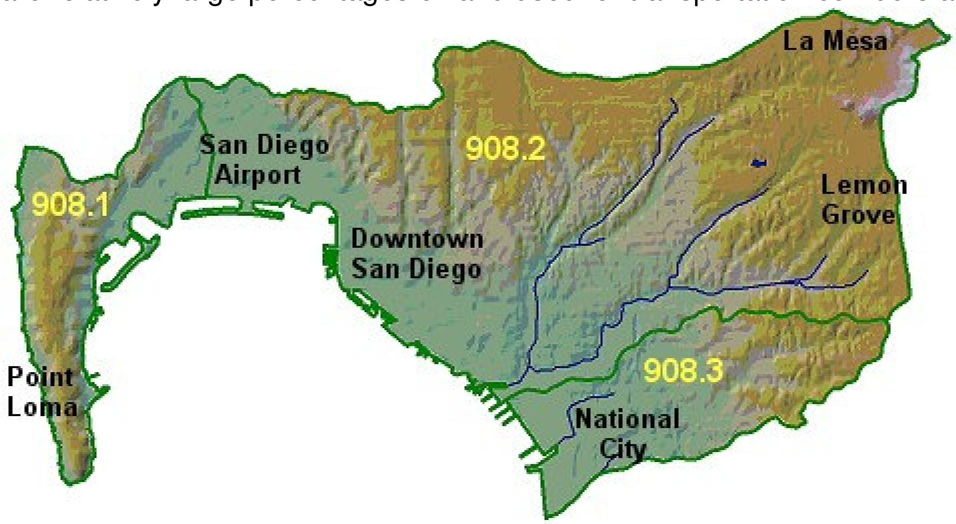
The five reservoirs supply water to as many as 760,000 residents in the region. Undeveloped parklands host a wide variety of intact habitats and endangered species like the arroyo toad, least bell's vireo, and the southwestern pond turtle. In addition, Famosa Slough, near the mouth of the San Diego River contains extremely productive wetlands habitat.

There are extensive groundwater resources beneath the San Diego River. Excessive extraction, increasing total dissolved solids, and MTBE contamination now threatens this resource.

Pueblo

Major Water Bodies:	Chollas Creek, Paleta Creek, and San Diego Bay
Major Impacts:	Surface water quality degradation, habitat degradation, sediment toxicity in San Diego Bay, and sewer overflows
Constituents of Concern:	trace metals, toxic substances, and coliform bacteria
Sources / Activities:	urban runoff

The Pueblo San Diego watershed encompasses approximately 60 square miles of predominantly urban landscape in the cities of San Diego, La Mesa, Lemon Grove, and National City. Approximately 75% of the watershed is developed. Residential, retail/ office, and industrial land uses account for 45%, 11%, and 10% of the total, respectively. In addition, there are relatively large percentages of land used for transportation corridors and highways.

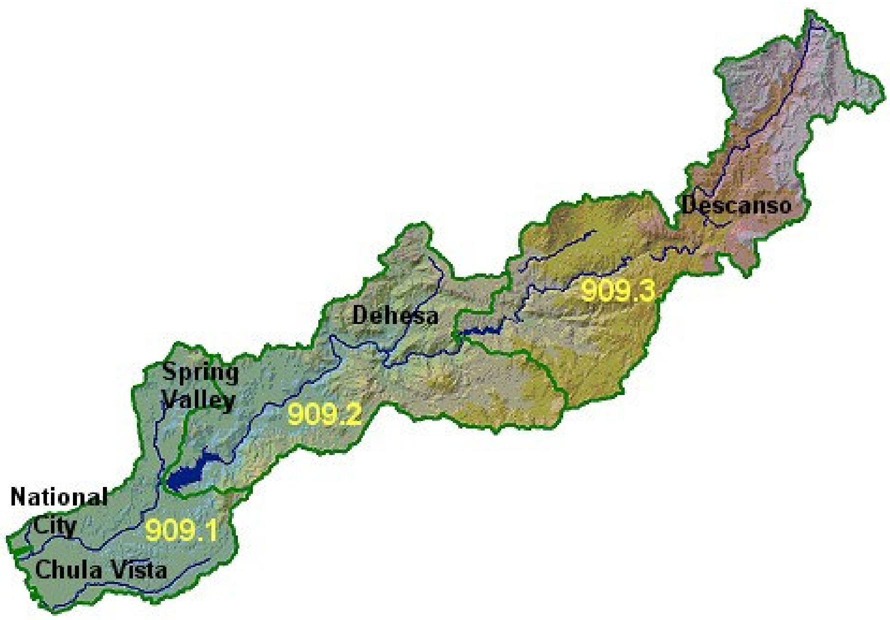


The watershed drainage consists of a group of relatively small local creeks and pipe conveyances, many of which are concrete-lined and drain directly into San Diego Bay. The creeks in the watershed are highly impacted by urban runoff, and Chollas Creek and the mouth of the creek in San Diego Bay are listed as 303(d)-impaired water bodies for various trace metals parameters and aquatic toxicity. Five sites in San Diego Bay that are impacted by runoff from the Pueblo San Diego watershed have been identified as hot spots by California's Bay Protection Toxic Cleanup Program.

Sweetwater

Major Water Bodies:	Sweetwater River, Sweetwater Reservoir, Loveland Reservoir, and San Diego Bay
Major Impacts:	Surface and groundwater quality degradation, habitat degradation and loss, and invasive species
Constituents of Concern:	coliform bacteria, trace metals and other toxics
Sources / Activities:	agricultural and urban runoff

The Sweetwater River watershed along with the Otay and Pueblo San Diego watersheds combine to form the San Diego Bay watershed area. The Sweetwater River watershed is the largest of the three encompassing 230 of the approximately 415 square mile total. Over 86% of the watershed is within unincorporated jurisdictions. The dominant land uses in the Sweetwater River watershed are urban (29%), open space / agriculture (22%), and undeveloped (49%).



The most important watershed issues are related to the protection of municipal water supplies, and the protection and restoration of sensitive wetland and wildlife habitats.

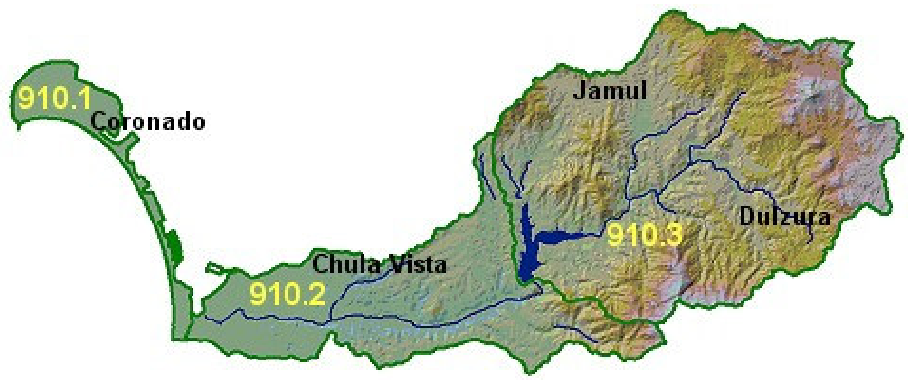
Between the headwaters and the outlet to San Diego Bay, the watershed contains a variety of habitat types including oak and pine woodlands, riparian forest, chaparral, coastal sage scrub, and coastal salt marsh. The urbanized lower portion of the Sweetwater watershed contains portions of several cities including San Diego, National City, Chula Vista, La Mesa, and Lemon Grove.

Otay

Major Water Bodies:	Upper and Lower Otay Reservoirs, Otay River, San Diego Bay
Major Impacts:	surface water quality degradation, reduced ground water recharge, sedimentation, habitat degradation and loss, flood control, and invasive species
Constituents of Concern:	coliform bacteria, trace metals and other toxic constituents
Sources / Activities:	urban runoff, agricultural runoff, resource extraction, septic systems, marinas and boating activities

The Otay River watershed encompasses approximately 160 square miles in southwest San Diego County and discharges to San Diego Bay. The watershed consists largely of unincorporated area, but also includes portions of the cities of Chula Vista, Imperial Beach, Coronado, National City, and San Diego.

The predominant land uses in the watershed are open space (67%) and urban/residential (20%). The major inland hydrologic features, Upper and Lower Otay Lakes, are two water supply reservoirs that also provide important habitat and recreational opportunities.



The current population in the Otay River watershed is approximately 150,000 people. At the present time, serious water quality problems are limited to the presence of elevated coliform bacteria in the Pacific Ocean receiving waters near Coronado. However, an expected population increase of 88% from 1998 – 2015 will substantially increase the volume of urban runoff in the watershed, and could significantly alter the present water quality status. In the absence of effective watershed-based management, the natural resources of the Otay River watershed may be significantly degraded.

Tijuana

Major Water Bodies:	Tijuana Estuary, Tijuana River, Cottonwood Creek, Pine Valley, Campo Creek, Barrett Lake, Lake Moreno
Major Impacts:	surface water quality degradation, trash, sedimentation, eutrophication, habitat degradation and loss, flooding, erosion, and invasive species
Constituents of Concern:	Freshwater: coliform bacteria, nutrients, trace metals, pesticides, miscellaneous toxics, low dissolved oxygen, and trash Groundwater: TDS, nitrates, petroleum, MTBE, and solvents
Sources / Activities:	urban runoff, sewage spills, industrial discharges, agricultural, orchards, livestock, domestic animals, and septic systems

The Tijuana River watershed encompasses a region of approximately 1,750 square miles on either side of the California – Baja California border, and in terms of water quality degradation is probably the most severely impacted watershed in San Diego County. Although only 27% of the watershed area is within California, the river discharges to the Tijuana Estuary and Pacific Ocean on the U.S. side of the international border.

The Tijuana River watershed is classified as a Category I (impaired) watershed by the State Water Resources Control Board due to a wide variety of water quality problems. These problems are largely a result of non-point agricultural sources on the U.S. side of the border and a large variety of point and non-point sources on the Mexican side. The Tijuana Estuary, a National Estuarine Sanctuary that supports a variety of threatened and endangered plants and animals, is threatened by inflows from the Tijuana River containing high concentrations of coliform bacteria, sediment, trace metals (copper, lead, zinc, chromium, nickel, and cadmium), PCBs, and other urban, agricultural, and industrial pollutants.

CALIFORNIA WATER BOARDS

STRATEGIC PLAN SUMMARY

2008-2012

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

10-23-08 GU_MB

September 2008

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Message from the State Water Board Chair and State Water Board Executive Director

The Water Boards' *Strategic Plan 2008-2012* sets a new course for the State and Regional Water Boards.

Put simply, the *Strategic Plan* shows us where we want to go, how we want to get there, and how we will measure our progress.

This summary version of the *Strategic Plan* is a snapshot of the objectives and actions that we have established to meet our seven strategic goals. It is not meant to be detailed, but aims to give the reader an overview of our priorities and activities. To see the plan in its entirety, use the link below.

http://www.waterboards.ca.gov/water_issues/hot_topics/strategic_plan/2007update.shtml

Our underlying message is clear: be forward-thinking, use the best science available, and conduct business in an appropriately consistent and transparent manner, while protecting water quality and balancing the competing demands on our water resources.

Tam M. Doduc
State Water Board Chair

Dorothy Rice
Executive Director

Who We Are

The State Water Resources Control Board and the nine Regional Water Quality Control Boards have broad responsibilities for ensuring the protection of California's surface and ground water quality, and for balancing competing demands on our water resources. Each Regional Water Board has nine part-time members who represent water supply, irrigated agriculture, industry, and municipal and county government for that region. The State Water Board has five full-time members who, like Regional Board members, fill specialty positions. State and Regional Board members are appointed to four-year terms by the Governor and are confirmed by the Senate.

In recognition that California's water pollution problems are influenced by environmental and social factors that vary regionally, the nine Regional Water Boards are based on watersheds, or hydrologic areas (see map on the last page). The Regional Water Boards serve as the frontline for State and federal water pollution control efforts. Each Regional Water Board conducts activities and makes water quality decisions for the protection of the waters within its region. These activities include developing water quality control plans (basin plans) for their watersheds that establish water quality standards and strategies, issuing waste discharge requirements (permits) based on the basin plans and State Water Board plans and policies, monitoring water quality, determining compliance with requirements, and taking enforcement actions.

The Regional Water Boards and the State Water Board work to ensure the protection of water quality in areas such as stormwater, wastewater treatment, water quality monitoring, wetlands protection, ocean protection, environmental education, environmental justice, contaminated sites cleanup, low-impact development, and enforcement. Where water quality issues cross Regional Water Board boundaries or have significant statewide application, the State Water Board may develop water quality control plans and policies, including standards, and general permits. The State Water Board also approves regional basin plans, reviews petitions of Regional Water Board actions, administers financial assistance programs (such as for water pollution control or cleanup), addresses enforcement, and provides administrative and other functions that support the Water Boards.

Last, the State Water Board is responsible for allocating water rights and adjudicating water right disputes. This joint authority of water allocation and water quality protection enables the Water Boards to comprehensively address protection of California's waters.

Our Vision

A sustainable California made possible by clean water and water availability for both human uses and environmental resource protection.

Our Mission

To preserve, enhance, and restore the quality of California's water resources, and ensure their proper allocation and efficient use, for the benefit of present and future generations.

Principles and Values

- Protection
- Sustainability
- Integrity
- Professionalism
- Leadership
- Collaboration
- Service
- Education/Outreach

Goals

Goal 1. Implement strategies to fully support the beneficial uses for all 2006-listed water bodies by 2030.

Goal 2. Improve and protect groundwater quality in high-use basins by 2030.

Goal 3. Increase sustainable local water supplies available for meeting existing and future beneficial uses by 1,725,000 acre-feet per year, in excess of 2002 levels, by 2015, and ensure adequate flows for fish and wildlife habitat.

Goal 4. Comprehensively address water quality protection and restoration, and the relationship between water supply and water quality, and describe the connections between water quality, water quantity, and climate change, throughout California's water planning processes.

Goal 5. Improve transparency and accountability by ensuring that Water Board goals and actions are clear and accessible, by demonstrating and explaining results achieved with respect to the goals and resources available, by enhancing and improving accessibility of data and information, and by encouraging the creation of organizations or cooperative agreements that advance this goal, such as establishment of a statewide water data institute.

Goal 6. Enhance consistency across the Water Boards, on an ongoing basis, to ensure our processes are effective, efficient, and predictable, and to promote fair and equitable application of laws, regulations, policies, and procedures.

Goal 7. Ensure that the Water Boards have access to information and expertise, including employees with appropriate knowledge and skills, needed to effectively and efficiently carry out the Water Boards' mission.

Goal 1: Implement strategies to fully support the beneficial uses for all 2006-listed water bodies by 2030.

- **Prepare, adopt, and take steps to carry out Total Maximum Daily Loads (TMDLs), designed to meet water quality standards, for all impaired water bodies on the 2006 list.**

  - ✓ Develop standard TMDL plan format, considering pollutant or TMDL groupings, and address all impairment pollutants in priority watersheds.

  - ✓ Where pollutant source control measures and a water body's capacity to receive pollutants is insufficient to meet water quality standards, consider whether it is appropriate to amend water right permits to augment stream flows or to revise standards.

  - ✓ Identify and take steps and strategies to restore water quality through policies and permits, which may eliminate need for a TMDL.

- **Manage urban runoff to reduce pollutant loadings, reduce wet weather beach posting by 75 percent by 2020, eliminate dry weather beach closures and postings by 2012, and promote sustainable water supplies.**

  - ✓ Encourage or require low impact development/green infrastructure techniques that promote stormwater reuse.

  - ✓ Establish a Low Impact Development Center in the Central Coast Region and collaborate with stakeholders to address impediments to LID and stormwater reuse.

  - ✓ Update coastal municipal stormwater permits to address beach closures and postings, and develop a statewide monitoring strategy to collect and post municipal, industrial, and construction stormwater data to inform regulatory decisions.

- **Take appropriate enforcement actions and innovative approaches as needed to protect and restore all surface waters.**

  - ✓ Update the State Water Board's Water Quality Enforcement Policy, and reduce the backlog of facilities subject to mandatory minimum penalties.

  - ✓ Pilot enforcement programs and innovative approaches to protect and restore coastal, ocean, and other surface waters by addressing "nurdles," spills, illegal discharges, irrigated agriculture, and other pollutant sources.

Goal 2: Improve and protect groundwater quality in high-use basins by 2030.

- **Start an integrated groundwater protection approach for high-use groundwater basins that regulates activities that impact or could impact beneficial uses, recognizes surface and groundwater interactions, and promotes local management of groundwater resources.**

  - ✓ Prepare and post an online map and water quality information on high-use groundwater basins, and regulate unregulated discharges that cause declining groundwater quality.

  - ✓ Encourage local entities to develop regional strategies to protect high-use groundwater basins, and work to direct funding for Integrated Regional Water Management Plan (IRWMP) development to assist those efforts.

  - ✓ Obtain resources to limit extractions in high-use basins where groundwater quality is declining and no regional protection strategies are in place.

- **Identify strategies to ensure that communities relying on groundwater contaminated by human-caused sources have a reliable drinking water supply.**

  - ✓ Work with other agencies to identify and address improperly destroyed, abandoned, or sealed wells that may contaminate groundwater used by the identified communities.

  - ✓ Take appropriate regulatory or enforcement action to address identified sources of groundwater contamination, and work to expedite funding for IRWMP development for these communities.

- **Ensure viability of high quality groundwater basins.**

  - ✓ Issue new or revised waste discharge requirements (WDRs) to high priority facilities.

  - ✓ Coordinate with the Department of Toxic Substances Control to focus on enforcement actions, investigations, and cleanup of contamination that has or could harm drinking water sources.

Goal 3: Increase sustainable local water supplies available for meeting existing and future beneficial uses by 1,725,000 acre-feet per year, in excess of 2002 levels, by 2015, and ensure adequate water flows for fish and wildlife habitat.

- **Promote best management practices (BMPs) and improve compliance with requirements for water conservation, consistent with the Bay-Delta Strategic Workplan, and other State and regional efforts.**

  ✓ Work with other agencies and stakeholders to assess and update urban BMPs and efficient water management practices for agriculture, as appropriate.

  ✓ Work with the Department of Water Resources to ensure that urban water suppliers effectively implement water demand management measures, and take action to limit waste and unreasonable water use where appropriate.

  ✓ Validate water conservation plans and actions required under water right permits and licenses.

- **Promote recycled water use and stormwater reuse as locally available, sustainable supplies, consistent with implementation of the *California Global Warming Solutions Act of 2006*, and other State and regional efforts.**

  ✓ Where recycling of treated effluent is not maximized at wastewater treatment plants in areas of imported water supply, require that water recycling plans be developed and carried out.

  ✓ Work with agencies and stakeholders to develop a stormwater reuse target that will be used to update Goal 3.

  ✓ Revise funding criteria, where allowable, to ensure that Water Board-funded grant and loan projects enhance water reuse, water recycling, and groundwater recharge.

- **Ensure that adequate stream flows are available to protect fish and wildlife habitat while meeting the need to divert water for other uses.**

  ✓ Work with the Department of Fish and Game and others to list priority streams for developing minimum stream flow objectives, and prepare one to three minimum stream flow proposals for consideration by the State Water Board.

  ✓ For priority streams where minimum flow objectives are not being met, determine what State Water Board-mandated actions are necessary to protect the public trust.

Goal 4: Comprehensively address water quality protection and restoration, and the relationship between water supply and water quality, and describe the connections between water quality, water quantity, and climate change, throughout California's water planning processes.

- **Prepare, as a part of the *California Water Plan*, a comprehensive California Water Quality Plan to guide the State's water management activities, including protecting and restoring water quality through integrated statewide policies and plans, regional water quality control plans (Basin Plans), and the potential effects of climate change on water quality and supply.**

  ✓ Create a Memorandum of Understanding with the Department of Water Resources to coordinate the development of a California Water Quality Plan and its incorporation into the *California Water Plan.*

- **Consistently organize and update Basin Plans to provide a clear structure of key elements and to fully integrate with Statewide policies and plans, such as the *California Ocean Plan.***

  ✓ Using statewide stakeholder assessments of State and regional needs for a statewide Basin Plan and Ocean Plan update, as well as stakeholder input on timing (related to the California Water Plan Update cycle), scope, and approach for Basin Plan updates, develop a statewide Basin Plan format and a user's guide and regulatory compendium.

- **Collaborate in third-party-initiated processes to meet Basin Plan amendment needs that address Water Board requirements and stakeholder interests.**

  ✓ Work with stakeholders to identify and prioritize opportunities that provide resources to address basin planning issues of mutual concern during triennial reviews.

Goal 5: Improve transparency and accountability by ensuring that Water Board goals and actions are clear and accessible, by demonstrating and explaining results achieved with respect to the goals and resources available, by enhancing and improving accessibility of data and information, and by encouraging the creation of organizations or cooperative agreements that advance this goal, such as establishment of a statewide water data institute.

- **Improve Water Board systems, programs, functions, and business processes to enhance effective and consistent implementation of plans, policies, laws, and regulations, and to reduce processing time and costs.**

  - ✓ Prepare an inventory of Water Board programs and functions, and develop performance-based plans for effectiveness, efficiency, and clear results.

  - ✓ Improve Water Board processes, beginning with water right application processing and discharge permitting for readily identifying violations.

  - ✓ Develop and start an approach to link Underground Storage Tank reimbursements with measurable environmental progress.

  - ✓ Conduct Water Board organization and program reviews.

- **Enhance Water Board water quality data systems, and accessibility of web-based water body and facility data and information.**

  - ✓ Start CIWQS (database) Review Panel recommendations to improve data for Water Board regulatory programs.

  - ✓ Advance the start of the *Groundwater Quality Monitoring Act of 2001.*

  - ✓ Use online mapping technology to present Water Board data.

- **Develop recommendations for a publicly-accessible, statewide network to display all water quality data used for planning and decision-making.**

  - ✓ Determine scope and content of data network.

- **Create clear public access to web-based information, including a water quality report card that communicates the quality of the State's waters, Water Board performance in protecting those waters, and other issues.**

  - ✓ Considering stakeholder input, develop annual web-based reports on Water Board program effectiveness, beginning with compliance and enforcement.

Goal 6: Enhance consistency across the Water Boards, on an ongoing basis, to ensure our processes are effective, efficient, and predictable, and to promote fair and equitable application of laws, regulations, policies, and procedures.

- **Target consistency improvements in process and policy for Water Board enforcement activities to promote compliance.**

  - ✓ Adopt and begin revisions to the State Water Board's Water Quality Enforcement Policy to ensure consistent enforcement response, assessment of penalties for Class 1 violations, and assessment of liability in excess of economic gain from non-compliance.

  - ✓ Develop uniform hearing procedures for contested enforcement matters and templates for enforcement activities, separate enforcement and permitting staff, and instill processes to review draft WDRs and WDR waivers for enforceability.

- **Target consistency improvements in program delivery identified through past input, and solicit input on consistency issues as they arise.**

  - ✓ Develop guidance for evaluating effectiveness of municipal stormwater permits that will also apply, if feasible, to non-municipal stormwater permits and be used for developing all subsequent stormwater permits, beginning with the Phase II municipal separate storm sewer systems permit to create a baseline for consistency.

  - ✓ Implement public participation policies, procedures, or guidelines to improve Water Board procedures for adopting policies and regulatory actions.

  - ✓ Establish consistency issues as standing item at biannual meetings of State and Regional Water Board members, and establish a pilot program for interagency agreements when more than one Regional Water Board has jurisdiction over a regulated facility.

  - ✓ Initiate triennial review process for the State Water Board's "anti-degradation" policy.

Goal 7: Ensure that the Water Boards have access to information and expertise, including employees with knowledge and skills, needed to effectively and efficiently carry out the Water Boards' mission.

- **Enhance professional development opportunities for employees to increase their knowledge, skills, and expertise.**

  ✓ Assess training needs, and develop and deliver courses and core curricula to meet those needs.

  ✓ Develop a rotational program for all classifications to foster inter-program and inter-government collaboration.

- **Expand recruitment efforts of qualified professionals to fill Water Board vacancies.**

  ✓ Establish a recruitment plan and recruiter training, and create partnerships with relevant State university systems, to attract qualified prospective employees.

- **Ensure information, including scientific research and developing science regarding emerging pollutants, is easily accessible by staff.**

  ✓ Prepare inventory of Water Board and Water Board-funded research, and establish research agenda to guide funding of future needed research.

  ✓ Establish an electronic repository for sharing best practices, models, templates, plans, policies, and research.

- **Leverage resources and expertise to enhance existing workforce capacity and field presence.**

  ✓ Develop partnerships with other agencies with environmental inspection and regulatory enforcement authority.

  ✓ Develop partnerships of federal, State, and local interests to examine connections between water quality, water quantity, and climate change on the coast from central California to Oregon border.

  ✓ Establish a mechanism to make regional and subject matter experts available to any Water Board organization, and use staff teams to enhance Water Board effectiveness across regions and programs.

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CALIFORNIA

Water Boards

STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

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California Environmental Protection Agency
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State Water Resources Control Board
Tam M. Doduc, Chair

10/10/08
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The Watershed Approach

Water Facts

photograph courtesy of © Environmental Services, City of Portland, Oregon/Kevin Robert Perry

Water Saving Solutions: Stopping Pollution at its Source with Low Impact Development

For more information, please contact **Noah Garrison** or **David Beckman** at (310) 434-2300

America's urban landscape is affecting our cities' water supply and water quality. Runoff from urban areas is a leading cause of water pollution in the United States, and in many areas people are using water faster than it can be replenished. More than 100 million acres of land have been developed in the United States, and with development and sprawl increasing faster than population growth, the risks to water supply and quality are growing. Low impact development, or LID, is a simple and cost-effective green development strategy that can help cities, states, and even individuals meet the water supply challenge, clean up our existing water resources, and, in many places in the West, curb global warming pollution by reducing the amount of electricity used to supply water.

How Does LID Work?

When it rains, the traditional urban landscape of roadways, sidewalks, and buildings directs rainfall from paved surfaces into storm drains, picking up animal waste, trash, and chemicals along the way—and ultimately dumps this pollution into our waterways. This causes water quality problems that can make people sick, impair ecosystems, and weaken coastal economies that depend on clean water for tourism revenue.

LID uses smarter city design such as permeable pavement to infiltrate rainwater into the earth and recharge groundwater supplies, rain barrels to capture rainwater for use where it falls, and green roofs to filter pollutants and evaporate runoff. This reduces the runoff that contaminates waterways, while often collecting clean water that can be used to meet our water supply needs. With population growth and global warming putting ever-increasing strains on water availability, particularly in parched Western states, LID provides clean water resources we cannot afford to squander.

NRDC
The Earth's Best Defense
www.nrdc.org/policy
August 2009

Water Facts

Water Saving Solutions: Stopping Pollution at its Source with Low Impact Development

In addition to reducing stormwater pollution and increasing water supply reliability in a region prone to natural disasters, LID can reduce flooding and erosion associated with urban runoff, reduce the “heat island” effect from solar radiation in urban settings, and provide green space and open land, enhancing property values. The use of LID can also reduce the costs of municipal stormwater infrastructure and decrease the frequency and severity of combined sewer overflow events.

Implementing Water Saving Technology in California

LID techniques can deliver water, energy, and greenhouse gas emissions savings for Californians. A recent joint analysis by NRDC and the University of California, Santa Barbara’s Donald Bren School of Environmental Science and Management shows that LID can play a significant role in addressing issues of water supply and climate change throughout California and the Southwest United States. The study found that implementing LID practices that emphasize capture and infiltration at new and redeveloped residential and commercial properties in the urbanized areas of Southern California and portions of the San Francisco Bay area has the potential to increase local water supplies by up to 405,000 acre-feet of water per year by 2030—roughly two-thirds of the amount of water used by the entire City of Los Angeles each year.[2] See NRDC’s Technical Report on LID, available at: http://www.nrdc.org/water/lowimpactdev/

© EPA/Abby Hall

Drainage swale, shown here in Seattle, captures rainwater and reduces pollution

LID Increases Local Water Supplies

Traditional stormwater management conveys runoff from rain, snow, or over-watered lawns away from its source as quickly as possible, dumping it into streams, lakes, or the ocean with little or no treatment, which is both polluting and wasteful. In contrast, by collecting water on site, or infiltrating water into soil to recharge groundwater supplies, LID helps capture and retain rainwater to increase local water supplies.

NRDC, in cooperation with leading stormwater experts, has calculated that 100 percent of the runoff from paved surfaces generated by the typical annual rainfall that occurs on many, if not most, commercial and residential developments in California can be retained onsite to recharge groundwater, or captured for onsite use. Even in densely populated and developed urban centers, significant quantities of water can be captured for use in landscape irrigation, for flushing toilets, or for other non-drinking water applications. LID is a holistic water resources solution because, in most cases, the water saved and repurposed through LID designs is water that would otherwise have been discharged from sites, creating the polluted runoff problem affecting local streams, rivers, and coastal waters.

LID Strategies Can Reduce Global Warming Emissions

In many places, particularly in the West, water is pumped hundreds of miles and over mountain ranges to reach cities, where it is used in homes and businesses. The energy used to transport the water over long distances results in the release of greenhouse gases that contribute to climate change. Overall, the collection, distribution, treatment, end use, and safe disposal of drinking water and wastewater consume tremendous amounts of energy nationwide and release approximately 116 billion pounds of carbon dioxide (CO_2) per year—as much global warming pollution each year as 10 million cars.[1] But for every gallon of water saved through the use of LID practices, one less gallon of water needs to be supplied from sources that are energy intensive, since LID provides a local supply of water that reduces the need to carry water over long distances from the source to the tap. The energy-water connection is particularly strong in the driest regions of the United States, such as the Southwest, where significant amounts of energy are used to import water. Implementing LID practices is an important tool for governments and communities to reduce and respond to climate change.

A recent analysis by NRDC and the University of California at Santa Barbara highlights the significant energy and climate benefits that would result from widespread implementation of LID in California. In California, the water sector is the largest energy user in the state, estimated to account for 19 percent of the total electricity consumed. A significant portion of this electricity is used to convey water across the state. The NRDC-UCSB report, *A Clear Blue Future*, estimates that by 2030, 1,225,500 megawatt hours of electricity savings can be achieved each year through use of LID practices in California, representing enough energy to power more than 102,000 single-family homes for one full year. Reducing imported water from distant sources in Northern California or from other energy-intensive sources such as ocean desalination could prevent as much as 535,500 metric tons of CO_2 from entering the atmosphere annually, the equivalent of taking nearly 100,000 cars off the road each year.

The rapid rate at which buildings in the United States are replaced or redeveloped magnifies the potential to achieve water resources, energy and climate benefits. By the year 2030 some 50 percent of the residential and commercial buildings in the United States will have been built after 2000, and each of these buildings presents an opportunity to integrate LID practices that can harness water supplies.

LID offers a number of opportunities to reduce the energy required to supply water:

- Capturing water or infiltrating it onsite can offset the energy-intensive pumping needed to convey water to arid regions, such as Southern California.
- Capturing water or infiltrating it onsite also can reduce the need to desalinate or otherwise purify ocean water, an energy-hungry practice.
- Allowing water to permeate the earth can recharge groundwater aquifers so that their levels rise, allowing pumping to occur from shallower, less energy-intensive depths.

California could save more than 1.2 million megawatt hours of electricity each year through LID practices—enough energy to power more than 102,000 single-family homes for one full year.

LID Is Cost Effective

The U.S. Environmental Protection Agency states that "LID practices can reduce project costs and improve environmental performance."[3] As a result, LID practices can provide a targeted, cost effective means of addressing issues of water pollution, water supply, and climate change all at once.

Greening Cities in California Can Help Solve Water and Energy Challenges

Rain Garden / Photo Courtesy of USDA NRCS

Nationwide, about 4 percent of power generation is used for water supply and treatment, but in certain parts of the United States the number is far higher. California is particularly vulnerable: conveying water in the state requires electricity at a rate far above the national average. As in many western states, the sources of water used for urban or agricultural supply in California are often far removed from the cities and fields they must reach. As a result, water travels long distances from its source, resulting in huge expenditures of energy to pump the water through deserts or over mountain ranges. The California State Water Project, which transports water from the San Joaquin-Sacramento Bay Delta over hundreds of miles and thousands of feet of elevation to supply Southern California's more than 20 million residents, is the state's single largest user of electricity. The massive amount of energy needed to transport water emits greenhouse gases such as CO_2, which contributes to global warming. As a result, the safe and sufficient supply of water in California is both a casualty of global warming, and a contributor to it.

LID, however, can provide other sources of water, primarily produced from local sources that require significantly less energy to supply. It takes up to *twenty times more energy* to supply water to Southern California through the State Water Project as it does to supply groundwater locally. Where rooftop runoff is captured in tanks for use in gravity fed irrigation systems, no electricity use may be required at all. LID strategies implemented widely can significantly increase the amount of water available to recharge groundwater or for capture and onsite use, and help offset the need to supply water through the much more energy-intensive State Water Project.

Water Facts

Water Saving Solutions:
Stopping Pollution at its Source with Low Impact Development

Putting LID to Work in Your Community

■ **Individuals** can plant landscaping native to their region's climate to reduce the need for extra watering, and install rain barrels or cisterns to gather rain for the garden instead of using water from the tap. Homeowners can redirect downspouts so they empty water onto vegetation, and plant rain gardens at the bottom of inclines to absorb rainfall so it replenishes aquifers instead of carrying runoff pollution into our waterways.

■ **Businesses** can install green roofs and integrate cisterns to harvest rainwater for non-potable uses such as landscape irrigation or to flush toilets.

■ **Developers** can use permeable pavement and other porous materials in new development and redevelopment, and preserve open space in construction.

■ **Governments and municipalities** can use LID on a larger scale to cut back on city-wide runoff and the sewage overflows that occur when too much rainwater causes sewer systems to dump waste into our waterways. Governments can also offer tax credits to business and individuals who invest in green infrastructure improvements. Several cities across the country are also initiating programs to "green" their streets through utilizing permeable pavement. Governments and municipalities can also require the use of LID practices in retrofits, redevelopment, and new properties to achieve water quality and water supply goals.

© EPA/Abby Hall

Rain barrels, such as this one in Santa Monica, California, capture rainwater for the garden

© Ken Weston and Reza Iranpour/City of Los Angeles

Green roof in Vista Hermosa Park, Santa Monica Mountains Conservancy, Los Angeles

[1] EPA, *National Water Program Strategy: Response to Climate Change* (2008), at 24-25, at http://www.epa.gov/water/climatechange/strategy.html.

[2] One acre-foot contains 325,851 gallons or enough to flood a football field to the 91 yard line with water a foot deep, or enough to supply roughly two families in California for a full year.

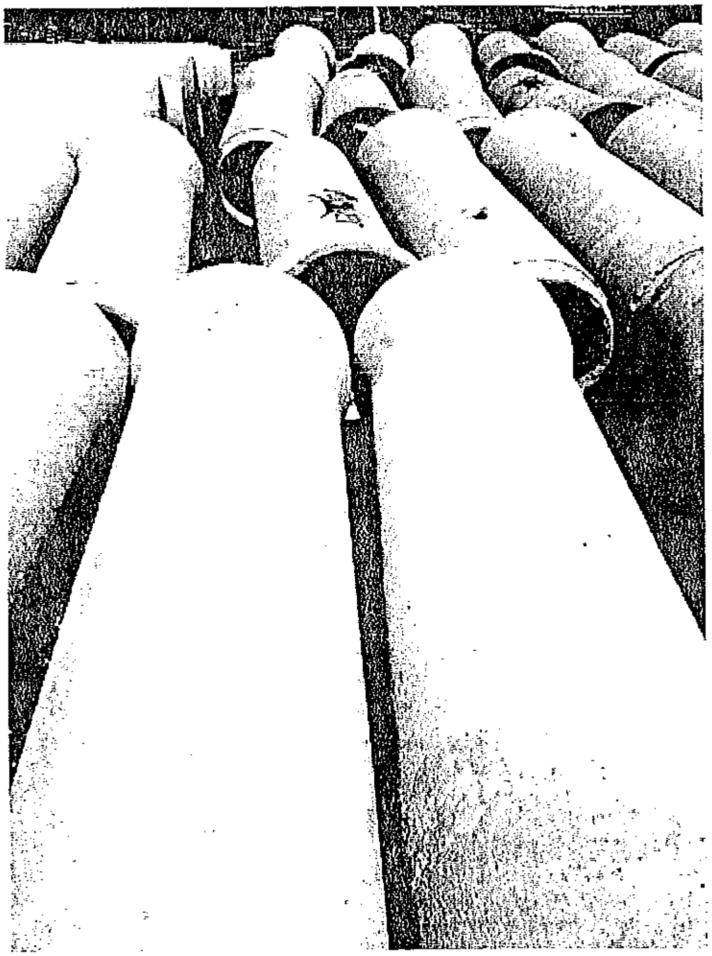
[3] U.S. Environmental Protection Agency, December 2007, *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*, http://www.epa.gov/owow/nps/lid/costs07/.

Park project is part of stormwater renaissance

Runoff to be saved, not routed to ocean

By Mike Lee, UNION-TRIBUNE

Monday, August 9, 2010 at 9:30 p.m.



San Diego's latest push to reduce beach and bay pollution looks like a common storm water project — an open trench, mounds of dirt and large sections of pipe stockpiled at Memorial Park.

But in this case, it's a radical departure from 50 years of urban planning designed to route storm water to the ocean as quickly as possible. The changes are driven by tougher requirements to meet the standards in the U.S. Clean Water Act.

Beneath the surface of the park on Ocean View Boulevard, city officials are betting $300,000 on a novel approach that could become widespread across the region.

The pilot project is designed to capture rainwater from a nearby parking lot, remove some contaminants and hold it in an underground basin so it can infiltrate the soil rather than rushing into nearby Chollas Creek — one of the most-polluted waterways in the county. It's the first project of its kind by the city, and it's among several efforts sprouting countywide.

It's all part of a renaissance in thinking about storm water. New goals include retaining water on site, removing contaminants and reusing the water where possible. Widespread adoption of the techniques will be costly, but not as expensive as building treatment plants to remove pollutants, such as copper from brake pads, pesticides and fertilizers from gardens and bacteria from animal feces.

"We are trying to bring back the hydrological

LOW-IMPACT DEVELOPMENT

Several techniques help reduce storm water flows and the amount of waterborne pollutants that reach local waterways. They include:

- Detention basins
- Permeable pavement
- Planted roofs
- Rain barrels
- Vegetated swales

"The beauty of it is that to a great degree you blend it into the project and it becomes functional so that it doesn't stick out," Tesoro said.

Back at Memorial Park, the city's goal is to complete work by November in time for the rainy season. The underground reservoir wasn't specifically mandated by pollution regulators but the city is under orders to reduce pollutants in Chollas Creek.

Construction will involve a new catch basin in the parking lot, which is covered with oil, dirt and debris. Collected storm water will flow into an underground pipe through a screen to remove trash, sediment and other contaminants. When water reaches the 50,000-gallon reservoir, it will soak into the ground through the porous bottom surface.

The basin is designed to handle the size of a rainstorm that happens every five years. Additional flows will be routed to storm water channels.

"Everything that gets in it is going to have time to seep out," said Harris, of San Diego's Storm Water Department. "It effectively increases capacity at other points in the (storm drain) system."

Park patrons shouldn't notice anything more than new grass over the construction zone after the work in done.

Harris said San Diego is planning another runoff-control experiment this fall with a "green lot" at Kellogg Park in La Jolla. The $982,000 project will remove 18,000 square feet of asphalt concrete in the parking lot and replace it with pavement that allows water to penetrate into the ground.

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Rainwater as a Resource:

A Report on Three Sites Demonstrating Sustainable Stormwater Management

TreePeople



Acknowledgments

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TreePeople's mission is to inspire the people of Los Angeles to take personal responsibility for the urban forest — educating, training and supporting them as they plant and care for trees and improve the neighborhoods in which they live, learn, work and play.

Photo on page 1 by Melinda Kelley.

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Welcome.

Thank you for your interest in finding solutions to urban water quality, supply and protection issues. We've produced this report and analysis of three of the demonstration projects TreePeople has implemented as a means of advancing the state of the art of adapting cities to increase their safety, civility and sustainability.

As founder and president of the nonprofit organization TreePeople, I've spent much of the last 37 years bringing trees and people together to improve the quality of life in Los Angeles and reduce its energy, water and waste footprints. Over time I've learned that it is possible to transform cities from being amongst the most environmentally destructive forces on the planet into more benign, safe and sustainable systems.

Although cities consume huge amounts of natural resources and produce waste that is then converted into pollution, we can no longer write off cities as having nothing to offer the sustainability movement. Given the urgency of confronting climate change, rapidly increasing levels of respiratory disease in urban populations, the worldwide ubiquity of water quality and supply issues, and the compromised state of nearly every natural ecosystem on earth, it's time for cities to lead the way and share our best-tested ideas for healing the planet. It's also time to share what hasn't worked.

TreePeople has a long history of utilizing evaluation of its events and innovations – whether tree plantings, speaking engagements, community workshops or youth education programs – as the quickest path to strengthening and improving our programs and the organization itself. In each situation, we seek to learn what worked, what didn't and how to do better next time. This method has helped build TreePeople into a thriving community-based institution. I've always lived by the principle that mistakes and failures are compost for success.

The integrated urban watershed management movement is still young, but there is urgency here in the United States and abroad driving adoption of these proposals and approaches. To bring these methods to wide-scale use means building, testing, demonstrating and learning from even more projects. Helping cities fight the causes of climate change and adapt to its consequences adds even more impetus. The U.S. Environmental Protection Agency has identified over $300 billion for nonintegrated water supply and wastewater projects for U.S. cities in the next 20 years. Those single-purpose projects will, for the most part, serve as Band-Aids without improving other related problems facing the cities that build them.

On the other hand, this massive investment – informed instead by integrated approaches such as the ones studied in this report – could leverage those funds to solve multiple problems and profoundly improve the quality of life of urban residents.

If you are reading this report, you are either an innovator or problem-solver in search of solutions – and as someone aware of the tremendous challenges ahead, we hope you'll take an active part in securing a thriving future for the Los Angeles region and beyond. We hope you'll make use of the information in this report as you test and attempt further solutions. Please keep us informed of your own results and progress.

Congratulations and thank you again for being part of the solution.

Andy Lipkis, *Founder and President of TreePeople*

About Our Work

TreePeople's work is about inspiring people to transform their cities, currently significant sources of damage to human health and the environment, into sustainable urban ecosystems. We do this by creating "functioning community forests"— that is, restoring nature's cycles in urban areas – through strategically planting trees, mulching greenwaste, capturing and using stormwater right where it falls, and educating communities and engaging them in taking responsibility for the environment.

Although we have been planting and caring for trees since 1973, of all our programs our work on critical water issues has elicited the greatest range of responses: inspiration to do more; confusion about how to achieve this goal; and a mix of support and skepticism that the concepts we advocate will see large-scale adoption.

TreePeople has managed the implementation of a number of demonstration projects showcasing alternative stormwater management approaches and practices, among which are the three projects featured in this report. At the time these projects were initiated, government agencies around Los Angeles were not practicing integrated urban watershed management. At least within the governmental arena, multipurpose projects – which combine flood reduction, water conservation and stormwater protection with a host of other social, environmental and economic benefits – were considered neither necessary nor financially and technically feasible.

Rather than relying only on studies to prove otherwise, we chose to construct tangible projects that would enable public agency staff, policymakers and the public to see these projects working, and then to imagine them scaled-up to the citywide or countywide level. The demonstration sites have helped initiate an ongoing process of significant changes in local and state agency missions, funding policies, designs, projects, plans and programs.

As we continue our efforts to affect the environmental, social and economic health of the Los Angeles region and beyond, we reflect on our experiences with past projects and look ahead toward the work that must still be done.

Purpose of This Publication

The demonstration sites have spurred much interest in alternative stormwater management scenarios and technologies. We receive many inquiries about these projects from a variety of sources, and until now we have lacked a way to accurately and efficiently share the documentation and evaluation of these projects.

The purpose of this publication is thus to disseminate information about the demonstration projects, presenting a candid discussion of the processes that were involved in their implementation and sharing the lessons we learned along the way.

Our intent in producing this report is not to see the projects replicated, but rather to encourage other implementers to improve upon the concepts piloted at the three sites. Information about the retrofit processes is meant to provide as complete a picture as possible of the intricacies involved. Plans and technical information are meant as a guide, and individual conditions would preclude anyone from using them off-the-shelf.

About This Report

Definitions for terms in *italics* can be found in the glossary at the end of this publication. Appendices will be available on compact disc (for printed reports) and as separate downloadable attachments (for reports in electronic format).

Background

TreePeople launched the Transagency Resources for Environmental and Economic Sustainability (T.R.E.E.S.) Project in 1994 in response to a simple observation: conventional management of cities results in the misuse and loss of vast amounts of natural, social and economic resources. The sheer amount of natural capital that it takes to feed a city and the devastation that cities create in downstream communities serve as ever-present reminders that urban places were built with a lack of understanding and appreciation of nature's cycles. Cities have proven to be tremendously damaging to those living both within and outside their boundaries, and – when managed using the conventional methods that built them – are ultimately unsustainable. The T.R.E.E.S. Project was initiated to demonstrate that shifting the flow of – and indeed recycling – environmental, human and economic resources can result in healthier and more sustainable environments.

In the Los Angeles region, conventional development practices have meant that the city is increasingly covered with impervious surfaces, leaving fewer places where stormwater can soak into the ground and reach the aquifer. With no place else to go, water flows across the impervious surfaces, picking up oils, pesticides, animal waste, atmospheric deposits and trash. Massive flood control projects are undertaken to rush this water off the streets and into channelized rivers and the ocean, rendering natural water bodies unsafe for humans and wildlife. As the effects of global climate change begin to be felt, the precious resource of rainfall, which could be used to augment local water supplies, is mostly squandered instead. At the same time, more than half of the water needs of the county's ten million residents are met by costly imports from distant locations – a practice that has been notoriously harmful to places such as the Owens Valley, Mono Lake and the Colorado River basin.

To mitigate these problems, a variety of separate water-related agencies proposed spending in excess of $10 billion to construct numerous uncoordinated projects that would act as temporary solutions without moving the region closer to sustainability.

The T.R.E.E.S. Project sought to prove that it was technically and economically possible to retrofit and manage the region as one integrated urban watershed ecosystem by combining those funds for one coherent plan. In addition to conducting a robust, integrated cost-benefit analysis, the T.R.E.E.S. Project needed to develop sound engineering plans to guide the retrofit process. To do this, the project turned to the collective expertise that a variety of professionals would bring by participating in a *charrette*.

In May 1997, TreePeople convened the four-day Second Nature charrette – a conference of engineers, landscape architects, urban foresters, architects and planners who created retrofit designs for capturing and using stormwater on sites representing five of the major land-use types in Los Angeles. The participants' assignment: to design feasible retrofits for five existing properties. The ultimate goal: retrofitting Los Angeles to function as a community forest.

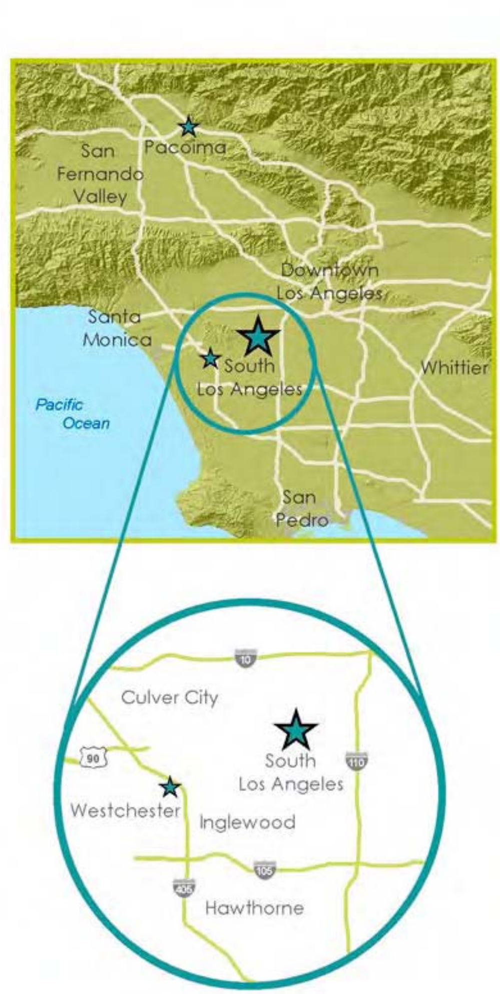
Each of the teams was charged with designing a retrofit for an existing residential, public, commercial or industrial site, using *best management practices* (BMPs) to make it function as a miniature urban forest watershed.

At the charrette the design teams concerned themselves with the environmental impacts of our water use, not only in the city, but also upstream, where the water comes from, and downstream, where it ends up. The conference resulted in the publication of a book of BMPs and design ideas titled *Second Nature: Adapting L.A.'s Landscape for Sustainable Living*. Those BMPs were used to guide and inform the three demonstration projects detailed in this report.

Since that time, TreePeople has continued to innovate upon the concepts first iterated at the charrette while also advocating their adoption at the local and regional level and beyond. The opportunity exists for us to reduce water importation significantly, prevent water pollution and flooding through increased onsite retention, reduce landfill volumes considerably and create employment opportunities – all while improving the quality of life of our communities and ecosystems.

Single-Family Home Greening and Stormwater Management

Demonstration site in
South Los Angeles, California



TreePeople

Introduction

At the four-day Second Nature charrette in 1997, teams of designers created retrofit designs to facilitate the sustainable management of stormwater on five existing sites representative of Los Angeles' predominant land uses.

Due to limited financial resources, TreePeople could only implement a single charrette design and thus sought to identify the one with the most potential for replication. The prevalence of single-family residences in Los Angeles made that land-use type a logical choice. The intent of this pilot retrofit was to demonstrate the feasibility of sustainable approaches to managing urban watersheds and to inspire policy shifts that would encourage their widespread adoption. Building the demonstration site at a single-family home meant that a citywide application would be immediately evident.

> Rather than fight nature's cycles of flood, drought and waste, the single-family home works with them, capturing and retaining onsite the runoff from a 100-year storm event.

Rather than fight nature's cycles of flood, drought and waste, the single-family home works with them, capturing and retaining onsite the *runoff* from a *100-year storm* event. A combination of technologies was used at the site, including retention grading, *swales* and a *cistern*. Stormwater that falls on the property is either directed to the ground, where it percolates and feeds the *aquifer*, or is stored in the cistern for later use in irrigation. Swales are designed to utilize yard waste as mulch, eliminating the need for transport to and space in a landfill.

Mark Drayse

During quarterly tours, visitors learn how the house was retrofitted to function as a miniature urban forest watershed.

TreePeople leads quarterly tours of the site, during which students, members of the public, government officials, landscape architects and city leaders learn about the opportunity to bring Los Angeles into closer harmony with its environment.

Project Objectives

- Demonstrate how a single parcel can act as a miniature watershed, and how thousands of similar parcels can be networked to meet a region's water management and flood prevention needs
- Capture onsite stormwater falling on the property from up to a 100-year storm
- Utilize a cistern to store some of the stormwater for later use in irrigation
- Infiltrate remaining water to recharge the aquifer, thereby virtually eliminating runoff
- Minimize the solid waste stream and detain irrigation water by reusing greenwaste onsite as mulch

Background

Selecting a Site

Intent on finding a site that would demonstrate the feasibility of a wide-scale retrofit, TreePeople solicited input from various agencies and organizations, including the U.S. Army Corps of Engineers, the Los Angeles Department of Water and Power (DWP), Mothers of East Los Angeles and the Concerned Citizens of South Central Los Angeles. A suitable site would be representative of the average Los Angeles home and would be located in a low- to middle-income area, demonstrating the applicability of the Transagency Resources for Environmental and Economic Sustainability (T.R.E.E.S.) model across the economic spectrum.

With these criteria in mind, the late Mrs. Rozella Hall, owner of a home on a small lot in South Los Angeles, offered her property for the retrofit. Mrs. Hall was profoundly interested in transforming her home to function sensibly while demonstrating the watershed functions that a single parcel can perform. In turn, TreePeople found Mrs. Hall's personal interest in the project ideal.

In local circles the project has become known as the "Hall House" demonstration site and that is how it will be referred to in the remainder of this document.

Site Profile

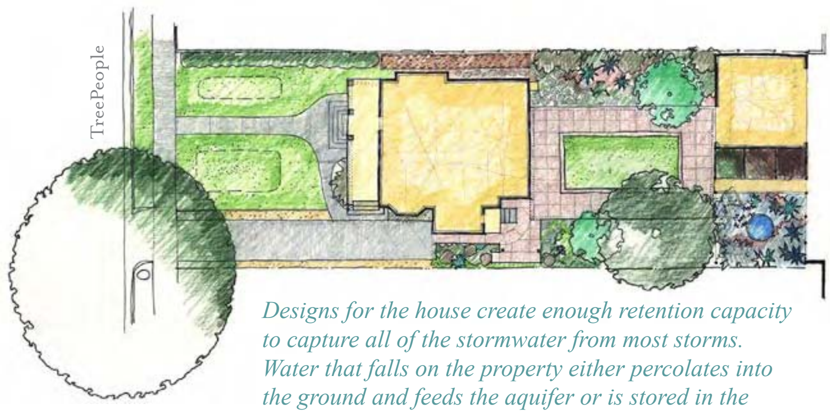
The Hall House is located in a low-income area in South Los Angeles, near the intersection of Western and Vernon Avenues. The Craftsman-style bungalow house was built in the early twentieth century on a lot measuring 50 by 150 feet, a typical lot size for homes built in Los Angeles in the first part of the twentieth century. The wood-frame house, a garage and paved areas cover approximately 60 percent of the 7,500-square-foot lot. The remainder of the property consists of turf, shrubs, planted areas and mature trees.

The house is located within the Ballona Creek watershed. The soil at the site is a well-drained loamy sand with moderately rapid subsoil permeability – ideal for infiltration BMPs.

TreePeople

The Hall House, located on a small lot in South Los Angeles, demonstrates the feasibility of restoring some of the watershed functions of urban sites.

Designs



TreePeople

Designs for the house create enough retention capacity to capture all of the stormwater from most storms. Water that falls on the property either percolates into the ground and feeds the aquifer or is stored in the cistern and later used for irrigation.

Project Features

As a demonstration project, the Hall House retrofit uses a variety of BMPs that illustrate some of the greening options available to homeowners or developers interested in managing their properties as miniature watersheds.

The BMPs used at the site include:

- A **cistern system**, comprising two connected 1,800-gallon tanks that retain stormwater for irrigation use, and a **first-flush diversion unit**. This unit collects the "first flush" of water that occurs during a storm and stores it long enough so gravity can settle out pollutants that accumulate on the roof. Remaining water is delivered to the cistern;
- A **vegetated and mulched swale** filled with yard trimmings that captures and slows rainwater runoff so it can be absorbed by the soil;
- **Retention grading** in the frontyard and backyard, which allows large quantities of stormwater to be retained onsite and percolate into the ground rather than wash down storm drains;
- A **drywell** filled with sand and crushed rock, which prevents water that falls on the driveway from reaching the street as runoff. This unit cleanses polluted water from the driveway before it percolates into the ground to recharge the aquifer.

Initial Proposals

The homeowner, Mrs. Hall, had limited ability to perform yard work or to hire others to do it for her. Consequently, the team produced a design that met all of the environmental performance requirements without requiring a burdensome amount of work for the homeowner.

The initial proposals lay out a simple design strategy. A cistern would be installed on the site to capture roughly a quarter of the stormwater that falls on the roof. Water stored in the cistern would be used to irrigate the lawn. The lawn areas would be depressed to allow the remaining stormwater to collect and be absorbed by the grass and the soil, which is relatively free of clay particles and can soak up large amounts of water quickly. A permeable pavement driveway would be installed to absorb water falling in this area and to reduce the amount of impermeable surfaces on the property.

Built Designs

The charrette plan presents the bulk of the elements that were ultimately constructed at the site, including retention grading, a vegetated swale and a cistern. A fourth element, the driveway drywell, was added later and is an alternative to the permeable driveway proposed at the charrette.

Another element that differs from the original design is an overflow pipe required by city regulation that conveys stormwater not captured by the BMPs from the property to the street. Although legally necessary, the overflow element is superfluous because of the property's ability to capture large volumes of stormwater.

The cistern was fabricated at a factory located in the San Fernando Valley and trucked to the site. Once there, a crane was necessary to lift it from the street, over the house and into its final location. With exception to manufactured elements such as the cistern, the contractor on the project performed construction of the BMPs and installation of the irrigation system and much of the landscaping.

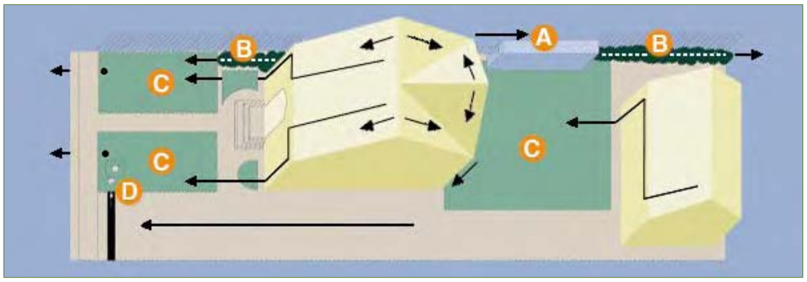
Construction was completed by July 1998, and a completion celebration was held in August.

BMPs

The operation of the demonstration site is illustrated in figure 1. Rain falling on the hard surfaces of the site (the roof and pavement) is directed to depressed lawn areas (C), or the cistern (A). Overflow amounts are carried by the vegetated swale (B), which also receives greenwaste (lawn clippings, leaves and twigs) from the site. Water flowing down the driveway toward the street is intercepted by a grated trench drain and diverted to the drywell (D).

The design strategy maximizes rainwater storage while minimizing grading and earth removal. Low maintenance is a must at this site, so all equipment and plantings function with little or no maintenance. These constraints

Fig. 1 Hall House Diagram



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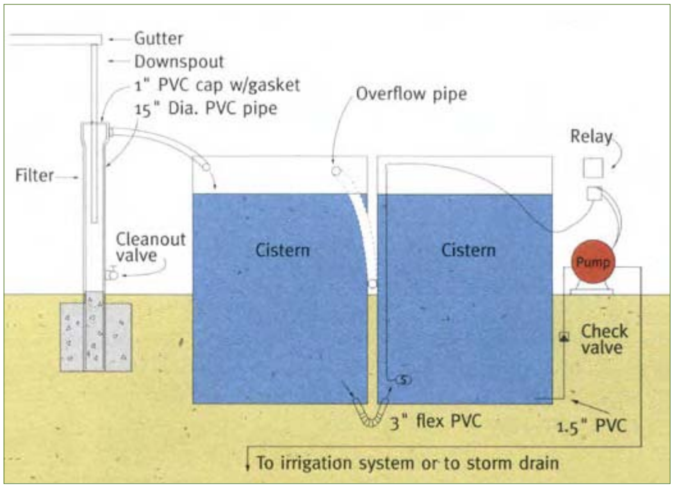
Arrows in the diagram indicate the direction of stormwater flow. Letters designate the location of the four BMPs, including the cistern (A), the vegetated swale (B), retention grading (C) and the driveway grate and drywell (D).

notwithstanding, the demonstration site successfully captures and holds all of the water falling during a two-inch storm. To accomplish this, the three lawn areas are reconfigured as shallow retention basins. Safety considerations require a maximum depth of six inches for these basins. Lowering the lawn panels two inches below existing grade while building up surrounding four-inch berms provides the maximum six-inch storage capacity in each panel. The berms are covered with shrubs, ground covers or turf in order to stabilize them and to prevent foot traffic that might compromise the effectiveness of the retention system.

Cistern System



TreePeople

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The cistern system captures stormwater falling on a portion of the roof. Together, the cistern's two recycled plastic tanks provide 3,600 gallons of storage space. A pump distributes water to the irrigation system.

A cistern, composed of two tank-modules, collects rainwater from the southeast quadrant of the roof. Stored water is used to irrigate the lawn and gardens. A roof-wash unit collects the first-flush water that falls during the first part of a storm and sequesters it long enough so that gravity can settle out the buildup of atmospheric deposits and bird feces. The first flush is then drained into the adjacent lawn panel while the clean water decants into the cistern. The double cistern at the demonstration site is made of polypropylene, a recycled (and recyclable) plastic that is plentiful in Los Angeles' waste stream. Each cistern tank holds 1,800 gallons of water. An electric pump distributes the water to the irrigation system. Attachment specifications include a piece of flexible three-inch PVC pipe with one end in the floor of each tank. A double backflow valve ensures that cistern water does not back up into the city water supply. Once the tanks are empty, a manually-operated set of valves shuts off the cistern supply and another set is opened to deliver municipal water for irrigation.

The total height of each of the two tanks is 11 feet, of which roughly six feet is above ground. The width above ground (from front to back) is two feet; below ground the width is four feet. The breadth (side-to-side) is eight feet. About two-thirds of the capacity is underground. The shape and the partial burial increase its stability and reduce the aboveground profile. The dimensions above ground allow the cistern to be placed discreetly next to a fence or hedge. Multiple modules could be connected in series to increase storage capacity and to form a fence or barrier.

Vegetated/Mulched Swale

Swales are used at the demonstration site to create an attractive space that also performs vital stormwater and greenwaste functions. The mulched swale is the repository of recycled greenwaste from the property. It is designed to slow the flow of stormwater and to filter pollutants so that water can be absorbed into the earth and toxic substances be removed. A swale can be used in any residential setting and may be covered with grass, vegetation or mulch.

Retention Grading

The frontyard and backyard retention grading creates "sunken gardens" that hold rainwater until it can be absorbed by the ground. This BMP works best in highly permeable soils (Los Angeles types 2 and 3). At the demonstration site, three gutter downspouts were redirected from hardscape (and the public storm drains) to the permeable graded areas. The runoff from the front half of the roof is directed into six-inch depressions in the front lawn, while the southwest roof quadrant and half of the garage roof drain to the backyard.

David O'Donnell

The sunken lawn panels, elevated at the perimeter to ensure retention capacity, provide temporary storage for up to 5,800 gallons and allow water to infiltrate into the ground and replenish the aquifer.

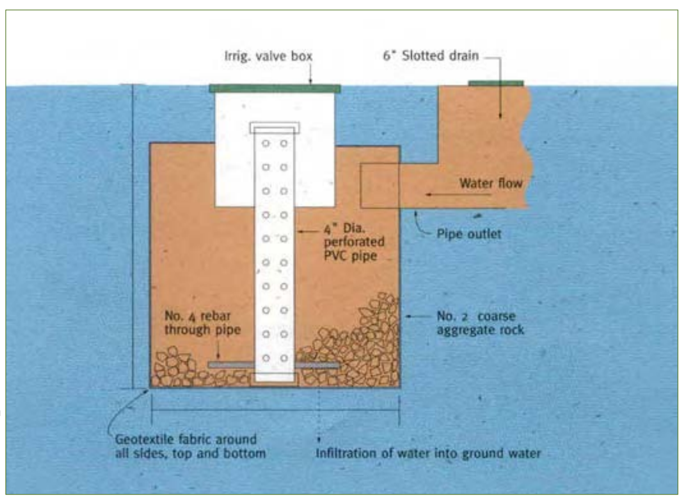
These mini retention structures are capable of handling a flash flood that could occur during a 100-year storm event. When properly maintained, the total retention capacity of the graded areas is approximately 5,800 gallons. During a more intense storm, excess rainwater would flow into the existing storm drain system. The system is designed to infiltrate all water within 72 hours.

On properties with less absorbent soils, the depressed area can be underlaid with coarse aggregate rock to increase the site's holding capacity and the amount of water that eventually infiltrates.

Driveway Grate and Drywell

David O'Donnell

The driveway grate, an unobtrusive addition to the property, directs stormwater down into the underground drywell.



TreePeople

Once water passes through the driveway grate, it flows underground through sand and crushed rock. The system filters water and retains it until it can be absorbed by the ground below.

Stormwater flowing down the driveway runs into a grated trench, which carries it to a box containing sand and crushed rock that captures pollutants. The system serves the dual purpose of retaining and cleansing rainwater. It gives the water time to percolate into the ground and prevents motor oil and other pollutants from flowing into storm drains and creeks and out to local beaches and bays.

Benefits, Costs and Funding

Benefits

The house successfully captures and holds all of the water falling during a two-inch storm, thus eliminating runoff from many storms and reducing runoff volumes from large flood events.

The infiltration of stormwater yields benefits for flood management and water quality. Monitoring at the site concluded that soil appears to be a very efficient means of removing contaminants from stormwater. While bacteria were detected in stormwater samples, they were not detected, or were detected at very low concentrations, in *lysimeter* and groundwater samples.[1]

The house successfully captures and holds all of the water falling during a two-inch storm, thus eliminating runoff from many storms and reducing runoff volumes from large flood events.

Water conservation and the reduction of garden waste are two additional benefits. Significant reductions in the stream of greenwaste save the city collection, transportation and processing costs while reducing air pollution, noise and traffic congestion.

The focus on increasing the number of trees and plants onsite mitigates the urban *heat-island effect* and creates air quality benefits while diminishing the city's contributions to global climate change.

Costs

Perhaps the most pertinent aspect in determining replicability of a demonstration site such as the Hall House is cost, yet demonstration sites often suffer from higher costs because of the price associated with BMP components not readily available on the market.

Such is the case with the cistern at the Hall House, which was a custom-manufactured recycled plastic prototype and was engineered – at a higher cost – to be earthquake- and UV-proof. In order to fabricate the prototype, a unique unit had to be designed, engineered, tested and fiberglassed, pushing the total cost of manufacturing and installing the cistern to approximately $25,000.

The cistern was designed with the intention of having local manufacturers reproduce it on a large scale. Mass production would significantly reduce unit costs while also providing local employment in manufacturing and installation. Further, the intended use of locally recycled plastics would spur the development of a substantial recycled materials market and help cities sustain their recycling programs.

The Hall House cistern, however, represents only one of several options. Readymade water-storage products, including fiberglass and polyethylene tanks, are available for purchase and can be used instead of a custom-made unit. More economical homemade alternatives can also be used to construct a cistern.

Other aspects affecting cistern cost include the unit's placement above or below ground, its holding capacity, and the quality of filtering and pumping equipment. Depending on these factors, a homeowner can expect to pay anywhere from a few hundred dollars for a small, homemade cistern to several thousand dollars for a larger, professionally manufactured cistern with automated functions.

Figure 2 presents information collected by the project architect and contractor and is meant to give a general idea of what a retrofit similar to that at the Hall House might cost a homeowner. The approximate costs are for a 7,500-square-foot property, with 4,500 square feet occupied by structures and impermeable materials. The cistern's cost is intentionally omitted because of the wide range in prices between simpler, homemade systems and more complex, professionally manufactured models.

[1] The Los Angeles and San Gabriel Rivers Watershed Council, "Los Angeles Basin Water Augmentation Study Phase II Final Report," August 2005.

Fig. 2 Estimated Costs of a Retrofit Similar to the Hall House Retrofit

Project Components	Do-it-yourself Costs (materials & permits)	Optional Costs (contracted labor)	Total (incl. optional costs)
Retention Grading	$800	$800	$1,600
Driveway Grading and Drywell	$1,400	$500	$1,900
Vegetated or Mulched Swale	$30 (for seed)	$250	$280 - $1,000
Roof Downspout Extensions (4 total)	$10 - 30/each	$45 - 65/each	$220 - 380
Overflow Pipe to Street	$550	$700	$1,250
Estimated Total Costs	$2,820 - $3,620	$2,430 - $2,510	$5,250 - $6,130

Funding

Funding for the Hall House retrofit was drawn from a collection of sources that launched the T.R.E.E.S. Project. These included a challenge grant from the USDA Forest Service and grants from the City of Los Angeles Bureau of Sanitation Stormwater Program, the Los Angeles Department of Water and Power, the U.S. Environmental Protection Agency, the City of Santa Monica, the Los Angeles County Department of Public Works, the Metropolitan Water District of Southern California, the Los Angeles Urban Resources Partnership, the Southern California Association of Governments and Environment Now. Several donations from private donors were also instrumental in establishing the T.R.E.E.S. Project.

Post-Completion

Monitoring

In cooperation with TreePeople, in 2000 the USDA Forest Service, Center for Urban Forest Research installed equipment at the demonstration site and at a control site next door to record weather information and monitor the performance of the BMPs and their effect on runoff.

The monitoring study measured soil characteristics, water use for irrigation, and quantity and quality of runoff, among other indicators of BMP performance. The study made several findings, including these:

- The BMPs are effective in reducing surface runoff, conserving municipal water supplies while maintaining an irrigated landscape, and reducing stormwater runoff and its pollutant load.
- The driveway drywell appears to be a cost-effective means of reducing runoff from roof and paved surfaces.
- Water quality of runoff on the street was consistently worse than the runoff sampled at the Hall House.

Between 2002 and 2005, the Los Angeles and San Gabriel Rivers Watershed Council (LASGRWC) continued and expanded upon the monitoring activities started by the Forest Service. The council's monitoring was part of a Water Augmentation Study of the Los Angeles Basin that is exploring the potential for augmenting local groundwater supplies and reducing polluted runoff by infiltrating more stormwater, a resource that otherwise flows unused to the ocean.[2]

[2] A full copy of the monitoring report on this and other sites is available from the Los Angeles and San Gabriel Rivers Watershed Council, www.lasgrwc.org.

Monitoring tasks included taking stormwater runoff samples at both the demonstration and control sites and collecting soil samples for analysis from the front lawns of both homes. Surface stormwater samples were collected at the roof drain and the driveway. Samples were also collected from a single lysimeter (used for measuring water that percolates into soil) installed eight feet below ground surface in the front yard.

In most instances, monitoring results indicated that the soil was effective at removing pollutants from stormwater. Monitoring showed that water samples taken from the lysimeter contained lower concentrations of metals and volatile organic compounds (VOCs), including acetone, lead, zinc and total arsenic – indicating that soil at the site is able to capture pollutants in water. Concentrations of oil and grease were also significantly less in groundwater than in water collected at either the roof drain or driveway.[3]

Percolation rates were lower at the demonstration site than at the control site, particularly in the front lawn panels. Since the same soil type exists at both properties, we surmise that soil compaction must have taken place as a result of the lawn panel excavation.

Operations and Maintenance

From the start, the retrofit designs were tailored around minimal maintenance, so as to place the least physical and financial burden on the owner. Even so, the numerous BMPs that utilize natural elements require some maintenance to function properly.

Maintenance tasks fall into several categories:

- **Greenwaste:** fallen, dead or damaged leaves and branches should be processed into mulch. Mulch is then spread in the swales, under hedges on the berms, around trees and in planting beds. Soft stems, leaves and flowers can be composted, but proper attention to compost processing is required. A chipper is kept onsite to aid in processing greenwaste and eliminating greenwaste flow to the landfill.
- **Garden Upkeep:** vegetation should be maintained to prevent overgrowth that blocks natural light from reaching the inside of the home, prevents access to BMP components, and potentially damages structures.
- **Cistern:** if vector or bacteria problems are of concern, stored water may require treatment with chlorine or mosquito dunks. Occasional cleaning of the cistern is also advised, as are inspections to ensure that air and light do not enter the cistern. Although algal growth has not been a problem at the Hall House, measures to prevent development of algae are recommended if sunlight penetrates the cistern.
- **Irrigation:** the pump that moves water from the cistern to the irrigation system shuts off when the water level in the cistern reaches a pre-determined low point. The irrigation system must then be fed by city water (one manually-operated valve must be closed to shut off the cistern feed and another opened to turn on the city water supply).
- **Driveway Drywell:** the driveway grate quickly fills with leaves and sediment and must be cleared regularly. Since its function is to absorb pollutants from the driveway, the drywell's sand and crushed rock filling should be inspected before the rainy season to prevent clogging and reduced infiltration. The water level in the observation well should be measured after a storm. If the water level does not drop in the days following a storm, the drywell may be clogged and the sand and crushed rock filling may need to be replaced.
- **First-flush Unit:** the decanter component must be emptied regularly to create room for the first flush of the next storm. This is done by opening a valve at the bottom and letting the water run out onto the lawn.
- **Swales:** swales should be monitored and mulch replenished as needed. In grassy swales, turf should be mowed during the growing season.
- **Retention grading:** retention grading should be inspected for sediment accumulation or loss and appropriate maintenance done after moderate or heavy storm events. Berms should be inspected and any necessary repairs performed.

[3] The Los Angeles and San Gabriel Rivers Watershed Council, "Los Angeles Basin Water Augmentation Study Phase II Report," August 2005.

Successes


Becky Villaseñor

A mock storm "rained" 4,000 gallons onto the Hall House property during a demonstration following the project's completion.

On a sunny day in August 1998, 4,000 gallons of water "rained" from fire hoses onto Mrs. Rozella Hall's home, putting to work the newly installed BMPs. Rather than gush down the driveway and into the street and the storm drain, every drop was captured onsite, either percolating into the soil or collecting in the cistern. There to witness the demonstration were members of the public, media representatives and agency leaders, including senior representatives from the city's Watershed Protection Division, the Department of Water and Power, the USDA Forest Service and the City of Los Angeles Board of Public Works.

Among those present was Carl Blum, then deputy director of the Los Angeles County Department of Public Works (DPW) and head of its flood control division. With Los Angeles sprawling ever outward, DPW had traditionally constructed flood control projects aimed at one primary concern: protecting the city from flooding. An effective way of achieving this was to rush stormwater out of the city via storm drains and channels. The methods used at the Hall House, in stark contrast to DPW's approach, demonstrated solutions aimed at much more than flood prevention. The multipurpose and interlinked BMPs addressed issues of stormwater pollution, flooding, water supply and waste management. These connections helped break through conventional notions dictating the use of vast municipal resources to address individual problems.

The mock rainstorm laid the foundations for a partnership among DPW, TreePeople and other stakeholders to retrofit the 2,700-acre Sun Valley watershed. The area consists of neighborhoods built without storm drains, and is the location of the county's largest unresolved urban flooding problem. The county's plan treats stormwater as a resource and aims to keep it all in the watershed to control flooding, reduce water pollution, conserve potable water and recharge local aquifers. The plan is noteworthy in that it favors stormwater BMPs over the more conventional approach – a large storm drain that would tax the capacity of the Los Angeles River and route polluted runoff to the ocean.

Since its completion in 1998 the Hall House has generated tremendous interest and excitement around the potential of retrofitting the urban landscape to function with consideration to nature's cycles. When the T.R.E.E.S. Project began, stormwater capture and reuse were not under the policy purview of government agencies in and around Los Angeles. But since the retrofit was completed, TreePeople has hosted tours for hundreds of individuals, including city leaders and agency representatives, fostering support and enthusiasm that has helped shift policy around the region.

Challenges and Lessons Learned

The T.R.E.E.S. Project developed around the concept that a region-wide sustainability retrofit would find its impetus through innovative, local demonstration projects. These projects would then generate replication of sustainable practices, and change at the policy level would naturally follow. The choice to first retrofit a single-family house fit this ideal, as this path of least bureaucratic resistance offered a realistic opportunity for replication. Working on this scale, TreePeople did not come upon significant regulatory restrictions or problems obtaining permits. Nevertheless, various other challenges were encountered and lessons were learned specifically because the demonstration site was located at a private residence.

Site Ownership

When the Hall House was retrofitted in 1998, TreePeople found a dedicated partner in Rozella Hall. Mrs. Hall was eager to offer her home as a demonstration of sensible, replicable practices, and, as an established member of the community, was working toward larger neighborhood projects, including alley greening. Mrs. Hall had the opportunity to witness the completion of the project and to participate by keeping a journal of energy and water use, costs, and landscape maintenance practices. Sadly, she passed away shortly after the retrofit's completion.

Challenge: Ownership of the home was transferred to Mrs. Hall's daughter, but Rozella's emotional investment and enthusiasm were hard to match. As a result, in the following years the Hall House BMPs and the property as a whole received a different level of attention and care than previously offered by Mrs. Hall. The quality of the site as a demonstration diminished both functionally and aesthetically – yet, cognizant of the owner's right to privacy, TreePeople has had limited capability to interfere.

Lesson: Due to private ownership, public access for tours must be necessarily limited. With few exceptions, tours are conducted no more than quarterly in order to limit household disruption.

A privately owned site is also vulnerable to ownership transfer. Unless use of the house as a demonstration site is written into the deed, sale of the home would likely result in loss of the use of the site.

With sufficient financial resources, these challenges could have been averted through TreePeople's purchase of a suitable site for the project.

Choosing a Suitable Location

Challenge: The site's location has also played a key role in its success as a demonstration project. The site choice has affected both the quality of care that the property has been given and the level of participation in tours.

Lesson: The fact that the Hall House is in South Los Angeles, a part of the city noted for violence and blight, has affected the number of individuals willing to attend a tour. The distance of the site from TreePeople's headquarters (over 20 miles and up to an hour away) has also made it difficult for staff to manage its conditions closely.

Although TreePeople deliberately selected an economically depressed area to prove the viability of engaging in similar retrofits citywide regardless of the availability of financial resources, some problems have resulted specifically because of the site's location.

Contract With the Property Owner

Challenge: The Hall House project did not include a formal contract between the homeowner and TreePeople that specified the length of time that the site would be used for public demonstration purposes or that bound the homeowner to a specific maintenance schedule.

Lesson: Although the relationship-based project did not seem to call for such an agreement, a contract likely would have ensured that the condition of the site and BMPs remained consistent with TreePeople's original expectations and standards.

Choosing Sensible BMP Designs and Products

Challenge: The custom design and manufacture of the cistern was the result of an expensive and laborious process. While great effort was put into the design, there was no guarantee that the prototype would function as intended.

Lesson: If presented with a similar challenge today, TreePeople would look toward the array of products available on the market for a more economical and accessible alternative to storing captured stormwater.

Although the cistern has met its intended function, improvements to the design could be made. Access to the hatch doors is awkward despite a built-in ladder. The overflow outlet was placed at the back of the cistern but located higher than the bottom of the hatch doors, so were the cistern to overfill, the water would leak out through the hatch seams before reaching the overflow. Also valuable would be an externally viewable scale indicating the level of water in the tanks. An operations manual could have solved many of the problems encountered, but as the unit was custom-built, no such instructions were available.

Another design flaw is that the cistern allows emptying and cleaning via a pump, but that the pump is designed to flush water into the street rather than onto the swales and yard for infiltration. The purpose of pumping water into the street was to create an option for the cistern to act as part of a networked reservoir that could be emptied in advance of a storm and then capture peak storm flows to reduce the municipal flooding risk. This design, however, leads to losing collected stormwater to the storm drain – and, if the water were contaminated, would actually contribute polluted runoff. Ideally, the design would have included two options: one pump to direct water to the street and another to pump water to the lawn panels on the property.

Choice of Plant Species

Challenge: The choice of plant species has required greater garden upkeep than originally planned, and has produced more greenwaste than can be easily used as mulch on the property.

Lesson: The project partners, with input from the homeowner, chose to keep a traditional garden style. Demonstrating stormwater capture and use – not water conservation – were key objectives of the project, so using plant species requiring moderate watering did not run counter to the project's intent. Even so, the area covered in water-loving turf lawn was reduced by roughly 15 percent.

A more aggressive reduction in lawn area combined with a greater use of native and drought-tolerant species would have dramatically reduced water use, required less maintenance and added another sustainable element to the demonstration.

Project Costs

Challenge: As a prototype, the retrofit costs associated with the Hall House project – including custom design, engineering and fabrication of BMPs – together with the lack of availability of products, make some of the specific BMP components demonstrated at the house unsuitable for replication.

The primary purpose of the demonstration was to show policymakers that it was technically and socially feasible to retrofit a home to safely capture and use large volumes of rainwater without requiring unacceptable lifestyle changes from residents. The principles showcased at the site were also meant to illustrate the viability of substantially reducing stormwater flow, water pollution, water and energy use, and greenwaste. These objectives were met. Policymakers understood that economies of scale would result from a city- or watershed-wide retrofit, and that future retrofits would thus be more financially feasible, especially when combined with subsidies and incentives.

Nevertheless, without understanding the cost structure behind the Hall House project, the price tag can cause apprehension among those interested in similar retrofits.

Lesson: In all communication about the demonstration site, emphasizing its prototype purpose is essential. The project does not end with completion of construction, and the costs associated with the prototype are not representative of the costs of wide-scale adoption of similar stormwater management technologies. The real work of shifting both policies and the urban landscape begins with the end of construction.

Once the systemwide feasibility of these technologies is understood in the policymaking arena, the project partners should encourage do-it-yourself gardeners and small-scale landscaper contractors to implement similar retrofits easily and inexpensively. A new set of demonstration sites should be built and be geographically, socially and economically accessible to diverse markets of homeowners and renters. A cooperative technology development program (such as that for developing energy-conserving refrigerators) should be created, possibly with support from large government agencies. Such a program would make the various BMP technologies available to consumers. Finally, a program to facilitate and provide incentives for wide-scale retrofits should be created.

Baseline Data

Challenge: Monitoring and observations at the Hall House and at the control site next door have shed light on the effectiveness of the project's components. However, the lack of baseline data on water consumption levels for irrigation, runoff quantity and quality, and percolation rates makes accurate quantification of the project's benefits difficult.

Lesson: The purpose of the numerous BMPs utilized at the site was the exploration and illustration of available stormwater management and greening options. Although these technologies have largely succeeded in performing their intended purposes, baseline data should have been gathered prior to the retrofit so as to make possible definitive conclusions about the BMPs' performance.

Policy landscape

Challenge: Building codes for the City of Los Angeles do little to encourage onsite stormwater retention, storage and infiltration. For example, regulations on gutters and site drainage require that stormwater be directed to the street.[4]

Lesson: The project partners designed the retrofit to not stray far from existing regulations, and were able to receive the necessary permits for capturing and storing water onsite. Nevertheless, policies that actively support alternative stormwater management practices would promote the widespread adoption of the concepts showcased at the Hall House.

(There is a move currently underway by the City of Los Angeles to revise these policies through the implementation of the Integrated Resources Plan for wastewater.)

Partners

TreePeople conceived the project as part of its Transagency Resources for Environmental and Economic Sustainability (T.R.E.E.S.) Project, which promotes the integrated and sustainable management of urban watersheds. TreePeople organized the 1997 Second Nature charrette, a four-day conference that convened interdisciplinary teams to design retrofits for five existing properties in Los Angeles. The organization sought funding for the pilot retrofit at the Hall House and managed general aspects of the project.

The charrette design team produced the preliminary designs for the retrofit in 1997. The team included: Leo Marmol, architect and team facilitator; Tom Richman, landscape architect; Leslie Ryan, landscape architect; Gail Boyd, engineer; and Sharon Lockhart, environmental consultant. Graduate students on the team were Ramsey Badawi, Bonnie Dell Angelo and Ellen Hu.

CH2M HILL provided engineering services and formalized the charrette team's drawings.

PS Enterprises managed implementation of the project. Rick Ruiz was the project manager.

Robert Cornell and Associates provided contractor services, including construction of the BMP components and installation of landscaping and irrigation.

Karen Bragg aided in landscape installation and provided landscape maintenance services immediately following the project's completion.

[4] Los Angeles Municipal Code, Chapter IX, Building Regulations: **91.7013.9. Gutters. (Amended by Ord. No. 171,939, Eff. 4/15/98.)** Eave or ground gutters shall be provided to receive all roof water and deliver it through a non erosive device via gravity to a street or watercourse if the slope of the underlying natural ground exceeds three percent or if more than three feet (914 mm) of compacted fill or more than one foot (305 mm) of uncompacted fill is placed on the ground. **91.7013.10. Site Drainage. (Amended by Ord. No. 171,939, Eff. 4/15/98.)** All pads with cut or fill shall slope a minimum of two percent to an approved drainage device or to a public street. Where used, the drainage device shall be an adequately designed system of catch basins and drain lines which conducts the water to a street.

Background on School Projects

As one of the region's largest property owners, and as the second most populous public school system in the nation, the Los Angeles Unified School District (LAUSD) has a tremendous impact on quality of life in Southern California. From the everyday experiences in student life, to impacts on the urban *heat-island effect* and local *watersheds*, the district's land-use management choices for its school campuses have considerable effect on whether regional environmental and public health issues are mitigated or exacerbated.

The school district has an annual budget of $13 billion to service 850,000 students and operate more than 1,000 campuses and other facilities in its 710-square-mile service area.[1] Still, resources are not unlimited. Over the years, LAUSD has resorted to paving its campuses to reduce landscape maintenance costs. Many campuses have become expanses of heat-retaining asphalt. Together with buildings and other impervious surfaces, pavement on school grounds raises ambient temperatures, increases urban stormwater runoff, contributes to local flooding and diminishes groundwater supplies.

Ultimately, the most direct consequences of hot, unshaded campuses are borne by the students, whose health and learning conditions are compromised. During hot weather, blacktopped campuses amplify the urban heat-island effect and can raise classroom temperatures to the point where students and teachers lose the ability to focus, learn and study. Approximately 80 percent of a person's lifetime sun exposure occurs before age 18.[2] It is of little surprise, then, that childhood skin cancer is on the rise. Between 1973 and 2001, incidences of melanoma in children rose an average of three percent annually.[3] For adolescents who receive the bulk of their sun exposure at school, having no refuge from the sun and heat emanating from asphalt playgrounds can lead to a host of medical problems later in life.

In 1997, residents of Los Angeles County passed Proposition BB, a $2.6-billion bond to fund upgrades to aging campuses and construction of new ones. A significant portion of these funds – $187 million – was earmarked for repaving schoolyards, and another $250 million for installing air conditioning equipment in classrooms. TreePeople's Andy Lipkis and Steve Soboroff, then advisor to Los Angeles Mayor Richard Riordan, became aware of the situation and advocated for some of the repaving money to be used for campus greening instead.

Lipkis and Soboroff argued that Proposition BB funds could be used for multi-benefit projects that would make campuses more energy efficient and save the district money, both by reducing the size of air conditioning equipment needed and by lowering the amount of electricity required to power the equipment. In addition to cooling the schools, these projects would beautify campuses, reduce stormwater pollution, decrease flood risk, reduce sun exposure, improve air quality and mitigate the urban heat-island effect. With new water quality regulations (in the form of Total Maximum Daily Loads, or TMDLs) scheduled to come online for the Los Angeles area, Lipkis argued that the repaving budget should be used to ensure that campuses would meet the emerging standards and avoid the cost of reengineering for compliance at a later date.

The Proposition BB oversight committee and the school board ultimately agreed to reallocate 30 percent of the paving budget – about $62 million – to campus greening projects.

In 1998, the Los Angeles Department of Water and Power (DWP) partnered with LAUSD and several nonprofit groups – including the Hollywood Beautification Team, Los Angeles Conservation Corps, North East Trees and TreePeople – to initiate its Cool Schools program. The program, aimed at the citywide greening of blacktopped campuses in order to reduce energy use, funded the planting of more than 4,200 trees at 40 campuses during its first phase.[4] Both Broadous and Open Charter received Cool Schools funding. Two schools selected for additional work were designated Sustainable Schools. One of these was Broadous Elementary, which received funding from DWP to install a stormwater management system. The other Sustainable School was Multnomah Street Elementary in El Sereno, a neighborhood in the east part of Los Angeles. North East Trees oversaw the installation of a cistern on that campus.

Few policymakers or operations managers in the school district understood the health, energy conservation and stormwater pollution issues in existence at many of campuses. Also misunderstood was the ability of proper campus management to mitigate and even reverse these problems in order to protect student and community health. Despite the directive to green the schools, school construction managers greeted proposals to implement integrated water quality, energy-saving and health-protecting designs with skepticism and resistance, and ultimately an unwillingness to implement the needed best management practices (BMPs). To break through this resistance, TreePeople determined to implement demonstration projects that would illustrate the multipurpose viability of utilizing these technologies.

[1] LAUSD figures are for 2005-2006.
[2] Boe, Kathy and Tillotson, Elizabeth A. "Encouraging Sun Safety for Children and Adolescents." *The Journal of School Nursing:* June 2006; Vol. 22, No. 3, pp. 136-141.
[3] John J. Strouse, Thomas R. Fears, et. al. "Pediatric Melanoma: Risk Factor and Survival Analysis of the Surveillance, Epidemiology and End Results Database." *Journal of Clinical Oncology:* July 20, 2005; Vol. 23, No. 21, pp. 4735-4741.
[4] USC Sustainable Cities Program, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program," January 2001.

Campus Greening and Stormwater Management

Demonstration site at
Hillery T. Broadous Elementary School
Pacoima, California

TreePeople

Introduction

The stormwater management demonstration project at Hillery T. Broadous Elementary School illustrates the viability of using an integrated, cooperative approach between government and nonprofit entities to create an environmentally sustainable school campus.

The project was designed to provide a working demonstration of a multi-benefit, multi-agency approach to managing the urban environment while addressing site-specific problems. By capturing, treating and infiltrating stormwater that used to flood and run off the campus, the project turns stormwater into a resource. The retrofit of the campus was designed to produce an array of benefits, including:

- Alleviation of flooding on campus (allowing students to access classrooms that were isolated on rainy days)
- Alleviation of flooding in areas surrounding the campus
- Replenishment of groundwater
- Reduced energy use by shading air conditioning units
- Reduced polluted stormwater runoff to local water bodies
- Shading of play areas to improve student health and safety
- Opportunities to use greenwaste onsite to reduce the solid waste stream to landfills
- Creation of green recreation space and outdoor education areas

The project received major funding from the Los Angeles Department of Water and Power (DWP) Cool Schools program. Broadous was designated a Sustainable School and received funding from DWP to install a stormwater management system. (See "Background on School Projects" on page 17 for more information on the Cool Schools program.)

The greening of Broadous Elementary occurred in two phases. The first was in 1999, when the school community came together to plant dozens of trees during two TreePeople-sponsored tree planting events. The second phase began shortly thereafter and was marked by the construction of the infiltration field. Another series of tree planting events followed the completion of the stormwater facility in 2001.

Broadous Elementary School's transformation from an urban, hardscaped campus into a sustainable place for learning and playing was made possible through the collaboration of government and nonprofit representitives, and thus serves as an early example of an integrated, interagency approach to solving regional infrastructure and natural resource issues.

The primary collaborators on this project were the Los Angeles Unified School District (LAUSD), DWP and TreePeople.

The interests, expertise and resources of each stakeholder were instrumental in leveraging this effort from concept to completion. While much of the process required partnerships that were nontraditional at the time, the campus greening and stormwater management demonstration project at Broadous Elementary ultimately shows not only the viability of the retrofit itself, but also the feasibility of using an interagency approach to address problems of environmental quality, public health and distribution of environmental and fiscal resources.

Project Objectives

- Reduce flooding on and near the campus
- Create natural outdoor learning and playing areas
- Increase green space by replacing approximately one-third of the playground asphalt with a grassy ball field, trees and other landscaped areas
- Collect, treat and store stormwater until it can be absorbed by the soil
- Replenish the aquifer with a supply of treated water


Rebecca Drayse

Prior to the project, the Broadous campus was almost entirely covered with impermeable surfaces.

Site Selection and Profile

Shortly after beginning its Cool Schools program, DWP sought to showcase the potential benefits of the citywide greening initiative by funding the sustainable transformation of a school campus. In response to DWP's search, a nonprofit community improvement group, Pacoima Beautiful, directed TreePeople's attention toward Broadous Elementary.

During the rainy season, Broadous students and their families often found themselves asking whether neighborhood flooding was severe enough to prevent them from getting to school. Many times, it was easier to stay home than to contend with the challenges of getting to and from school on a rainy day. Beyond the loss of instruction time for students, absenteeism has financial ramifications because school funding is partially based on attendance. With widespread absences during the rainy season, much-needed funding at Broadous was lost.[1]

The flooding problem in Pacoima is aggravated by the same development practices that have covered much of the region with impervious structures, roads and parking lots. Stormwater that falls on these surfaces cannot be absorbed onsite and thus adds to the volume of urban runoff.

The project partners saw the Broadous project as an opportunity to restore some of the site's natural functions by removing impermeable surfaces and creating a campus "forest" capable of intercepting and absorbing rainfall.

The campus was almost entirely covered by buildings or pavement, offering students little shade in a part of the city prone to soaring summer temperatures. The site also generated stormwater runoff in a neighborhood already susceptible to winter flooding. These characteristics made the campus ideal as the subject of a Sustainable School retrofit that would include campus greening and the installation of stormwater *best management practices* (BMPs).

Broadous Elementary School's 7.4-acre campus is located in Pacoima, California, in the northeast San Fernando Valley portion of the City of Los Angeles. It lies within the Tujunga sub-watershed of the Los Angeles River watershed. Soils at the site are sandy and highly permeable, suggesting that incorporating infiltration technologies to reduce runoff from the site would be feasible.

The project partners saw the Broadous project as an opportunity to restore some of the site's natural functions by removing impermeable surfaces and creating a campus "forest" capable of intercepting and absorbing rainfall.

[1] During the 2006-2007 school year, Broadous Elementary served 894 students in grades K through 5. Students were 95 percent Latino, four percent African-American and less than one percent white. Due to high enrollment numbers, Broadous is on a year-round four-track system. The school receives Title I federal funding.

Designs

Landscaping

The landscaping at Broadous provides the first contact for rainwater and is also a living textbook for students. Students, teachers and neighbors made suggestions for the greening of the campus and their input was incorporated into the designs created by landscape architecture firm Mia Lehrer + Associates.

A vegetated *swale* originates on the slopes of a grassy mound dubbed Mount Broadous. The swale simulates the form and function of a river and meanders through the campus, conveying water away from school buildings, walkways and impervious surfaces and toward the infiltration system. Trees and permeable groundcover act like a sponge, absorbing rainwater where it falls. Among the tree species planted were crepe myrtle (*Lagerstroemia indica*), coast live oak (*Quercus agrifolia*), camphor (*Cinnamomum camphora*), tipu (*Tipuana tipu*) and London plane (*Platanus acerifolia*).

As a result of the retrofit and the designation of the campus as a Sustainable School by DWP, canopy cover nearly doubled from nine to 16 percent.[2] Roughly one-third of the pavement was replaced with trees, vegetation and grass.

Mia Lehrer + Associates

Originally, the Broadous campus had very few trees and other vegetation to provide refuge to students on hot days.

Mia Lehrer + Associates

About a third of the impervious surfacing was replaced with trees, grasses and shrubs.

Project Features

With the support of the school district, in 2001 the site was retrofitted using BMPs that capture, treat and hold virtually all of the rain that falls on campus, reducing flood risk on the campus and surrounding areas while recharging groundwater. The project consists of the following components:

- A **unit that treats stormwater** collected from the campus;
- An underground **infiltration system** that stores water until it can be absorbed by the soil;
- A **vegetated swale** that meanders through the campus and functions as a "river," conveying water toward the infiltration system;
- A system of **permeable groundcover** and **strategically planted trees** that slows, filters and safely channels rainwater through the campus;
- Two **outdoor classrooms** located atop vegetated mounds; and
- A **drainage system** that conveys stormwater to the treatment and infiltration area.

David O'Donnell

A grassy swale winds through the campus and channels stormwater toward an infiltration system.

[2] Travis Longcore, Ph.D., Kyle Fitzpatrick and Maureen Phelan, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program," University of Southern California, Sustainable Cities Program, January 2001.

Approximately one-third of the playground asphalt (over 100,000 square feet) was replaced with a grassy ball field, trees and landscaped areas, allowing much of the campus to function as a miniature watershed.

Built Designs

Although the original project objectives were met, some of the elements in the initial design proposal were not realized. Fruiting trees were not planted because of school district concerns over high-maintenance tree species. A demonstration and community garden was not established because a bungalow structure was placed on the intended garden site – although the school did eventually build raised garden beds through a state-funded nutrition program.

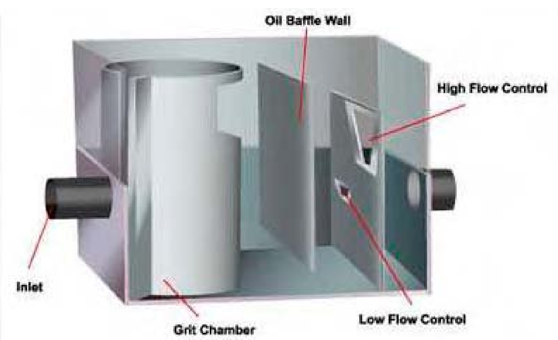
Still, the existing elements succeed in directing all stormwater falling on the site to either percolate in the tree wells, swales and other vegetated areas, or be collected, treated and held in the underground basin until the ground can absorb it. Approximately one-third of the playground asphalt (over 100,000 square feet) was replaced with a grassy ball field, trees and landscaped areas, allowing much of the campus to function as a miniature watershed.

For construction plans, see "Broadous As-Built Drawings" (Appendix A-1).

Stormwater BMPs

Design criteria for Broadous Elementary included the mitigation or elimination of the flooding problem on the campus, the reduction of pollutant loads in runoff to the storm drain system and the recharge of groundwater. To meet these criteria, the following BMPs were installed: vegetated swales, a stormwater treatment unit and an infiltration field.

Stormwater that is not captured by trees and vegetation flows to catch basins and into the treatment unit, where trash, oil and pollutants are removed. Once treated, the water is directed to the infiltration gallery under the playing field, where it is absorbed by the soil.



Contech Construction Products, Inc.

The Vortechs 9000 treatment system uses swirl technology and gravity to separate and retain pollutants, oils and trash.

Treatment

Runoff from the campus flows first through catch basins and into the separator – a Vortechs 9000 unit manufactured by Contech Construction Products, Inc. (formerly Vortechnics). Essentially a large concrete box enclosing a set of steel baffles, the separator works hydraulically to settle sediment (which could otherwise clog and eventually fill the infiltration units), skim off oil and other pollutants, and segregate trash. Maintenance hatches provide access for periodic inspections and cleaning.

Infiltration

After it passes through the separator, pipes distribute the stormwater to the infiltration field, an underground storage area that retains water until soil can absorb it. The plastic Cultec Model 400 infiltrator units are roughly U-shaped, with the opening at the bottom. Their function is to create storage space for water while bearing sufficient weight to allow the unimpaired use of the surface above the system. They rest on a base of drain rock and are covered with another layer of crushed rock. A sheet of filter fabric excludes fine silt, which has the potential to cause clogging. The 7,600-square-foot field has 220 such units. Together they can hold up to 95,200 gallons, or 0.3 acre-feet of water, at one time.

Montgomery Watson Constructors

Two hundred and twenty infiltrator units below the ball field hold up to 95,200 gallons of water.

The system is designed to collect 100 percent of the runoff from a 10-year storm. In a year of average rainfall, all the runoff from the site is retained and infiltrated by the system.

Both the separator and the infiltration units are buried under a grassy playing field that replaced a barren expanse of asphalt. The only sign of the system's presence is the separator's maintenance hatch.

Mulch

A third, nonstructural BMP was designed to assist in attaining the project's goals. Plans called for the greenwaste produced on the campus to be kept onsite and used as mulch. Mulch retains moisture for more efficient irrigation, slows runoff for greater infiltration, and begins the process of capturing pollutants. Since greenwaste constitutes a significant portion of the municipal waste stream, keeping it onsite would reduce the need for offsite processing and hauling to landfills, which in turn would save the school district and city money.

Although integral to the design, the school district has not implemented the use of greenwaste as mulch on the campus.

Benefits, Costs and Funding

Benefits

The retrofit of the Broadous campus produced numerous environmental and social benefits.

Environmental Benefits – Water

By capturing onsite virtually all of the rain that falls on campus, the project:

- Alleviates campus flooding;
- Eliminates runoff;
- Mitigates flooding and erosion downstream;
- Reduces water imports;
- Improves water quality; and
- Recharges the aquifer.

Monitoring conducted at Broadous by the Los Angeles and San Gabriel Rivers Watershed Council suggests that the BMPs improve water quality and that soil removes contaminants from percolating stormwater. While bacteria were detected in stormwater samples, they were undetected, or detected at very low concentrations, in lysimeter and groundwater samples.[3]

A runoff modeling study by the University of California at Riverside (UCR) confirms the runoff and infiltration benefits of the project. Under a pre-retrofit modeling scenario, the average yearly runoff volume from the Broadous campus was approximately 126,000 cubic feet. Under a second, post-retrofit model, runoff was reduced by 99.9 percent. Average infiltration (conservatively calculated from 46 years of rainfall data for downtown Los Angeles, where rainfall is generally less than in Pacoima) increased by nearly three acre-feet per year.[4]

Environmental Benefits – Trees and Landscaping

Landscaping at the campus yields a host of benefits as well, including:

- Reducing energy use by shading school buildings, windows and air conditioners;
- Improving student health and safety by shading play areas;
- Providing much-needed recreation space where heat-retaining asphalt once existed;
- Providing opportunities to reduce the greenwaste stream to landfills by using greenwaste as mulch onsite; and
- Reducing contributions to the heat-island effect.

[3] The Los Angeles and San Gabriel Rivers Watershed Council, "Los Angeles Basin Water Augmentation Study Phase II Final Report," August 2005.

[4] Autumn Dewoody, W. Bowman Cutter and David Crohn, "Costs and Infiltration Benefits of the Water Augmentation Study Sites," University of California, Riverside, Department of Environmental Sciences, April, 2006.

The table *(fig. 3)* was adapted from the University of Southern California study "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program." The study was conducted prior to the project's completion and thus evaluates projected rather than observed benefits of the tree-planting project. The assessment, conducted with CITYGreen software, developed by American Forests, evaluated the benefits brought to the campus by landscaping and does not include an evaluation of the benefits of the structural BMPs that were part of the more comprehensive retrofit.

Fig. 3 Environmental Benefits of the First Campus-Greening Phase

(does not include benefits from structural BMPs such as infiltration system)

Buildings and Permeable Surfaces	BEFORE	AFTER
Permeability (acres and %)	0.50 (5%)	1.98 (21%)
Tree Benefits		
Tree Canopy	9%	16%
Carbon Storage (tons per acre)	5.03	5.29
Carbon Sequestration (tons per year per acre)	0.01	0.12
Energy Savings (% per year)	19.9%	20.1%
Stormwater Benefits		
Runoff Reduction	6.5%	11.2%
Avoided Storage (cubic feet per acre)	386	574
Air Pollution Benefits		
Ozone Removal (lb/acre)	3.2	5.6
SO_2 Removal (lb/acre)	1.0	1.7
NO_2 Removal (lb/acre)	1.8	3.2
PM10 Removal (lb/acre)	2.8	4.8
CO Removal (lb/acre)	0.4	0.6

Adapted from USC Sustainable Cities Program, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program," January 2001.

Social Benefits

The retrofit at Broadous Elementary produced social benefits as well. Where rain once caused flooding, preventing children from reaching classrooms, students now have the opportunity to grasp how natural water cycles work by seeing water flow down from Mount Broadous in the upper part of campus and "downriver" along the swale. In an urban watershed that has sealed the earth with impermeable surfaces and disrupted natural cycles, the school provides the opportunity for this part of Pacoima to contribute to a healthier environment.

In a neighborhood where many children are considered at-risk due to high levels of youth gang involvement, Broadous students enjoy an environment that welcomes and supports healthy physical

David O'Donnell

The most direct benefits of the transformation of the campus include fun and physical play and are enjoyed by Broadous students.

play. Green spaces such as those found at Broadous generate significantly higher levels of play among children than do barren spaces.[5] Students further benefit from participating in planning, planting and maintaining the campus forest, which offer them a sense of validation, empowerment, belonging and ownership and help to advance environmental justice in this neglected part of Los Angeles.

Costs

The cost of installing the treatment and infiltration systems and planting trees was approximately $306,738, with the majority of funding coming from DWP's Cool Schools program.

Fig. 4 Project Costs

BMP CONSTRUCTION COSTS		
Contractor		$167,249
Stormwater Treatment Unit		$21,000
Infiltrator Units		$29,747
Total Construction Costs	**=**	**$217,996**

ADMINISTRATION		
Project Administration		$48,935
Total Administration Costs	**=**	**$48,935**

TREE PLANTING AND TRAINING COSTS		
Tree Planting - Trees		$14,500
Tree Planting - Materials		$3,500
Tree Planting - Labor		$5,000
Campus Greening Workshop		$3,000
In-Class Curriculum		$5,625
Curriculum Development		$3,000
Administration		$5,182
Total Tree Planting Costs	**=**	**$39,807**

TOTAL COSTS* = $306,738

**LADWP's Cool Schools program paid for installation of the stormwater treatment and infiltrator systems, as well as tree planting costs. LAUSD paid for installation of the ball field, grassy swale, outdoor classrooms and irrigation system. The latter cost figures were not provided to TreePeople.*

Funding

Los Angeles Department of Water and Power - Cool Schools Program

DWP's Cool Schools program provided $286,000 for the project. In addition to funding tree plantings at Broadous, DWP designated the campus a Sustainable School and funded significant portions of the more extensive retrofit that included stormwater treatment and infiltration systems.

TreePeople

Working with Montgomery Watson Harza, TreePeople removed the asphalt over the infiltration area and installed the infiltration system. The system was then turned over to the school district's Proposition BB bond project manager.

Proposition BB and LAUSD

With Proposition BB County funds, LAUSD funded the installation of the ball field, grassy swale, outdoor classrooms and irrigation system. LAUSD also paid for asphalt resurfacing where needed.

Montgomery Watson Harza

Due to the innovative, high-profile nature of the project and the opportunity to partner with a nonprofit organization, MWH (formerly Montgomery Watson Americas) offered pro bono design and engineering services for the treatment and infiltration system.

[5] Andrea Faber Taylor, Angela Wiley, et. al., "Growing Up in the Inner City: Green Spaces As Places to Grow." *Environment and Behavior:* 1998; Vol. 30, No. 1, pp. 3-27. Researchers found that in barren spaces, levels of play were approximately half as much as those found in spaces with more trees and grass. The incidence of creative play was significantly lower in barren spaces than in relatively green spaces.

Anne and Kirk Douglas Playground Award

A $25,000 Anne and Kirk Douglas Playground Award supported the planting of 250 new trees on the campus and surrounding streets.

USDA Forest Service – Greenlink Program

The Greenlink Program was created in the mid-1990s to promote the connection between urban neighborhoods and their surrounding wildlands. The Forest Service provided $10,000 toward the Broadous project through this program.

Post-Completion

Monitoring

Between 2001 and 2005, the Los Angeles and San Gabriel Rivers Watershed Council (LASGRWC) conducted water quality monitoring at Broadous. Monitoring was done as part of the "Water Augmentation Study" of the Los Angeles Basin, which is exploring the potential for increasing local water supplies and reducing water pollution by capturing and infiltrating stormwater that would otherwise run off to the ocean.[6]

Surface stormwater samples were collected at one location in the playground. During the first two monitoring seasons, single grab samples were collected at approximately 30-minute intervals for the first two hours of storm runoff.

A lysimeter, originally at a depth of 60 feet but later moved to 24 feet, collected soil pore fluid samples. The shallower placement made sampling easier and allowed a more accurate characterization of the quality of water exiting the infiltration BMP. Samples were typically taken daily for two to three days, beginning one day after the collection of a surface sample.

Groundwater samples were collected from two monitoring wells. These samples were collected periodically.

With regard to nitrate, TDS, chemical oxygen demand, total and dissolved copper, total and dissolved lead, and total and dissolved zinc, stormwater infiltration does not seem to have had an adverse effect on water quality. Concentrations of some constituents, including E. coli and total and fecal coliforms, were in some cases significantly lower in lysimeter and groundwater samples than in surface stormwater.[7]

Loss in Soil Percolation Rates

No monitoring for changes in soil permeability was performed, but a reduction in the percolation rates of the soil above the infiltration field has been noted, with occasional standing water following storms. One possible explanation is that soils were over-compacted during construction. Further investigation is required to determine if this occurred and whether it has compromised the system's ability to absorb the stormwater that falls directly atop the infiltration gallery.

Operations and Maintenance

In order to ensure proper system function, maintenance is required on the collection system and the stormwater treatment unit.

Stormwater Treatment System

- Inspection of the system, which includes logging sediment levels and checking for vector problems, takes about 12 hours per year.

[6] A full copy of the monitoring report on this and other sites is available from the Los Angeles and San Gabriel Rivers Watershed Council, www.lasgrwc.org.

[7] The Los Angeles and San Gabriel Rivers Watershed Council, "Los Angeles Basin Water Augmentation Study Phase II Report," August 2005.

- Maintenance includes removing and disposing of the contents of the treatment unit and treating for vector problems. It requires approximately 24 licensed waste disposal operator hours and a nominal number of vector specialist hours per year.
- Before being removed from the unit, contents must be classified by a licensed disposal company.
- The sedimentation chamber requires cleaning by a vacuum truck about once a year. Access is through a manhole. Sediment is generally classified as non-hazardous and does not typically exceed 750 gallons of liquid and solid waste.
- The oil and grit chamber must be cleaned approximately every two years. This waste is generally classified as hazardous; its quantity does not typically exceed 60 gallons.

Infiltration System

Cultec, Inc., the manufacturer of the infiltrations units, states that maintenance on their product is not necessary since preventative treatment is required prior to the water entering the chambers.[8]

See "Broadous Operation, Maintenance and Inspection Costs" (Appendix A-2).

Successes


Melinda Kelley

Approximately 100,000 square feet of asphalt were removed and replaced with trees, grass and other vegetation.

In all, more than 250 new trees were planted in and around the campus, and roughly one-third of formerly paved playground space was unpaved and covered with grass and vegetation. Broadous students, teachers and parents, together with TreePeople staff and volunteers, planted a campus forest. Its care and maintenance continues. Perhaps more remarkably, this integrated effort relied on the collaboration of agencies across the government spectrum, as well as private and nonprofit organizations. This partnership model and the stormwater management project that it produced have spurred much interest in and hope for the way we manage our cities.

Energy Savings and Water Quality Improvement

Before the Cool Schools greening, tree canopy cover at Broadous was nine percent. Canopy cover nearly doubled to 16 percent following implementation of the landscape plans.[9] The DWP-sponsored greening yielded immediate benefits, which, with proper care, can grow to bring about even greater benefits in the form of increased runoff reduction, water quality improvement and energy savings.


David O'Donnell

A grassy swale leads water to the ball field, below which an infiltration system holds up to 0.3 acre-feet of stormwater at one time. Captured water is slowly released into the ground underneath, where it replenishes the aquifer.

Flood Mitigation

Historically, the campus and some of the surrounding streets have been susceptible to flooding. Even during moderate rains, heavy volumes of water flow on street surfaces, often pooling

[8] On their Web site (www.cultec.com) Cultec, Inc. states: "Preventative maintenance is required prior to the water entering the chambers. Therefore, maintenance on the chamber bed is eliminated."

[9] Travis Longcore, Ph.D., Kyle Fitzpatrick and Maureen Phelan, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program." University of Southern California, Sustainable Cities Program, January 2001.

and creating difficult conditions for pedestrians. The BMPs reduce 99.9 percent of the runoff from Broadous – equivalent to nearly 126,000 cubic feet of water annually – from reaching surrounding streets and exacerbating existing flooding conditions.[10]

Stormwater Quality and Groundwater Quantity

The stormwater BMPs succeed in improving the quality of runoff and in effect eliminating water that used to run off the campus. Stormwater that falls on the campus now serves to replenish the aquifer.

Teaching Opportunities

At Broadous, landscaping has taken a departure from LAUSD's traditional playground design criteria. Here, landscaping is treated as a living textbook. Designs use the entire campus to demonstrate on a micro scale what exists just beyond: mountains to the north and a network of streams that comes alive during a storm. Science curricula were developed in conjunction with campus greening, giving children the opportunity for hands-on experience in an outdoor classroom.

Community Engagement

Pacoima Beautiful and TreePeople's involvement in the Broadous project provided meaningful community engagement. The community provided input on what was wanted and needed in this underserved neighborhood. Participation in this planning process helped shape the final design elements of the project.

Challenges and Lessons Learned

Retrofitting a school campus involves many parties and numerous levels of bureaucracy. Both factors tend to extend a project's timeline and add to its final cost. The challenges encountered and lessons learned during the Broadous project underscore the importance of effective project management.

Extended Timeline

Challenge: From project kickoff to completion, the retrofit of Broadous Elementary took over three years. The length of the timeline and the likelihood of staff turnover both increase with the number of agencies involved.

Lesson: In multi-agency projects, allow at least twice the timeline you think is necessary. Complications arising from liability issues and delegation of responsibilities can create hurdles and stretch the project beyond the expected timeline, and make good project coordination essential.

Partnership and Communication Protocols

Challenge: The agreement process for establishing partnership protocols takes time and often takes second priority to project planning – but establishing these protocols is of particular importance in nontraditional, multi-partner projects requiring a great deal of commitment and patience.

Lesson: Redundancy is important, as people move on and positions remain. Regular meetings during design and construction, with representatives from all involved parties in attendance, are a must. Partners should be fully invested in the project to ensure its successful completion and continued care.

Protocol for sharing credit should be established together with general partnership protocols. This will prevent the project partners from being wrongly credited or omitted in publications and media pieces. Discussing the sharing of ownership at the beginning of the project should also set the tone for all project partners to share responsibility when things go well and if they do not.

[10] Autumn Dewoody, W. Bowman Cutter and David Crohn, "Costs and Infiltration Benefits of the Water Augmentation Study Sites." University of California, Riverside, Department of Environmental Sciences, April 2006.

Wide-ranging Support

Challenge: It is easy to lose sight of the benefits brought to the table by the collective knowledge and expertise of staff at all levels of the partnership. Deadlines and budgetary constraints create pressure that can lead to some partners being excluded from decision-making.

Lesson: Seek support from all staff levels in the partnership in order to get input from all those who will be involved – beginning with design, moving through construction, and ending with operations and maintenance. It is important that personnel who will be responsible for operating and maintaining the system be involved early in the design process to provide input and foster a sense of ownership. Local educators should be involved in the development of any project-related curricula and in ensuring that the curricula are applied.

If the project is multi-purpose, with funding from multiple partners, attempt to have relevant partners sponsor portions of the project consistent with their mission, mandate, core competencies and skills. If, for example, the project includes water quality or water supply components, it is ideal to have an agency with a water quality or water supply mission commit to provide the maintenance of the water quality infrastructure.

Maintenance and Other Ongoing Responsibilities

Challenge: In the absence of a written maintenance agreement for the Broadous project, partners whose contractual obligations ended when construction did nevertheless found themselves working without compensation in an effort to maintain the viability of the project. The lack of a comprehensive and easy-to-use operations manual, inadequate communication among the partners and turnover among the district's operations and maintenance staff exacerbated the problem.

Lesson: It is difficult to get anyone to accept liability as complicated issues arise. Construction and other liabilities (such as issues of contaminated soils disposal, underground utilities, and construction fencing to ensure student safety) nevertheless have to be adopted. It is advisable to budget extra time, care and resources toward these challenges, and to plan quarterly meetings between representatives from all involved parties for the first year after construction. Written maintenance contracts and clear instructions should be developed and agreed upon before the project is completed.

Despite the intensive resource demands of the planning and implementation phase, the project does not end once construction is complete. The project will only fulfill its purpose if there is sustained interest and a plan for continuity.

Making Obvious the Project's Meaning

Challenge: Staff, faculty and students move on and even those who stay cannot always be relied upon to interpret or defend the project. The Broadous project budget did not include funds for signage or other permanent interpretive elements. As a result, knowledge of the project's meaning – and even its existence – has been lost.

The significance of the project was not sufficiently evident to district personnel, and several disheartening events consequently occurred without notification to the other partners, including improper pruning and care of trees on the campus. In the summer of 2005, the district removed trees and grass from the swale and paved its entire length with concrete in order to accommodate the passage of delivery trucks.

Safety concerns about children playing in the area of the manhole covers made district engineers elect to bury all but the primary maintenance port on the treatment unit. If maintenance of the primary port is not performed regularly, other unit areas serviced by the secondary ports need to be cleaned out.

Due to the irregular maintenance schedule that followed the project's completion (two years before the first pumping and another two-and-a-half years until the next service) the other ports were located with difficulty and unearthed for service. Burying the ports makes evaluating the need for service difficult and tends to encourage a passive approach to maintenance.

Also challenging has been that the project offers students the opportunity for hands-on science education – but that the campus has not used education curricula that were developed for this purpose.

Lesson: The project should be visually memorialized, especially if design elements are underground and out of sight. Options for memorialization include interpretive signage, permanent student art projects, student participation, and before-and-after shots displayed where the students, staff and faculty can view them.

David O'Donnell

The grassy swale at Broadous was planted with trees and conveyed stormwater to the infiltrator below the ball field.

Sensible Design and Accurate Design Interpretation

Challenge: Some of the design elements chosen for Broadous required a great deal of care and attention but did not yield significant benefits. For example, redwoods (*Sequoia sempervirens*) were planted to represent one of California's many ecosystems even though Pacoima experiences hot, dry summers that are not appropriate for this species. As a result, the trees needed extra care and still failed to survive.

Rebecca Drayse

In order to facilitate truck access across the swale, the school district removed the vegetation and paved the swale with concrete. The rest of the project partners were not notified in advance.

In initial designs, the Mount Broadous mound and the grassy swale were meant to illustrate the watershed functions that mountains and rivers serve. Ultimately, due to district decisions that were perhaps driven by safety concerns, the top of Mount Broadous was flattened and the mound built as a small lump rather than a shape more representative of a mountain. The grassy swale, which was designed to act as a shallow canal, lost much of its anticipated channeling ability in the built version. The intended functions of these chief design elements were lost – and the elimination of these components should have perhaps been considered.

Lesson: Designs should not compromise common sense for optimism and wishful thinking. Practical design should complement the way that the space will be used, and close attention should be paid to accurate interpretation of design elements.

The swale could have been designed to include a permeable pavement crossing to accommodate truck traffic, which would likely have prevented the district from removing trees and grass and paving it.

Evaluation Criteria and Baseline Data

Challenge: It is difficult to make convincing claims about the project if you cannot talk confidently about pre-project conditions.

Lesson: Prior to starting construction, collect baseline data at the site. The effort should also include extensive "before" photography and the recording of anecdotal accounts.

Vector Issues

Challenge: Standing water occurs in many stormwater BMPs, making them potential breeding grounds for vectors.

Lesson: The Vortechs treatment unit at Broadous developed a mosquito problem, but the issue was not anticipated in the design phase, when a solution could have been included. Periodic treatment by a vector control specialist is therefore necessary.

Partners

TreePeople acted as the project manager and oversaw the design process. The nonprofit managed the design and installation of the stormwater capture, treatment and infiltration system and coordinated community plantings and environmental education around the project. Rebecca Drayse was the project manager.

Los Angeles Department of Water and Power (DWP) funded tree plantings and the installation of the infiltration system through its Cool Schools program. The program was the largest school-based tree planting effort in the city's history, and existed through collaboration among DWP, the Los Angeles Unified School District and community groups including the Hollywood Beautification Team, Los Angeles Conservation Corps, North East Trees and TreePeople.

Los Angeles Unified School District (LAUSD) is the property owner of the Broadous campus and installed the grassy swale, a new soccer field, two outdoor classrooms and an irrigation system.

Broadous Elementary students, teachers and neighbors shared ideas for greening the campus with TreePeople and Pacoima Beautiful. The Broadous community was instrumental in planning and planting the campus forest.

Pacoima Beautiful first brought TreePeople's attention to the Broadous campus. The nonprofit community improvement group surveyed the observations and desires of kids, parents, teachers, gang members and residents in relation to the campus and the neighborhood. The community's ideas were incorporated into a conceptual design that was delivered to Mia Lehrer + Associates. Pacoima Beautiful also participated in several community planting days.

Montgomery Watson Harza (MWH, formerly Montgomery Watson Americas) provided design and engineering services.

Montgomery Watson Constructors, the construction arm of MWH, was the contractor.

Mia Lehrer + Associates provided landscape architecture services. Final designs incorporated the conceptual designs that Pacoima Beautiful created with community input.

Los Angeles Conservation Corps (LACC) provides service project opportunities for at-risk youth. The group was initially involved in implementation of the retrofit, but ultimately decided that the project was not a match for the organization and pulled out before construction began.

Campus Greening and Stormwater Management

Demonstration site at
Open Charter Magnet Elementary School
Westchester, California

TreePeople

Introduction

The Open Charter Magnet Elementary School demonstration project is an example of a cooperative effort between government and nonprofit agencies in the making of an environmentally sustainable school.

The project was conceived to provide a working demonstration of new approaches to managing the urban environment while addressing site-specific problems. By capturing stormwater that used to run off the campus, the project reduces pollutant loads to nearby water bodies and provides a new source of water for irrigating the campus. The project is designed to provide a host of benefits, including:

- Reduction of polluted *runoff* from the campus to Ballona Creek and Santa Monica Bay
- Reduced energy use
- Shading of play areas to improve student health and safety
- Opportunities to use greenwaste onsite to reduce the solid waste stream to landfills
- Creation of much-needed green recreation space at this urban campus
- Creation of a water supply for irrigating the campus
- Creation of outdoor ecosystem learning spaces to support the school's environmental curriculum

The project was implemented in two general phases. First, strategic planting of 88 new trees and placement of vegetation and *swales* were conducted as part of a campus greening initiative funded by the Los Angeles Department of Water and Power's Cool Schools program.

The second phase, funded largely by a Santa Monica Bay Restoration Project grant, consisted of the design and installation of additional, more structural stormwater *best management practices* (BMPs) on the campus, including a treatment device and an underground *cistern*. This phase provided an opportunity to demonstrate the feasibility of greening a typically *hardscaped* elementary campus and using BMPs to emulate some of its original *watershed* functions.

The primary collaborators on this project were the City and County of Los Angeles, the Los Angeles Unified School District (LAUSD), the Los Angeles Department of Water and Power (DWP) and TreePeople.

The project is innovative in several ways. First, it uses new and alternative technologies to solve old urban problems. Second, it is the product of a collaboration among groups unaccustomed to working together – government agencies, the school community, the neighborhood and a nonprofit organization. The design and community building process held many challenges, but resulted in a transformed campus that provides a model for increasing urban green space, improving learning environments and mitigating urban environmental problems.

By capturing stormwater that used to run off the campus, the project reduces pollutant loads to nearby water bodies and provides a new source of water for irrigating the campus.

Project Objectives

- Protect Santa Monica Bay from the increased load of pollutants that would result from addition of a new bus and car parking lot on this campus
- Create natural outdoor learning and playing areas
- Increase green space by replacing a significant portion of the asphalt playground with a grassy ball field, trees and other landscaped areas
- Collect, treat and store the stormwater that falls on the campus
- Make stored stormwater available for use in irrigation

Background

Site Selection and Profile

Recognizing the potential impact of a single policy decision by an institution the size of LAUSD, TreePeople sought an opportunity to demonstrate the benefits of a more sustainable approach to campus design. The former Osage Elementary School campus, then being refurbished to house Open Charter Magnet School, seemed an appropriate site for a project intended to pilot a district-wide greening campaign.

Rebecca Drayse

Before the project, most of the campus was paved with asphalt. Few trees and grassy areas existed.

The Open Charter campus is in Westchester, on L.A.'s Westside, about two miles from Los Angeles International Airport (LAX).[1] It falls within the Ballona Creek watershed, in a middle- to upper-middle-class neighborhood of mostly owner-occupied single-family homes.

Prior to the project, the 6.75-acre campus was largely hardscaped and contributed to the *heat-island effect*. Stormwater runoff volumes at the school were so high that a single large catch basin, located in the southwest corner of the campus, was fenced to prevent accidents. These large quantities of water contributed to peak flows already exceeding the capacity of the city's existing stormwater infrastructure.

The renovation of the Osage Elementary campus into Open Charter Elementary included the creation of a bus and teacher parking lot in the area directly adjacent to the campus' single storm drain. The location of this parking lot meant that runoff from the campus would be inoculated with the pollutants from school busses that would sit idling in large numbers while waiting for students. That polluted stormwater would then be carried into adjacent storm drains, creeks and the ocean. The same effect occurs throughout the 128-square-mile Ballona Creek watershed, resulting in high bacteria counts that force frequent post-storm closures of Santa Monica Bay's popular beaches.

The recently formed Santa Monica Bay Restoration Project sought to support projects that could demonstrate technologies and management practices that – if adopted on a wide scale – would prevent pollution of the bay. The retrofit of Open Charter with stormwater BMPs set out not only to meet this goal, but also provide a host of other benefits to students, faculty and residents in the area.

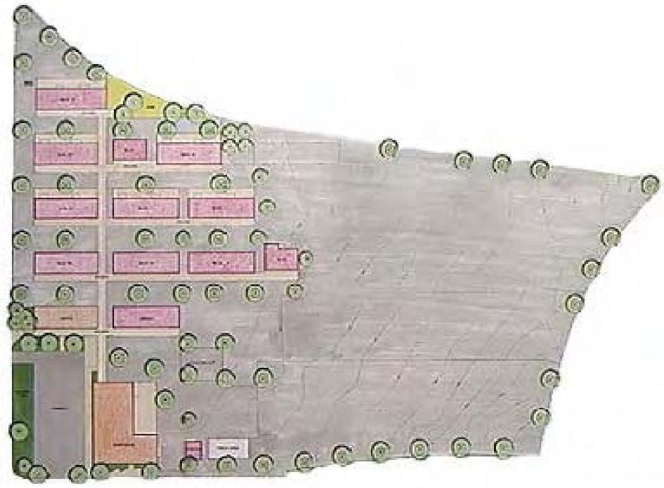
[1] During the 2006-2007 school year, Open Charter served 360 students in grades K through 5. Students were 38 percent white, 24 percent African-American, 21 percent Asian and 15 percent Latino.

Designs

Landscaping

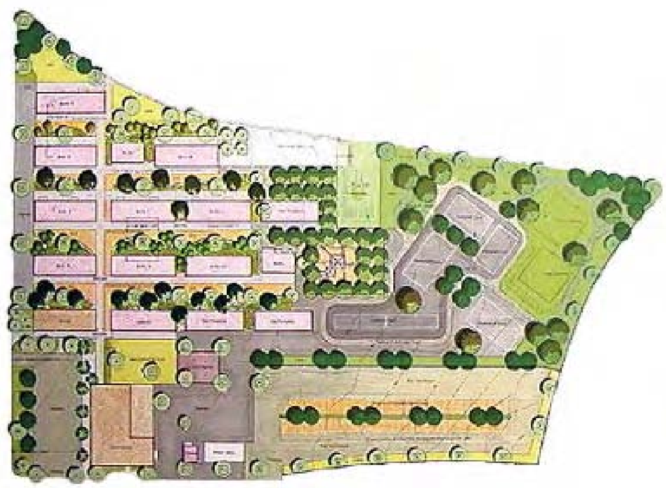
Landscaping is the first stop on the route stormwater takes across the Open Charter campus. A system of permeable groundcover, swales, trees and shrubs intercepts and soaks up rain, reducing runoff. The swales convey stormwater away from school buildings and walkways, while trees, shrubs and permeable groundcover absorb rainwater where it falls. The campus forest includes 150 trees, as well as shrubs, swales, gardens and grassy play areas. Among the tree species are coast live oak (*Quercus agrifolia*), sweet gum (*Liquidambar styraciflua*), London plane (*Platanus acerifolia*) and coast redwood (*Sequoia sempervirens*).

The campus forest, designed and implemented with the help of students, parents and teachers, uses various parts of the campus to represent the diverse landscapes of California – from redwood forests to desert gardens. Most of the plants were chosen to thrive in the local climate, but the learning opportunities that a variety of species could offer were also considered. Some species selected from other climate zones do require extra care.



Mia Lehrer + Associates

Prior to the project, the Open Charter campus was mostly covered by impervious surfaces. The planned addition of a bus and car parking lot would have further contributed to polluted runoff from the campus.



Mia Lehrer + Associates

The addition of trees, swales, vegetation and a cistern succeeds in effectively eliminating runoff.

Project Features

The demonstration project consists of three components that utilize "forest-mimicking" technologies:

- A system of **trees**, **vegetation** and **mulched swales** slows, filters and safely channels rainwater through the campus.
- A **treatment device** removes pollutants from water collected on campus.
- A 110,000-gallon underground **cistern** stores the treated rainwater and feeds the irrigation system.

Seeking to minimize the discharge of stormwater pollutants to Santa Monica Bay, the project's designers used these components to retrofit the site for the collection, treatment, storage and use of stormwater. BMPs were selected to work specifically with the site's unique features.

Soil tests revealed clayey-sand and silty-clay sediments with low percolation rates. The project engineers decided that storing stormwater would be more practical than attempting to infiltrate it.

Melinda Kelley

Trees and grassy areas on the campus intercept and capture rainfall. Stormwater not captured by the campus forest is channeled to a treatment and storage system below the ball field.

Ambitious designs proposed in the project partners' Santa Monica Bay Competitive Grant Program application incorporated BMPs that met the stormwater management criteria used by the L.A. County Flood Control District for a 100-year, 24-hour precipitation event. The designs called for the capture and treatment of all stormwater falling on the campus during such a storm, with special attention paid to the impermeable surfaces of roofs, driveways, parking lots and asphalt playing fields – all sources of polluted runoff.

The proposal met the Santa Monica Bay Competitive Grant Program's four criteria:

- Protect public health in Ballona Creek and Santa Monica Bay by eliminating the stormwater pollutants;
- Preserve and enhance the ecological integrity of the Ballona Wetlands Significant Ecological area;
- Incorporate BMPs as defined in the NPDES (National Pollutant Discharge Elimination System) permit; and
- Reduce runoff volume into Santa Monica Bay where the runoff travels across lands that contribute significant amounts of toxic pollutants to the storm drain system.

Melinda Kelley

Water drains into a storm drain after a mock flash flood at Open Charter. Rather than running off the campus and eventually into Santa Monica Bay, stormwater is collected and detained onsite by a system of BMPs including trees, vegetation, swales and a cistern.

Initial Proposals

In their Santa Monica Bay Competitive Grant Program application, the project partners included the following technologies for Open Charter Elementary's retrofit:

- Porous pavement in parking areas and asphalt play areas;
- Stormwater collection, infiltration and storage BMPs;
- Trees and vegetation; and
- Grass areas.

Design Process – BMP Selection

A significant portion of landscaping was completed in the first phase of the Open Charter retrofit. BMPs for the collection, treatment and storage of stormwater were the next features to be designed and installed.

Using County Flood Control District criteria, preliminary designs for water retention included installation of an underground cistern large enough to capture the estimated 825,000 gallons of rain that would fall on the campus during a 100-year, 24-hour storm. This capacity was chosen to provide watershed protection for a full range of storms, including low-probability events.

An early, rough cost estimate for the system came in at budget, but a second, more rigorous calculation by Montgomery Watson Harza (MWH), the project engineer, determined that the project would cost $750,000 – 50 percent more than the grant award.

Design Process – Evaluation for Cost Savings

In order to capture the high volumes of runoff, the design for the 825,000-gallon cistern extended to the site's limits of available space, making for an irregularly shaped cistern. This asymmetric design resulted in higher costs, due to the intricacies of excavating for, installing and lining the manufactured system. Maneuvering maintenance equipment through the space (which is required to guarantee proper function of the cistern) in that configuration further added to the system's long-term cost.

In early 2001, the cistern size was reduced to 430,000 gallons, the approximate capacity required to store the runoff from a 10-year, 24-hour storm. The new plan was approved by LAUSD, but MWH later produced a cost estimate of $895,000 – more than the larger cistern and even farther over budget. The increase was partly due to a significant increase in material and shipping costs for Invisible Structures' Rainstore3 product, which had been chosen for the cistern.[2]

Design Process – Further Design Evaluation

In mid-2001, the project partners held a value-engineering meeting to discuss cost-saving measures. The chief variables discussed were the capacity of the system and the materials to be used. One option the partners considered – replacing Rainstore3 with a more economical corrugated metal pipe system – would still cost over $650,000, excluding design amendments. Use of these conventional materials seemed less appropriate to the project's status as a demonstration of new technologies. More commonly seen in infiltration projects, the Rainstore3 product had only once before been used as a cistern – the 27,000-gallon unit installed by North East Trees at Multnomah Elementary School in L.A.'s El Sereno neighborhood.

The partners decided to continue with Rainstore3. They issued a request for proposals asking contractors to revise existing plans and provide the largest cistern possible within the $500,000 grant budget. Ultimately, a system that included a 110,000-gallon cistern was approved by the city and the school district. While its storage capacity was significantly reduced, the system's other elements remained unchanged. All campus runoff, whether destined for the cistern or the storm drain, would still pass through a treatment unit that would skim off oil and other pollutants, segregate trash and settle out sediment. The new design thus fulfilled the general grant objectives and complied as well with a more specific rule established by the L.A. Regional Water Quality Control Board after the grant had been awarded. That rule requires the onsite capture and treatment of the first three quarters of an inch of rain falling on the property.

Infiltration

The project's original design included porous pavement in the school's parking lot to allow stormwater to reach and infiltrate the underlying soils. Subsequent investigation revealed fairly tight soils at the site, which reduce the effectiveness of porous pavement as a stormwater BMP.

Designs were modified to divert parking lot runoff to the cistern via to the treatment unit. The shift from infiltration to storage did not affect the volume of water treated onsite.

Built Designs

All stormwater on the site is either percolated in the tree wells and swales; collected, treated in a sedimentation basin and stored in an underground cistern for later use; or treated and released to the storm drain system if the cistern is full. Water that enters the sedimentation basin is treated with chlorine tablets to prevent bacterial growth and discourage mosquito breeding after being stored.

[2] TreePeople obtained an estimate of $649,230 from an independent construction consultant, lower than the MWH estimate but still considerably over budget.

Stormwater BMPs

Except for the cistern's holding capacity and plans for pervious pavement in the parking lot, the system was built much as originally proposed. Stormwater that falls on the upper half of the campus flows into and through the vegetated swales where much of it is infiltrated into the soil. Overflow from the swales and runoff from the remaining half of the campus flow to catch basins in and around the ball field. From there, stormwater passes through the treatment unit, where sediment, grease, trash and pollutants are retained. The treated stormwater is then stored in the 110,000-gallon cistern and used to irrigate the ball field and other landscaped areas.

TREATMENT

Contech Construction Products, Inc. (formerly Vortechnics) manufactured the stormwater treatment unit. The Vortechs Model 7000 hydrodynamic system uses a combination of swirl-concentrator and flow-control technologies to remove sediment, particles, trash, oil and grease from stormwater.

Rebecca Drayse

The Vortechs 7000 treatment system uses swirl technology and gravity to separate and retain pollutants, oils and trash from stormwater.

The major sources of the pollutants targeted by the Vortechs unit are impermeable surfaces on the site, such as roofs, driveways, parking lots and playing fields. As stormwater enters the system it first flows through a swirl chamber, where it spirals gently. Here, gravitational separation of pollutants works to clean the water of heavy sediment. Over time, sinking pollutants accumulate on the swirl chamber floor and have to be removed by a vactor truck or other means. From the swirl chamber, water flows into a chamber with a baffle wall designed to capture floating pollutants and trash that were not captured in the swirl chamber. Water then enters a third chamber that regulates flow according to the volume of water. At this point, the treated stormwater is directed into a final chamber and to an outlet pipe that conveys it to the cistern, where it is stored, circulated and mildly chlorinated.

The Vortechs system has a peak treatment capacity of 11 cubic feet per second (cfs) and offers 4 cubic yards of sediment storage space. The unit's external dimensions are 15 feet by nine feet by eight feet.

The project partners considered other treatment systems, including the BaySaver Separation System and AquaShield's Aqua-Swirl Concentrator. Both are hydrodynamic systems that use swirl technology to separate pollutants from the stormwater. Although these alternatives may have provided the necessary function to the project, the Vortechs product had been selected in the original design. Any change would have required further redesign and resulted in increased costs.

[3] International Stormwater BMP Database. Statistical Analysis Report for Marine Village Watershed BMP site. Available from www.bmpdatabase.org.

STORAGE

Rebecca Drayse



The cistern's excavated hole was lined with impermeable liner, upon which Rainstore3 modules were stacked to a height of approximately eight feet. The sides and top of the assembly were then wrapped with the impermeable liner and the hole backfilled.

Rainstore3 Cistern

Invisible Structures, Inc. manufactured the Rainstore3 module used to construct the cistern. Each module is an open plastic grid that measures one meter squared by one-tenth of a meter (approximately 40 inches by 40 inches by 4 inches) and provides storage space for about 25 gallons of water. The modules can be stacked to create columns, which are arrayed in sufficient numbers to create the desired storage capacity. The entire assembly is wrapped with an impermeable liner of 40 mil PVC that retains water. A layer of geotextile on either side protects the liner. The manufacturer states that the system provides a higher percentage of void space than conventional methods and thus requires less excavation.

Accu-Tab Tablet Chlorination System

The stormwater treatment system removes sediment, garbage, oil and grease, but organic matter and bacteria may still enter the cistern. Chlorinating stored water reduces health risks and odors. The Accu-Tab chlorination system offers a reasonably safe and accurate method of administering chemical treatment of stored water. Slow-release chlorine tablets are automatically dispensed in a pump vault adjacent to the cistern. A secondary pipe carries some chlorine from the vault to the Vortechs unit as a precaution against mosquito breeding in the standing water that is likely with this design.

For construction plans, see "Open Charter As-Built Drawings" (Appendix B-1).

Benefits, Costs and Funding

Benefits

The benefits of the Open Charter retrofit run the gamut from the tangible to those more difficult to quantify. The primary goal of the project was to provide a working demonstration of new approaches to managing the urban environment while also mitigating physical conditions on the campus that had a negative impact on the quality of life of those near it. With these conditions alleviated, the campus would serve as an example of healthier land-use management practices. As such, the general goal of the project touches on different kinds of benefits – from issues of water quality and import, to those of green space and responsibility to downstream communities.

Environmental Benefits – Water

The water-related benefits derived from capturing, treating and storing stormwater include:

- Improving water quality in Ballona Creek and Santa Monica Bay;
- Significantly reducing stormwater runoff from the campus;

- Mitigating flooding and erosion downstream; and
- Reducing water imports.

In monitoring conducted on a project located in Lake George, New York, the Vortechs unit proved to be effective in removing suspended solids.[3] Suspended solids carry pathogens and pollutants, and their removal from stormwater thus improves water quality by decreasing pollutant loads. In the Lake George scenario, inflow levels of suspended solids were consistently much higher than post-treatment outflow levels.

Environmental Benefits – Trees and Landscaping

Landscaping the campus with trees, plants and grass yields a host of benefits as well, including:

- Reducing energy use by shading air conditioning units;
- Improving student health and safety by shading play areas;
- Providing much-needed recreation space where only heat-retaining asphalt once existed;
- Decreasing the solid waste stream to landfills by using greenwaste onsite as mulch; and
- Reducing contributions to the heat-island effect.

The table *(fig. 5)* shows the expected benefits of the greening portion of the Open Charter project. The assessment was conducted by the University of Southern California, using American Forests' CITYGreen software.[4] It did not include the stormwater BMPs, so the analysis reflects only a portion the project's true benefits.

Fig. 5 Environmental Benefits of the First Campus-Greening Phase

(does not include benefits from structural BMPs such as the cistern)

Buildings and Permeable Surfaces	BEFORE	AFTER		
Permeability (acres and %)	0.53 (7%)	1.53 (20%)		
Tree Benefits	**BEFORE**	**AFTER**	**10 YEAR**	**20 YEAR**
Tree Canopy	12%	14%	23%	29%
Carbon Storage (tons per acre)	5.95	4.80	8.26	10.03
Carbon Sequestration (tons per year per acre)	0.03	0.05	0.16	0.16
Energy Savings (% per year)	22.2%	2 .4% 3	32.1%	32.7%
Stormwater Benefits				
Runoff Reduction	8.5%	9.4%	15.7%	15.8%
Avoided Storage (cubic feet per acre)	491	495	849	852
Air Pollution Benefits				
Ozone Removal (lb/acre)	4.2	4.7	8.0	9.7
SO_2 Removal (lb/acre)	1.3	1.4	2.5	3.0
NO_2 Removal (lb/acre)	2.4	2.7	4.6	5.6
PM10 Removal (lb/acre)	3.6	4.0	6.9	8.4
CO Removal (lb/acre)	0.5	0.5	0.9	1.1

Adapted from USC Sustainable Cities Program, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program," January 2001.

[3] International Stormwater BMP Database. Statistical Analysis Report for Marine Village Watershed BMP site. Available from www.bmpdatabase.org.

[4] Travis Longcore, Ph.D., Kyle Fitzpatrick and Maureen Phelan, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program." University of Southern California, Sustainable Cities Program. January 2001.

Social Benefits

The benefits that Open Charter's retrofit offers for people are profound. Each school year, hundreds of Open Charter students enjoy a school environment that welcomes and supports healthy physical play and hands-on science education.

The majority of children in Los Angeles lack adequate access to parks.[5] Within this urban landscape, Open Charter provides a unique learning environment and the opportunity for children to see, smell, touch and learn about California's diverse ecosystems. The implementation of similar projects throughout the district could have a considerable and positive impact on its 700,000 K through 12 students.

Melinda Kelley

Open Charter students learn about the cistern. The stormwater management demonstration project offers an opportunity for hands-on science education.

Costs

Phase 1

The first phase of the project, which included strategic planting of 88 trees on the campus, cost approximately $44,000 and occurred through DWP's Cools Schools program.

Phase 2

The $500,000 Proposition A grant set the budget for the second phase, which included installation of the stormwater capture, treatment and storage systems. The project partners worked hard to stay within that budget. A financial cushion was set aside in the event of unexpected problems, such as construction complications. Ultimately, approximately $25,000 of this buffer amount was not spent, bringing the total expended portion of the grant to $476,925.

In addition to the Proposition A grant, the project benefited from several in-kind donations and funding sources that covered costs not traditionally associated with similar projects, such as funds required to execute a cooperative agreement between the City of Los Angeles, LAUSD and TreePeople.

The total cost of the project, including these less conventional costs, was $673,925.

Fig. 6 Project Costs

BMP AND LANDSCAPING COSTS		
Contractor		$343,381
Water Treatment Unit		$18,000
Cistern		$60,015
Landscaping (Phase 1)*		$44,000
LAUSD Site Work		$88,000
Total Construction Costs	**=**	**$553,396**

ENGINEERING AND ADMINISTRATION		
Construction Consultation		$16,000
Project Administration		$30,529
Engineering (incl. modifications)		$54,000
Cooperative Agreement		$20,000
Total Additional Costs	**=**	**$120,529**

TOTAL PROJECT COSTS = $673,925

** Landscaping that occurred during Phase 2 was paid for by LAUSD. These cost figures were not provided to TreePeople.*

[5] In the report *No Place to Play*, the Trust for Public Land states that two-thirds of children 18 and under in Los Angeles do not live within walking distance of a park. The Trust for Public Land, *No Place to Play*, www.tpl.org.

Funding

Proposition A (The Safe Neighborhood Parks Act of 1996) and the Santa Monica Bay Restoration Commission

In 1999, the Los Angeles County Regional Park and Open Space District awarded a $500,000 grant to the City of Los Angeles. These funds were transferred to the Santa Monica Bay Restoration Commission – an independent state organization whose mission is to ensure the long-term health of the bay and its watershed – which in turn funded the project at Open Charter Elementary.

Proposition A, passed by Los Angeles County voters in 1996, established a $319-million park and open space property assessment to fund acquisition and preservation of endangered wilderness lands and to rehabilitate and improve dozens of parks and recreational facilities. The grant awarded to the Open Charter project was drawn from a fund for restoration and improvement projects to Santa Monica Bay that reduce the toxicity of or pollutant load in urban runoff to the bay.

The grant was awarded in support of the following project components:

- Demolition, excavation and grading of areas proposed for construction;
- Purchase of supplies and equipment, including: backfill, piping, underground tankage, irrigation pumps, irrigation piping, related drainage supplies and appropriate pavement materials; and
- Design and installation of the above.

Proposition BB and LAUSD

The project's timing coincided with a wide-scale LAUSD infrastructure improvement campaign funded by Proposition BB, passed in 1997 (see "Background on School Projects" on page 17 for more information on Proposition BB).

With these funds, the district renovated the campus in preparation for its reopening to students. In addition, the district provided in-kind matching services in the amount of $88,000 (15 percent of estimated total costs) to cover various site work, including the irrigation system, landscaping over the cistern and construction inspection.

Los Angeles Department of Water and Power - Cool Schools Program

The program provided $44,000 in funding for ground preparation and planting of 88 new trees in the first phase of the project.

Montgomery Watson Harza

The engineering firm provided $20,000 in in-kind services to supplement design and engineering costs.

City of Los Angeles

The city provided $20,000 to TreePeople for the development of a cooperative agreement among TreePeople, the school district and the City of Los Angeles. The City Attorney required the completion of the agreement before the city was permitted to accept and administer Proposition A funds.

The City of Los Angeles Watershed Protection Division provided $30,000 for engineering of the stormwater capture, treatment and storage system.

Post-Completion

Monitoring Plan

Monitoring the project's performance is an integral part of determining its effectiveness and the feasibility of replicating its innovations across the district's facilities.

The Watershed Protection Division (City of Los Angeles Bureau of Sanitation) created a short-term monitoring plan for Open Charter. The plan calls for sampling at two points (at influent areas before water is treated, and at the irrigation pump station after water is treated) during storms where precipitation is greater than one-tenth of an inch. Samples monitor bacterial indicators, including total coliforms, E. coli and enterococcus, as well as evaluate the effectiveness of the chlorination system.

Monitoring Activities

Although the Watershed Protection Division agreed to monitor the site in the original grant request, no monitoring protocols were specified and no budget was allocated. Due to staff changes at the city and the lack of instructions, the monitoring plan was not finalized until the demonstration project had been complete for two years. As of the writing of this publication, site monitoring has not begun.

Questions regarding the maintenance and operation of the system by the school district caused a delay of sampling at the beginning of the 2006-2007 storm season and monitoring will now most likely begin in the 2007-2008 storm season.

Operation and Maintenance Plan

Like monitoring, maintenance of the project is an essential component of its success. Without adhering to a maintenance schedule to ensure proper operation, benefits such as water quality improvement and reduction of runoff are compromised. A document prepared by MWH in advance of construction identifies maintenance tasks, schedules and approximate costs.

Operation and Maintenance Activities

Effective delegation of operation and maintenance responsibilities has proven difficult. The development of a formal commitment, whereby LAUSD would assume responsibility for a regular maintenance and inspection schedule, has moved at a slow and unsatisfactory pace. Due to factors beyond the control of TreePeople and MWH, Open Charter's landscaping and water capture and treatment system received inadequate care following the project's completion and leading to the publication of this report. Dismaying occurrences, including neglected system maintenance and improper pruning of trees, have been reported on multiple occasions and appear to be the result of miscommunication within the school district.

Recently, positive actions have been taken toward preventing such events from reoccurring. TreePeople had a productive meeting with maintenance staff, a local school board member, parents and teachers which resulted in an action plan to create a maintenance manual for the cistern system and a written protocol for notification to the principal before any new tree pruning is performed. Trees that died from a broken sprinkler system were replaced and the sprinklers repaired. We hope this commitment to the maintenance of this valuable asset will be sustained.

See "Open Charter Operation, Maintenance and Inspection Costs" (Appendix C-2).

Successes

TreePeople led the school community in the removal of more than 30 percent of the asphalt on the campus, the creation of swales and miniature forest ecosystems between buildings, and the planting of 150 trees. TreePeople and the school community – including committed teachers, parents, students, volunteers and a supportive school principal and faculty – participated in each of three planting days and continue to take part in caring for the campus forest.


Melinda Kelley

Four thousand gallons of water "rained" from a fire hose during a mock flash flood that demonstrated the project's ability to capture and retain large volumes of stormwater falling onsite.

Stormwater Runoff Quantity

The campus greening campaign yielded immediate stormwater quality and quantity benefits. With proper tree care, these benefits can easily increase. Without considering the cistern, which stores stormwater not otherwise captured, trees and vegetation reduce runoff by nine percent.[6] As trees mature, that number can be expected to rise to 16 percent after ten years.

Melinda Kelley

Signs created by students hang at the ball field.

Raised Awareness of Stormwater as a Resource

Collaboration across diverse disciplines and agencies has helped foster awareness of stormwater as a valuable resource rather than a nuisance.

This model continues to attract attention – including interest from media and government representatives, and public requests for assistance in similar efforts. The high volume of interest expressed in the demonstration sites spurred the research and writing of this publication.

Teaching Opportunities

At Open Charter, trees define the play space. This is radically different from many of LAUSD's campuses, where playground design follows safety protocols with limited consideration given to how the space will be used. Beyond the pleasant interaction that students have with the campus during breaks and on their way to classes, the landscape design at Open Charter offers numerous teaching opportunities. Science and gardening curricula have been developed to give children hands-on experience in an outdoor classroom.

[6] USC Sustainable Cities Program, "Assessment of Los Angeles Department of Water and Power Cool Schools Tree Planting Program," January 2001.

Challenges and Lessons Learned

Given the complexity of the retrofit, the project at Open Charter held many challenges and offered numerous opportunities to learn from and improve upon the process.

Extended Timeline and Project Coordination

Challenge: From concept to completion, the retrofit of Open Charter into a stormwater management demonstration site took six years – a great deal longer than anticipated. The extended timeline was largely due to liability issues that arose among partners. Specifically, the cooperative agreement – required by the city attorney before the city could accept and administer $500,000 in Proposition A funds – took two years to complete and cost the city an additional $20,000.

During this period, representatives from over a dozen entities – including TreePeople, the City of Los Angeles, the County of Los Angeles, the Los Angeles Unified School District and the Los Angeles Department of Water and Power – integrated their efforts to complete this unconventional project.

The long timeline also exposed the partners to staff turnover, the related loss of project knowledge and material and service cost increases. This was the case with the cistern, which was originally designed to hold 825,000 gallons but was ultimately downsized to 110,000 gallons. Reasons for this rescoping included: the difficulty in constructing an awkward design that stretched to the limits of the property's space; an inaccurate cost estimate that was later corrected; and an extraordinary and unprecedented increase in construction and material costs associated with billions of dollars in concurrent public works and school construction projects throughout the Los Angeles area.

Lesson: In multi-agency projects, allow at least twice the timeline you hope for. Complications arising from liability issues and delegation of responsibilities can extend the project far beyond a projected timeline and require effective project management.

Factor in budget increases associated with an extended timeline. Assess the local construction cost inflation rate if the region is undergoing extensive construction, or if international demand for materials such as plastic, steel or concrete is causing increases.

Partnership and Communication Protocols

Challenge: Developing partnership protocols takes time and patience, especially in projects involving many partners.

The more partners involved, the higher the likelihood that key personnel will move on to new positions during the project's lengthy timeline – and that important information will be lost. A new person filling a position seldom has all facts at hand, and a lack of accurate records reflecting the progress to date leads to assumptions.

Lesson: Start your agreement process when you start your design process. Engage enthusiastic partners to ensure the successful completion of the project. Set protocol for crediting all partners under all circumstances to make sure credit is shared equally both during positive media attention and if things go wrong. Document the process, as detailed records of the facts, timeline and major decision points can serve to give the project context.

Maintenance and Other Ongoing Responsibilities

Challenge: In the months and years following completion of the retrofit, effective delegation of maintenance responsibilities has been problematic. The school district has been unsuccessful in providing the necessary care to various project components, including the treatment system and landscaping. Neglect and mistreatment of these compromise the system's effectiveness and decrease the benefits yielded. For example, severe mispruning left trees with a fraction of their original canopy, compromising their ability to intercept and retain stormwater and to provide shade. The first contact for stormwater is thus diminished, decreasing energy, water and air quality benefits.

Lesson: Spend extra time and care ironing out the details of who will be responsible for what, from budget issues and agreements, to construction liability and maintenance. In multi-agency projects, it is often difficult to get any party to accept liability.

Consider the importance of operations and maintenance – as the project is not over when construction ends. Develop written maintenance contracts and clear instructions and get general agreement from all partners before the project is completed.

At Open Charter, the cistern is not a typical structure for district maintenance staff to oversee. As it was custom designed, no system manual exists – only individual component manuals. In such a case, develop a custom maintenance manual with the site's operations and maintenance staff at the table.

Wide-ranging Support

Challenge: Ensuring the involvement of staff at all levels is difficult in multi-partner projects, yet it is the diverse knowledge that rests collectively with all partners that enriches the project. Failure to solicit input from all staff levels early on also makes the project vulnerable to problems that could be averted if the appropriate partner is given a chance to provide input.

Lesson: Establish wide-ranging support. Seek support from all staff levels in the partnership in order to get input from all those who will be involved – from design to maintenance.

If the project is multi-purpose, with funding from multiple partners, attempt to have relevant partners sponsor portions of the project consistent with their mission, mandate, core competencies and skills. If, for example, the project includes water quality or water supply components, it is far better to have an agency with a water quality or water supply mission commit to provide the maintenance of the water quality infrastructure.

Making Obvious the Project's Meaning

Challenge: The idea of stormwater BMPs can be difficult to grasp for someone new to these concepts. BMPs that are underground and out of sight can seem even more abstract. In the absence of interpretive elements, the meaning of a project can be lost soon after completion – making it susceptible to improper care and treatment.

Lesson: Memorialize the project at the site. Staff, faculty and students eventually move on, leaving no one behind who remembers the project's significance, or even its existence. The project should be visually memorialized with interpretive signage, displays or permanent photo and student art projects.

Evaluation Criteria and Baseline Data

Challenge: Drawing conclusions about the benefits the project brings and the effectiveness of the system's BMPs is difficult in light of the limited monitoring that has occurred at the Open Charter site. For TreePeople, which advocates for widespread application of the technologies utilized at this campus and other demonstration sites, the challenge is deriving reliable, replicable results that can be implemented at other projects.

Lesson: Collect quantifiable baseline data prior to the beginning of construction. Gather anecdotal reports of the site and complete photographic documentation of the site's conditions before beginning the project.

Sensible Design

Challenge: From selecting the right tree species to verifying that the design is realistic, continuously confirming the feasibility of the project's details is challenging but important.

Detailed and reliable cost estimates are imperative early on in a project – as the scope of the project obviously needs to fit the budget.

Lesson: Choose an appropriate and practical design. Ask a contractor to review custom design features early in the process for constructability feedback. In retrospect, the project partners would likely have used a treatment unit that provides more filtration than the one chosen.

Determine costs early on. The sooner a realistic scope is determined, the more likely the project will avoid insurmountable barriers.

Partners

The stormwater BMPs project at Open Charter Magnet School was a collaborative effort among TreePeople, the L.A. City Bureau of Sanitation, LAUSD, LADWP and Santa Monica Bay Restoration Commission/L.A. County Regional Park and Open Space District. Open Charter students, parents, administration, faculty and school board were also instrumental in the design and implementation of the project.

TreePeople conceived and managed the project as part of its T.R.E.E.S. (Transagency Resources for Environmental and Economic Sustainability) Project, which promotes the integrated and sustainable management of urban watersheds. TreePeople drafted agreements, performed contractor bidding, administered funds and managed design and construction. The nonprofit organization also coordinated community plantings and environmental education around the project. Rebecca Drayse was the project manager.

The City of Los Angeles acted as fiscal agent for funding supplied by the County of Los Angeles. The city provided funding for the cooperative agreement and is responsible for monitoring pollutant loads captured by the BMPs.

Santa Monica Bay Restoration Commission provided Proposition A funding for the treatment and storage system via its fiscal agent, the County of Los Angeles Park and Open Space District.

The Los Angeles Unified School District (LAUSD) provided $88,000 in matching funds for the project. As property owner, LAUSD also agreed to operate and maintain the stormwater demonstration site for the project's design life (estimated at 20 to 30 years). The district also provided concrete removal, installed the irrigation equipment and prepared the site for the school community-led first phase of greening, which included installation of the vegetated swales and tree wells.

Montgomery Watson Harza (MWH) provided design and engineering services, as well as $20,000 in in-kind services.

Mia Lehrer + Associates provided landscape architecture services.

Open Charter Elementary School students learned about the water cycle and resource management, and then made suggestions that were incorporated in the landscape design of Mia Lehrer + Associates. Parents, teachers and the school principal continue to provide leadership, tree care and oversight of site conditions.

Los Angeles Department of Water and Power (LADWP) provided trees through its Cool Schools program.

Doty Brothers Equipment Co., a construction services business located in Norwalk, California, was the contractor.

Conclusion

The projects at Hall House, Broadous Elementary and Open Charter Elementary give us glimpses into how action at the micro scale can begin to undo damage created at the macro scale. They also call attention to the recurring challenges inherent in undertaking endeavors of this sort – from the extraordinarily effective project facilitation and management that is required to execute them, to the irony of the relative availability of funding for building but not for maintaining them.

Most importantly, they point to the need for a much more serious public commitment to and investment in integrated, multipurpose, multi-partner management as a means of achieving local, regional, national and international goals of sustainability.

Although often challenging, multipartner, multipurpose projects are ultimately very valuable. The partnerships that form as a result and the awareness such projects raise about sustainable solutions to conventional problems are successes that are rarely achieved in traditional efforts.

The vision behind this integrated, multipurpose ecosystem approach is that it will ultimately become standard practice for planning, funding and managing urban land and infrastructure. Although this approach has shown great value in Los Angeles – and has led to significant changes in agencies, policies and approaches – it is not yet familiar to many politicians or the general public, and is not recognized by most governments as essential for all future resource management endeavors. Clearly, this practice is still in its infancy.

Since the completion of the three demonstration projects, TreePeople has been working with regional stakeholders to achieve wide-scale adoption of the underlying concepts showcased at the sites. Through site tours, additional charrettes, participation in projects that integrate the work of agencies across the spectrum, and efforts to influence regional water management policy, TreePeople has continued the work that was first iterated at the Second Nature charrette in 1997.

As a result, the tide has begun to turn. Since the completion of the Hall House retrofit, Los Angeles has witnessed a shift in the way that local agencies interact with one another and with the communities they serve.

Following the opening celebration and demonstration at the Hall House in 1998, former deputy director of the Los Angeles County Department of Public Works (DPW) Carl Blum gave his support to a partnership among DPW, the City of Los Angeles and TreePeople to develop and implement a multi-year, wide-scale watershed retrofit of Sun Valley. Sun Valley is a polluted, underserved community in the northeast San Fernando Valley. Having no storm drains or significant stormwater infrastructure, the community has long been plagued by chronic flooding. The ongoing project is seeing the transformation of one of the city's most disadvantaged and industrialized neighborhoods into a model of integrated watershed management.

The Hall House, Broadous and Open Charter pilots are widely seen as exemplars of the multipurpose approach and the interagency cooperation increasingly demanded by local, state and federal funders of watershed projects. City officials mention them in public presentations; they inform the larger-scale designs of public works departments; and they are discussed by regional watershed groups and depicted in their final plans.

The three sites have garnered attention from various media outlets, including the *Los Angeles Times*, the *Sacramento Bee*, *Daily News*, *LA Weekly*, ABC Weekend News with Peter Jennings, KTLA-TV, KCOP-TV, KPCC 89.3 FM, KCRW 89.9 FM, and KNX 1070 News Radio. The projects have also been featured in various professional journals, including *Government Engineering*, *Civil Engineering* (American Society of Civil Engineers), *Urban Land* (The Urban Land Institute), and *Western Water*.

And there is more reason to be hopeful. In recent years, both the state legislature and voters have passed numerous laws and initiatives aimed at improving water resources and requiring some form of integrated planning and multi-benefit outcomes. In 2004, Los Angeles County voters overwhelmingly approved Proposition O, a $500-million bond that is bringing the county closer to meeting federal Clean Water Act standards. Funds from this measure are already supporting projects that protect water bodies and water sources, reduce flooding and runoff, and capture, treat and use stormwater. In 2006, California voters passed Proposition 84, a $5.4-billion bond measure in support of projects related to water quality, safe drinking water, water supply, flood control, natural resource protection and park improvements.

The technologies outlined in this report have implications at multiple scales – from the single parcel to the region and beyond. If, for example, cistern systems like that at the Hall House were installed citywide, they could be designed to act as a flood-control device. When a major storm threatens, cisterns can be drained to the street prior to the storm hitting. This creates detention capacity, as stormwater can then be captured in the cisterns and the flow of water into the flood control system regulated. If implemented on a larger scale, cisterns around the Los Angeles basin could be equipped with remote-control switches that would enable flood control authorities to use them as a sort of "networked reservoir." An integrated effort of this sort would create an effective water conservation, pollution prevention and flood control system able to store or release water as needed.

To be truly effective, however, integrated management must shift from its growing use primarily in project design and planning and instead become institutionalized as a core government management practice. Achieving that vision requires a new investment in training engineers and practitioners in multi-stakeholder process facilitation and development of new policies, ordinances, software, protocols, management and accounting systems that ease and enable this large-scale conversion.

As TreePeople continues to advocate a holistic view of the urban landscape, we invite individuals, organizations and government agencies to do their part to advance the concepts presented in these pages. Whether restoring the watershed functions of a single home or adopting region-wide policy in support of integrated watershed and resource management, each step in the right direction can help turn the tide of damage done – and do much to promote healthier communities and cities.

For more information, please visit:

www.treepeople.org

www.treepeople.org/trees

www.sunvalleywatershed.org

Thanks to everyone who contributed to this report, including:

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Glossary

Acre-foot: the volume of water – 325,851 gallons – that would cover an acre of ground to a depth of one foot; roughly a year's supply for two families.

Aquifer: the underground bed or layer of earth, porous stone or gravel that contains or supplies groundwater. See groundwater.

Best Management Practice (BMP): in a given field, a tool or technique generally recognized as one of the best available. Stormwater BMPs include cisterns, infiltration basins, swales, strategic tree plantings and other technologies.

Canopy Cover: the portion of land area covered by the spread of a tree, including its leaves and branches.

Charrette: a planning or creative problem-solving activity in which an interdisciplinary group of participants is assigned a complicated design project and asked to complete it within a very short period of time.

Cistern: a tank or recess used to capture and store rainwater for later use.

Groundwater: water that saturates the soil at some distance below the surface, held in rocks and soil. See aquifer.

Hardscape: portions of a property covered by buildings, pavement and other hard and impervious materials.

Heat-island Effect: the increase in ambient temperature caused by a prevalence of heat-retaining buildings and paved surfaces. According to the U.S. Environmental Protection Agency, on hot summer days urban air temperatures can be up to 10°F hotter than the surrounding countryside.

Infiltration: the absorption of surface water by the soil. Also called percolation.

Lysimeter: an instrument used to measure water that percolates through soil.

Mulch: a ground covering, especially of organic materials, that holds water, slows evaporation and enriches the soil.

One Hundred-year Storm: a probability-based measure of storm magnitude. On average, a 100-year storm can be expected to occur every 100 years. Similarly, a 50-year storm is expected to occur every 50 years, on average.

Percolation: see infiltration.

Runoff: stormwater flowing across the surface of the earth. In urban environments, runoff becomes contaminated with pollutants as it flows across impermeable surfaces such as streets, roofs and parking lots.

Stormwater: rainwater that hits the surface of the earth. Stormwater can evaporate, percolate into the ground or flow across the surface to the nearest storm drain inlet, stream, or wetland area. If stormwater does not evaporate or percolate into the ground, it becomes runoff.

Swale: a natural or sculpted channel that slows runoff. Usually vegetated or covered with mulch, it can filter pollutants and increase aquifer recharge.

T.R.E.E.S. Project: Transagency Resources for Environmental and Economic Sustainability Project.

Vector: an organism, such as a mosquito or tick, that acts as a carrier of disease-causing microorganisms.

Watershed: the area of land drained by a particular body of water. Also called a drainage basin.

"In a city that imports more than half of its water, technology like that implemented at Open Charter could significantly impact Los Angeles. This technology reduces use of potable water for irrigation, decreases our demand for imported water and conserves unused water in a time of increased competition for limited supplies."

- **Shahram Kharaghani, Manager, Watershed Protection Division**
  City of Los Angeles Bureau of Sanitation

"As project manager for the Broadous and Open Charter retrofits, I can say that forging the necessary partnerships was incredibly challenging at times, but ultimately rewarding. New relationships were formed among entities that don't typically work together and a model for collaboration between local agencies and nonprofits was created. By continuing to listen to one another and work together, we can build on the lessons learned in these projects. They can help us create even better multipurpose projects to sustain our natural resources and make the best use of our scarce and precious public spaces."

- **Rebecca Drayse, Natural Urban Systems Group Director, TreePeople,**
  and project manager for the school demonstrations

"This project transformed our school into a beautiful oasis with grass ballfields, trees and gardens that actually help protect the surrounding neighborhood and the beach. The kids love tending to the trees and plants and watching things grow – it's a great way to teach about caring for the natural world."

- **Robert Burke, Open Charter Elementary School Principal**

The Sacramento Bee

May 26, 2002

HOW L.A. RAINFALL COULD MEET HALF ITS WATER NEEDS

But a slow change is creeping over the Southland. Ever on the lookout for the next new thing, and facing a price tag of billions of dollars to clean up the polluted mess its waterways have become, L.A. is embracing a radical idea: save and use its own rainwater instead of everyone else's. It's about to embark on what officials hope will be a model of water-wise urban planning for the entire country. Their goal – to make the concrete jungle behave more like a natural place.

"The information and demonstrations of the T.R.E.E.S. Project resulted in substantial changes in Los Angeles public works agencies and local policies."

State of the World's Forests 2003, United Nations Food and Agriculture Organization

Los Angeles Times

August 16, 1998

TREEPEOPLE'S L.A. PILOT PROJECT IS TESTING THE WATERS

In a city where so much of the land is paved or roofed over and where gutters run freely, TreePeople's ideas make good sense.

Los Angeles Times

March 4, 2005

LEARNING TO SAVE SOMETHING FOR A DRIER DAY

At Thursday's demonstration [at Open Charter Elementary School], a one-pint jar of murky water polluted with oil, trash and dust displayed what goes into the ocean after it rains.

The city of Los Angeles Bureau of Sanitation reported that in a 0.45-inch rain, approximately 3.8 billion gallons of runoff flow to the Pacific Ocean from the Los Angeles River, Ballona Creek, Santa Monica Bay and Dominguez Channel watersheds.

California Coast & Ocean

Autumn 2001

TREEPEOPLE'S SUMMER STORM

On a clear day in August 1998, a "hundred-year storm" – a storm so severe that it occurs, on average, only once a century – hit Mrs. Hall's home. With the cooperation of the DPW and other agencies, "we dumped 4,000 gallons of water on the house in 10 minutes," [Andy Lipkis said]. The water retention features worked as expected, and the water that fell on the property was absorbed into the ground. What fell on adjacent pavement ran into gutters, en route to the Los Angeles River.

Government Engineering

March/April 2005

COLLECTION AND REUSE OF STORMWATER: THE PHRASE "URBAN ENVIRONMENT" DOES NOT HAVE TO BE AN OXYMORON.

"As we look at how the system evolved over time we realize the way we designed the (stormwater) system was reactionary and single purpose in its approach," said Michael Drennan, [P.E. who worked with the engineering firm MWH on the Open Charter Magnet School job and was his firm's project manager]. "If you think about multiple objectives like flooding, pollution reduction, and water supply, then you might design a system like we did at Open Charter, which manages stormwater as a resource rather than a waste."

Daily Breeze

www.dailybreeze.com The South Bay's choice for 111 years

March 4, 2005

THINGS START TO FLOW FOR RECYCLING SYSTEM

It's a concept as old as time: In a parched desert, it helps to have a good bucket on hand when the precious rains finally come.

Make that bucket a 110,000-gallon underground tank and you've got enough water to transform one of the Los Angeles Unified School District's trademark blacktop campuses into a grassy, tree-dotted play space.

Rainwater as a Resource:

A Report on Three Sites Demonstrating Sustainable Stormwater Management

TreePeople

12601 Mulholland Drive, Beverly Hills, CA 90210
(818) 753-4600 www.treepeople.org

Selected Water Supply and Watershed Materials

Many more texts, websites, and articles are available on the topics below. For additional materials, please contact San Diego Coastkeeper staff or check our website.

Water Supply Overview

- Equinox Center, San Diego's Water Sources: Assessing the Options, 2010 (available at: http://www.equinoxcenter.org/publications.html)

Conservation

- Pacific Institute (Cooley et. al), California's Next Million Acre-Feet: Saving Water, Energy, And Money, 2010 (available at http://www.pacinst.org/reports/next_million_acre_feet/index.htm)
- Utility Consumers' Action Network (Smith), San Diego's Challenge of the Century, 2008 (available at http://www.ucan.org/water/water_conservation_efficiency/a_solution_san_diegos_water_crisis)

Tiered Pricing

- Equinox Center, A Primer on Water Pricing in the San Diego region, 2009 (available at http://www.equinoxcenter.org/assets/files/pdf/Equinox%20Water_Pricing_Brief%20102609.pdf)
- U.C. Berkeley, Goldman School of Public Policy (Griffin et. al), Implementing a Public Goods Charge for Water, 2010 (available at www.**water**plan.**water**.ca.gov/docs/cwpu2009/.../v4c02a19_cwp2009.pdf)

Rainwater Harvesting

- Burian and Jones, National Assessment of Rainwater Harvesting as a Stormwater Best Management Practice: Challenges, Needs, and Recommendations, 2010 (available at http://content.asce.org/conferences/lid10/index.html)
- Gold, et. al, Rainwater Harvesting: Policies, Programs, and Practices for Water Supply Sustainability, 2010 (available at http://content.asce.org/conferences/lid10/index.html)
- TreePeople (Ben-Horin), Rainwater as a Resource: A Report on Three Sites Demonstrating Sustainable Stormwater Management, 2007 (available at http://www.treepeople.org/rainwater-resource)

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Low Impact Development

- Fabry, et. al, Implementing Sustainable Green Streets and Parking Lots in San Mateo County, California, 2010 (available at http://content.asce.org/conferences/lid10/index.html)
- Hoenicke et. al, Forecasting Multiple Watershed-level Benefits of Alternative Storm Water Management Approaches in the Semi-arid Southwest: Required Tools for Investing Strategically, 2010 (available at http://content.asce.org/conferences/lid10/index.html)
- Low Impact Development Center (Kloss), Managing Wet Weather with Green Infrastructure, 2008 (available at http://yosemite.epa.gov/water/owrccatalog.nsf/e673c95b11602f2385256ae1007279fe/4a87179c754f234b8525751c00550b3b!OpenDocument)
- Natural Resources Defense Council, Water Saving Solutions: Stopping Pollution at its Source with Low Impact Development, 2009 (available at http://www.nrdc.org/documents.asp?topicid=3&tag=low+impact+development&more=&dtid=2)

Recycled Water

- Equinox Center, H2Overview Project: The Potential of Purified Recycled Water, July 2010 (available at: http://www.equinoxcenter.org/publications.html)
- Rodriguez, Indirect Potable Reuse: A Sustainable Water Supply Alternative, 2009 (available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2672392/)

Desalination

- Pacific Institute (Cooley and Gleick), Desalination, With a Grain of Salt - A California Perspective, 2006 (available at http://www.pacinst.org/reports/desalination/index.htm)