Section A: Introduction and Summary of Findings

The Water Purification Demonstration Project was a multi-year project designed to assess the feasibility of supplementing one of San Diego's local water supply reservoirs, San Vicente Reservoir, with purified water produced at an advanced water purification facility. The project is an integral component of the City's plan to improve water supply reliability by developing local, drought-tolerant water supplies. The Water Purification Demonstration Project involved installing and operating a demonstration-scale advanced water purification facility, studying San Vicente Reservoir, implementing a public outreach and education program, developing conceptual design criteria and costs for a full-scale advanced water purification facility and pipeline facilities, and developing a conceptual pipeline alignment.

The advanced water purification facility is a component of the Water Purification Demonstration Project.

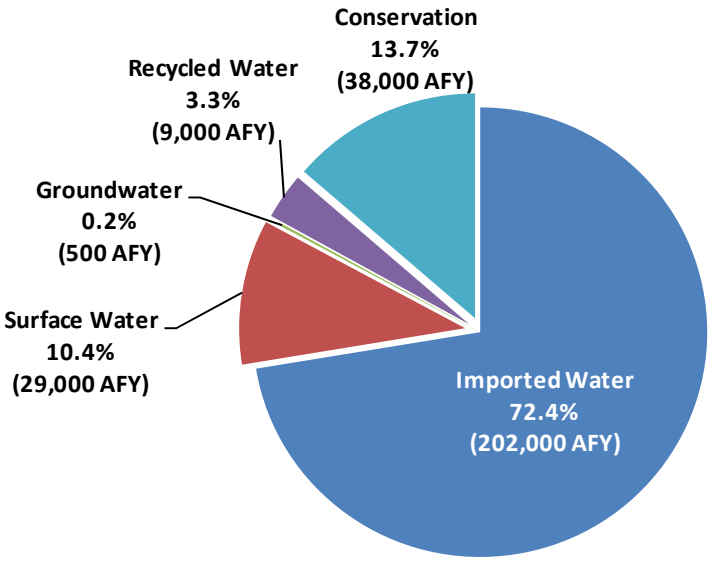
This Project Report provides an overview of the technical studies, advanced water purification facility testing, and public education and outreach efforts conducted as part of the Water Purification Demonstration Project. It also presents findings that support the conclusion that implementation of a reservoir augmentation project at San Vicente Reservoir would be feasible.

In 1813 Spanish settlers and missionaries completed a dam and flume on the San Diego River to supply water to Mission San Diego de Alcala. This effort to secure a dependable water source for the mission was the first water supply project on the West Coast. Two hundred years later San Diego continues its quest to secure reliable and locally controlled sources of water. Using modern technologies and advanced science, the Water Purification Demonstration Project moves the City toward a future of dependable water supplies.

San Diego's Water Supply Reliability Challenges

The City of San Diego (City) provides drinking water to more than 1.3 million people. In addition to supplying approximately 274,000 metered service connections within its own incorporated boundaries, the City supplies water to the City of Del Mar; Santa Fe and San Dieguito Irrigation Districts; and California American Water Company, which, in turn, serves the Cities of Coronado and Imperial Beach and portions of south San Diego (City of San Diego, 2011a). The City's projected total water use in 2015, including wholesale deliveries to other agencies, is

240,000 acre-feet (AF), which is equivalent to 78,000 million gallons, or 210 million gallons per day (mgd) (City of San Diego, 2011a). The City's actual water use in fiscal year 2012, which also included wholesale deliveries to other agencies, was 190,000 AF,(based on data from the City of San Diego, Public Utilities Department, Water Operations Division. This is equivalent to 63 million gallons or 170 mgd. Actual water use varies from year to year because of climatic and economic conditions. Further, the mandatory use restrictions enforced during the 2009/2010 drought appear to have had a lasting effect on water use, as demands have not yet rebounded to their pre-drought levels. The City meets water demands with the following supplies:



Existing water resource mix projected for 2015 normal/average hydrologic conditions (AFY = acre-feet per year) (City of San Diego, 2012c)

- Imported water, which includes water imported from the San Francisco Bay / Sacramento – San Joaquin Delta (Bay-Delta) in Northern California or the Colorado River
- Local surface water
- Groundwater
- Recycled water

San Diego is situated at the end of a complex network of state, federal, and local water projects.

In an average year, approximately 85 to 90 percent of the City's water supplies are imported water, which is water that is supplied from the Bay-Delta in Northern California or the Colorado River through a network of state, federal, and local pipeline facilities (City of San Diego, 2012b). The cost of imported water has increased significantly and is expected to continue to increase into the future. From 2007 to 2012, Metropolitan Water District's (MWD's) imported water costs increased by more than 12 percent annually, and MWD projects its 2014 full service water rate to be seven percent greater than its 2012 rate. Going forward, the San Diego County Water Authority (Water Authority) projects that its untreated water rates will double in less than 10 years (City of San Diego, 2012c).

Environmental stressors, such as ongoing drought in the Colorado River Basin, reduced snowpack and runoff in Northern California, and court-ordered pumping restrictions necessary to protect endangered species, have decreased the reliability of imported water supplies (City of San Diego, 2012b).

Imported water reliability issues, coupled with recurring droughts in the San Diego region, have placed considerable strain on the City's ability to meet water demands. The City has taken a variety of actions to maximize water resources and improve water supply reliability, including the following.

- The City supports a wide array of **water conservation measures** designed to reduce water demands and maximize water use efficiency. A signatory to the Memorandum of Understanding with the California Urban Water Conservation Council since 1991, the City employs a variety of urban Best Management Practices for conserving water (City of San Diego, 2011a). City-wide conservation efforts resulted in an approximate water savings of 34,000 AF in 2010 (City of San Diego, 2011a).
- In 2002, the City developed a **Long-Range Water Resources Plan** (LRWRP) that defines a plan to reduce reliance on imported water supplies and develop and maximize local water resources. The LRWRP is currently being updated (draft 2012 LRWRP) to reflect recent changes in the availability, costs, and reliability of various water supply sources (City of San Diego, 2012c).

A Word About Imported Water Reliability

Water is essential to our quality of life. The City imports 85-90 percent of its water supply from the Bay-Delta in Northern California and the Colorado River. In recent years, both Southern California and the Colorado River system have experienced drought conditions. In addition, legal and regulatory decisions to protect endangered species have restricted the amount of water that can be pumped from Northern California. Since San Diego is at the end of the imported water pipeline, and receives an average of 10-12 inches of rain each year, local, drought-tolerant water supplies are critical to securing a reliable supply of water now and in the future.

Local reservoir levels have been lower than typical due to dry conditions.

Pumping from the Bay-Delta is limited to protect endangered species such as the Delta Smelt.

- The City is a member of the Regional Water Management Group administering the **San Diego Integrated Regional Water Management Program**, which uses an integrated regional approach to address water management issues.
- The City is conducting independent studies as well as participating with the United States Geological Survey and the United States Bureau of Reclamation (Bureau of Reclamation) on **groundwater basin studies and hydrogeologic investigations** to better understand the complex hydrogeology of the San Diego coastal area, the water supply potential of the local groundwater basins, and the potential for desalination of saline groundwater located near the coast (brackish groundwater) (City of San Diego, 2011a).
- The City is implementing a **Water Reuse Program** designed to maximize water reuse.

The following sections discuss the elements of the Water Reuse Program, including the Water Purification Demonstration Project, in more detail.

Maximizing Local Supplies with the Water Reuse Program

In response to San Diego's ongoing water supply challenges, the City initiated a comprehensive Water Reuse Program in the early 2000's. The Water Purification Demonstration Project is the second phase of this initiative designed to maximize the use of recycled water throughout the City.

Phase 1: Water Reuse Study

In 2006, the City completed the Water Reuse Study, which included a comprehensive evaluation of all viable options to maximize the use of recycled water produced by the City's two water reclamation plants (City of San Diego, 2006). The study included analysis and research on the health effects of reuse options and implemented a comprehensive public participation process. Based on the information presented in the Water Reuse Study, a stakeholder group determined that the preferred option for maximizing use of the City's recycled water supply would be to augment existing supplies in the City's San Vicente Reservoir with recycled water—this option is referred to as "reservoir augmentation at San Vicente Reservoir." In response to both the Water Reuse Study and the stakeholder recommendation, the San Diego City Council (City Council) approved the second phase of the Water Reuse Program: the Water Purification Demonstration Project.

What is Reservoir Augmentation?

Reservoir augmentation is the practice of augmenting an existing drinking water supply reservoir by adding purified water. Purified water starts out as wastewater from homes or businesses. It is then collected and put through a series of treatment and purification steps designed to produce purified water that meets all drinking water standards.

Reservoir augmentation as identified in the Water Reuse Study would adhere to the multiple barrier concept that is fundamental to the provision of public health safeguards. These barriers include conventional water recycling treatment as practiced in the San Diego region for more than 30 years, advanced water purification technologies, blending with imported water in San Vicente Reservoir, drinking water treatment at a municipal water treatment plant, and distribution to the City's drinking water system.

Phase 2: Water Purification Demonstration Project

Phase 2 of the Water Reuse Program is the Water Purification Demonstration Project (Demonstration Project). The Demonstration Project, which is the focus of this Project Report, evaluated the feasibility of using water purification technology to produce water that could be sent to San Vicente Reservoir where it would be mixed with a combination of local and imported water supplies prior to being treated at a water treatment plant and distributed as drinking water (see Figure A-1).

(Potential) Phase 3: Reservoir Augmentation at San Vicente Reservoir

Because the concept of using purified water to augment San Vicente Reservoir has been determined to be feasible (as discussed in greater detail in subsequent sections of this Project Report), the Mayor and City Council may consider implementing a reservoir augmentation project at San Vicente Reservoir. The key facilities associated with a reservoir augmentation project at San Vicente Reservoir are presented in Figure A-2.

The City of San Diego's Water Reuse Program

- Phase 1 – The Water Reuse Study, published in 2006
- Phase 2 – The Demonstration Project, which evaluated the feasibility of using purified water to augment San Vicente Reservoir (No purified water was actually sent to the reservoir in Phase 2.)
- (Potential) Phase 3 – The future Full-Scale Reservoir Augmentation Project at San Vicente Reservoir

Figure A - 1: Phase 2 and Potential Phase 3 of the City's Water Reuse Program

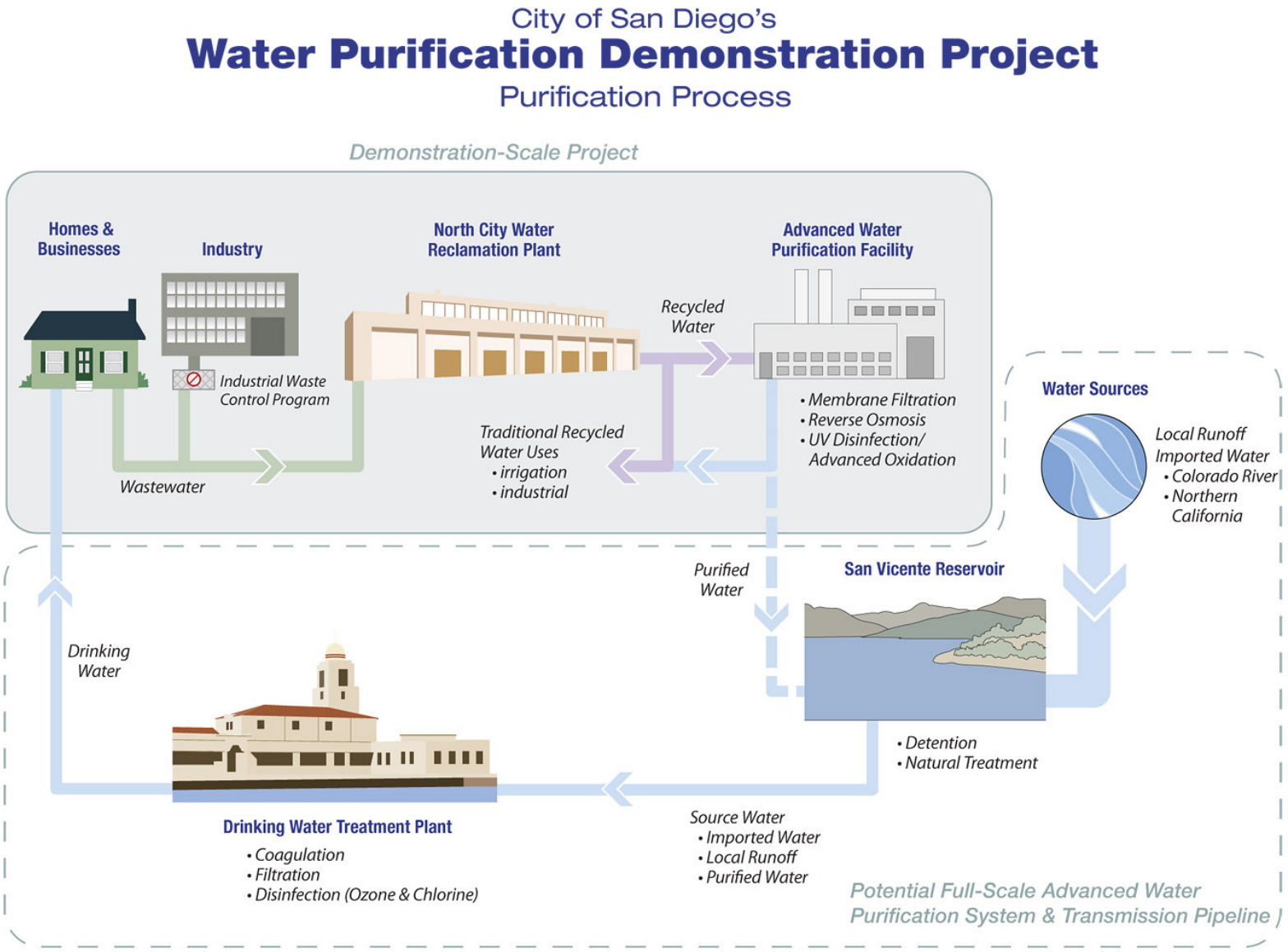
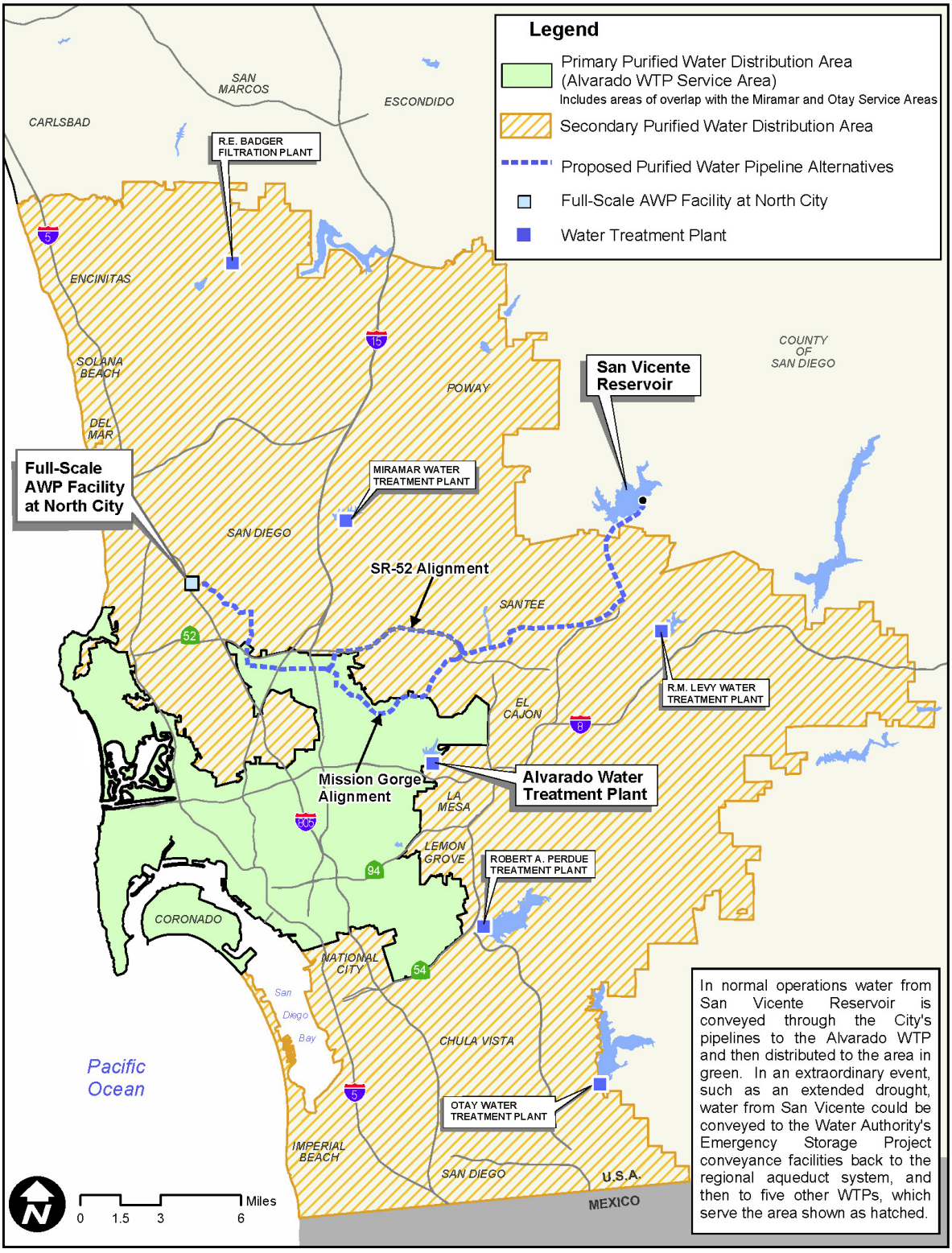


Figure A - 2: Service Area and Facilities of Full-Scale Reservoir Augmentation Project at San Vicente Reservoir



Navigating a Complex Regulatory Setting

Projects in California that involve supplementing ground and surface waters with purified water are regulated by both the California Department of Public Health (CDPH) and the State Water Resources Control Board (State Board) through nine Regional Water Quality Control Boards. To date, seven projects that augment local supplies with purified water have been permitted in California, shown in Table A-1.

Table A - 1: Purified Water Projects Permitted in California

Project Name	Agency	Start Year	Treatment Capacity (mgd)	Actual Deliveries (AFY)[3]
Montebello Forebay Groundwater Recharge Project	Los Angeles County Sanitation District	1962	47.5	50,000
Water Factory 21[1]	Orange County Water District	1977	15.0	10,000
West Coast Basin Seawater Barrier Project	West Basin Municipal Water District	1995	30	5,000
Alamitos Seawater Barrier Project	Water Replenishment District of Southern California	2005	3	3,000
Chino Basin Groundwater Recharge Project[2]	Inland Empire Utilities Agency	2005	18.0	10,000
Dominguez Gap Seawater Barrier Project	Water Replenishment District of Southern California	2006	4.5	1,000
Groundwater Replenishment System Seawater Barrier and Groundwater Replenishment Projects	Orange County Water District	2008	70	66,000 – 72,000

Footnotes:

1. Water Factory 21 began operation in 1976 implementing granular activated carbon. Reverse osmosis was added to treat half the flow in 1977.
2. Full capacity of the Chino Basin Groundwater Recharge Project is 84.4 mgd; however, only 18.0 mgd receives soil aquifer treatment (SAT).
3. AFY = acre-feet per year.

Although these seven permitted projects differ from the City's potential reservoir augmentation project at San Vicente Reservoir—they all focus on augmentation of groundwater supplies as opposed to augmentation of surface water supplies—most use the same water purification technology and have been permitted within the same regulatory framework as the City's potential project. Reservoir augmentation is practiced in other parts of the United States with less rigorous water purification processes. For example, since 1978 the Upper Occoquan Service Authority has added recycled water into a stream above Occoquan Reservoir, which supplies a drinking water treatment plant in Fairfax County, Virginia.

A key component of the Demonstration Project was coordination with both CDPH and the San Diego Regional Water Quality Control Board (Regional Board) to clarify permit conditions and develop sufficient information to determine the regulatory feasibility of a reservoir augmentation project at San Vicente Reservoir. A detailed discussion of regulatory coordination activities conducted as part of the Demonstration Project is presented in Section D of this Project Report.

California Department of Public Health

CDPH is responsible for overseeing public health issues in California and permitting public water supply projects, including projects using purified water to supplement a local water supply. CDPH is in the process of finalizing draft regulations for groundwater augmentation projects using purified water. State legislation passed in 2010 requires CDPH to establish regulations for water purification via surface water augmentation by 2016. In the meantime, surface water augmentation projects like the City's potential reservoir augmentation project at San Vicente Reservoir can be permitted on a case-by-case basis, using the pending groundwater augmentation regulations as guidance. The City's reservoir augmentation project at San Vicente Reservoir would need to meet all state and federal drinking water standards applicable to public water systems, as well as the water purification standards in California's draft groundwater augmentation regulations. The draft groundwater augmentation regulations are very stringent—in many cases exceeding drinking water standards.

Regional Water Quality Control Board

The Regional Board is responsible for developing and enforcing water quality objectives for surface and groundwater bodies within the San Diego region. Because the City's potential reservoir augmentation project at San Vicente Reservoir would involve releasing purified water into San Vicente Reservoir, the project would fall under the jurisdiction of the Regional Board. Unlike groundwater augmentation projects, which often require only a Waste Discharge Requirements (WDR) permit, projects involving release of purified water into surface water bodies require National Pollutant Discharge Elimination System (NPDES) permits. Approval of NPDES permits involves the United States Environmental Protection Agency (EPA) as well as the Regional Board.

An NPDES permit for the City's reservoir augmentation project at San Vicente Reservoir would place limitations on the purified water released into San Vicente Reservoir and incorporate water quality requirements and limits. Surface water quality objectives for San Vicente Reservoir are established by the Regional Board in the *Water Quality Control Plan for the San Diego Basin* (Basin Plan). The Basin Plan establishes water quality objectives for specific water bodies depending on established beneficial uses, which serve as the basis for some NPDES permit limits and conditions.

Regulatory acceptance of the City's Demonstration Project was validated through a Concept Approval letter from the CDPH, a Resolution of Support from the Regional Board, and a Letter of Concurrence from the Regional Board strongly supporting the efforts of the City and concurring on the preferred regulatory pathway.

Independent Advisory Panel

Demonstration Project IAP Members

One example of the high standards established by CDPH for projects involving water purification is the requirement to convene an Independent Advisory Panel (IAP) to provide expert peer review of the technical, scientific, and regulatory aspects of the City's water purification concept. An IAP, organized and managed by the National Water Research Institute (NWRI), was convened in 2009 to oversee the Demonstration Project.

The IAP consisted of 10 academics and professionals with extensive expertise in the science of water reuse, including chemistry, microbiology, treatment engineering, operations engineering, water reuse regulatory criteria, limnology, research science, toxicology, and public and environmental health. The IAP reviewed work products associated with the Demonstration Project and provided feedback on various aspects of the project.

The IAP is a fundamental component of the regulatory framework for the City's reservoir augmentation project at San Vicente Reservoir. This requirement is further discussed in Section D: Regulatory Coordination. Table A-2 summarizes the IAP meetings held in support of the Demonstration Project. Information on the IAP and its review and advisory activities can be found in Appendix F.

Table A - 2: Summary of IAP Meetings

Meeting No.	Date	Topic
1	May 11-12, 2009	Introductory meeting for the full IAP to discuss the Demonstration Project Scope
2	March 29-30, 2010	Limnology (reservoir-related) Subcommittee Meeting No. 1 to discuss set-up and calibration of the San Vicente Reservoir Model[1]
3	September 2, 2010	Limnology Working Group Meeting No. 1 to specify and discuss details pertaining to the San Vicente Reservoir Model[2]
4	October 21, 2010	Advanced Water Purification (AWP) Facility Subcommittee Meeting No. 1 to discuss the draft Testing and Monitoring Plan[3]
5	March 17, 2011	Limnology Working Group Meeting No. 2 to review San Vicente Reservoir modeling scenarios, determine potential "worst case scenarios," and discuss pathogen removal[2]
6	June 6-7, 2011	Second meeting of the full IAP to update the group on the Limnology Subcommittee, Limnology Working Group, and AWP Facility Subcommittee activities, and tour the AWP Facility
7	December 6, 2011	Limnology Subcommittee Meeting No. 2 to review and receive comments on the draft San Vicente Reservoir modeling study, and receive input on proposed reservoir public health-related regulatory conditions[1]
8	December 19, 2011	AWP Facility Subcommittee Meeting No. 2 to review AWP Facility operational and water quality data[3]
9	March 9-21, 2012	Conference calls to review and discuss Draft CDPH Proposal[4]
10	March 13, 2012	Limnology Subcommittee Meeting No. 3 to review the San Vicente Reservoir Water Quality Report[1]
11	November 15-16, 2012	Third meeting of the full IAP to review and comment on the Demonstration Project Report and Quarterly Testing Report No. 4 (CDM Smith and MWH, 2013b)

Footnotes:

1. The Limnology Subcommittee was comprised of four IAP members focused on the Limnology Study.
2. The Limnology Working Group was comprised of two IAP members and project staff specifically assigned to vetting the details of the reservoir study.
3. The AWP Facility Subcommittee was comprised of four IAP members focused on the operation and results of the AWP Facility.
4. An ad-hoc subcommittee provided review and comment via a series of conference calls in lieu of face-to-face meetings.

The Demonstration Project – a Path Forward

On October 29, 2007, the City Council voted to accept the Water Reuse Study and directed the Mayor and City staff to implement actions to demonstrate the feasibility of reservoir augmentation at San Vicente Reservoir. These actions, known as the Demonstration Project, were intended to evaluate the feasibility of implementing a reservoir augmentation project at San Vicente Reservoir by determining whether advanced water purification technology can safely and reliably produce purified water that could be sent to a reservoir and later treated at a drinking water treatment plant and distributed as drinking water.

Evolving Terminology

Over time, terminology associated with the City's reservoir augmentation project at San Vicente Reservoir has evolved in response to changes within the industry. When the project was first conceptualized, it was described as an Indirect Potable Reuse / Reservoir Augmentation Demonstration Project. This report refers to the same concept as the Water Purification Demonstration Project (Demonstration Project). Similarly, the Advanced Water Treatment Plant (AWT) conceptualized in early stages of the project is referred to in this report as the advanced water purification (AWP) facility. These changes in terminology reflect an industry-wide recognition that the processes implemented in the AWP facility extend beyond advanced water treatment, and may be more accurately described as water purification processes.

The budget for the Demonstration Project was $11.8 million. Funding for the project was secured through a $1.07 million California Department of Water Resources Integrated Regional Water Management Program (IRWM) grant, a $2.95 million grant from the Bureau of Reclamation, and a temporary water rate increase approved by City Council in November 2008. This temporary rate increase was in effect from January 2009 to September 2010.

Demonstration Project Components

1. Convene an Independent Advisory Panel
2. Design, construct, and operate a demonstration-scale advanced water purification facility at the North City Water Reclamation Plant
3. Conduct a study of San Vicente Reservoir to establish residence time and water quality parameters and conditions of purified water in the reservoir
4. Perform an energy and economic analysis
5. Define the state's regulatory requirements for a full-scale reservoir augmentation project at San Vicente Reservoir
6. Perform a pipeline alignment study
7. Conduct a public outreach and education program

Note: the 2007 City Council directive referred to the advanced water purification facility as the advanced water treatment (AWT) plant and purified water as AWT water. This has been modified to reflect industry-wide changes in terminology.

Figure A-3 presents an overview of the tasks completed as part of the Demonstration Project, consistent with the City Council's aforementioned actions in 2007 and 2008. Key tasks and meetings, reports, and important outcomes are highlighted.

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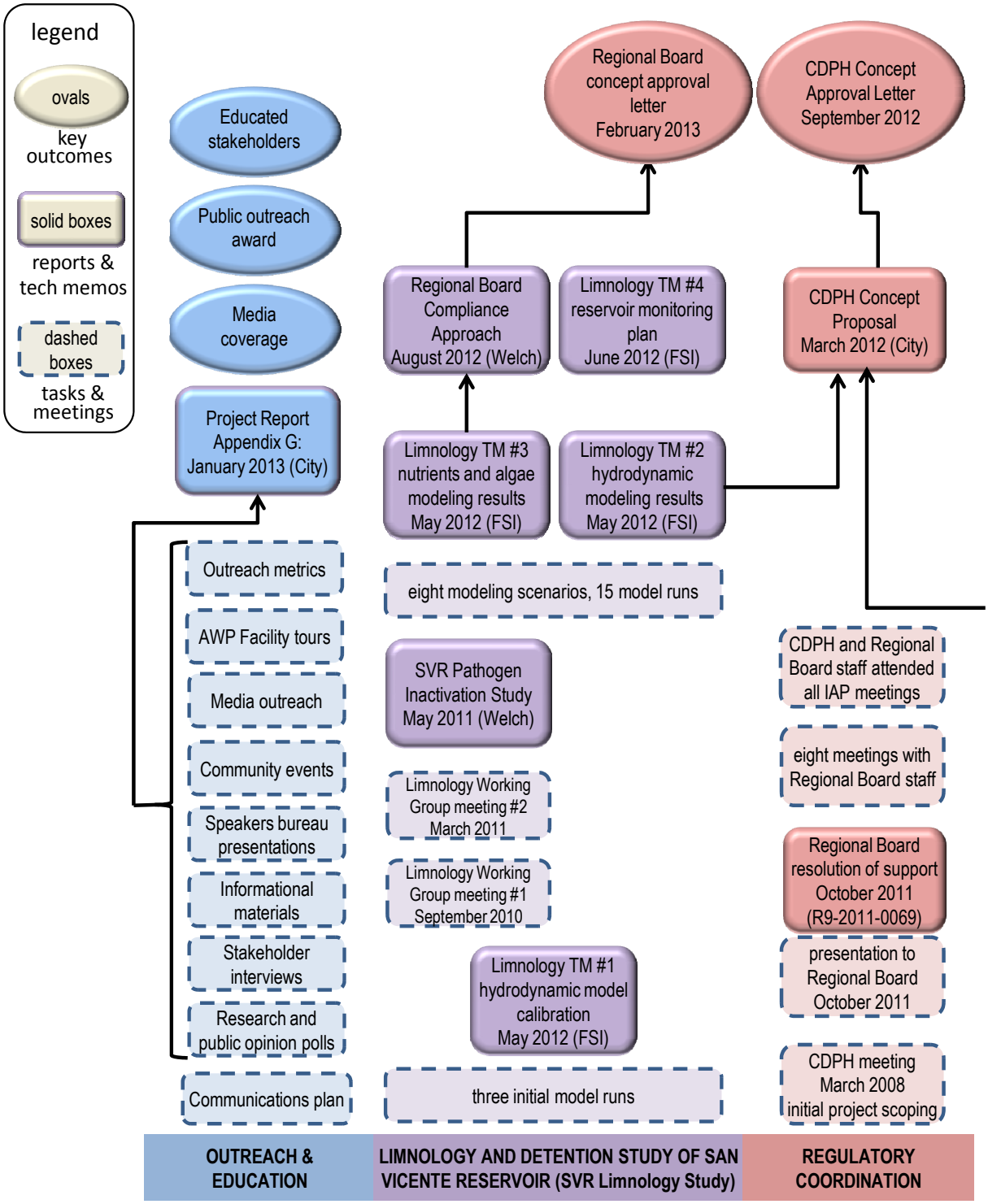
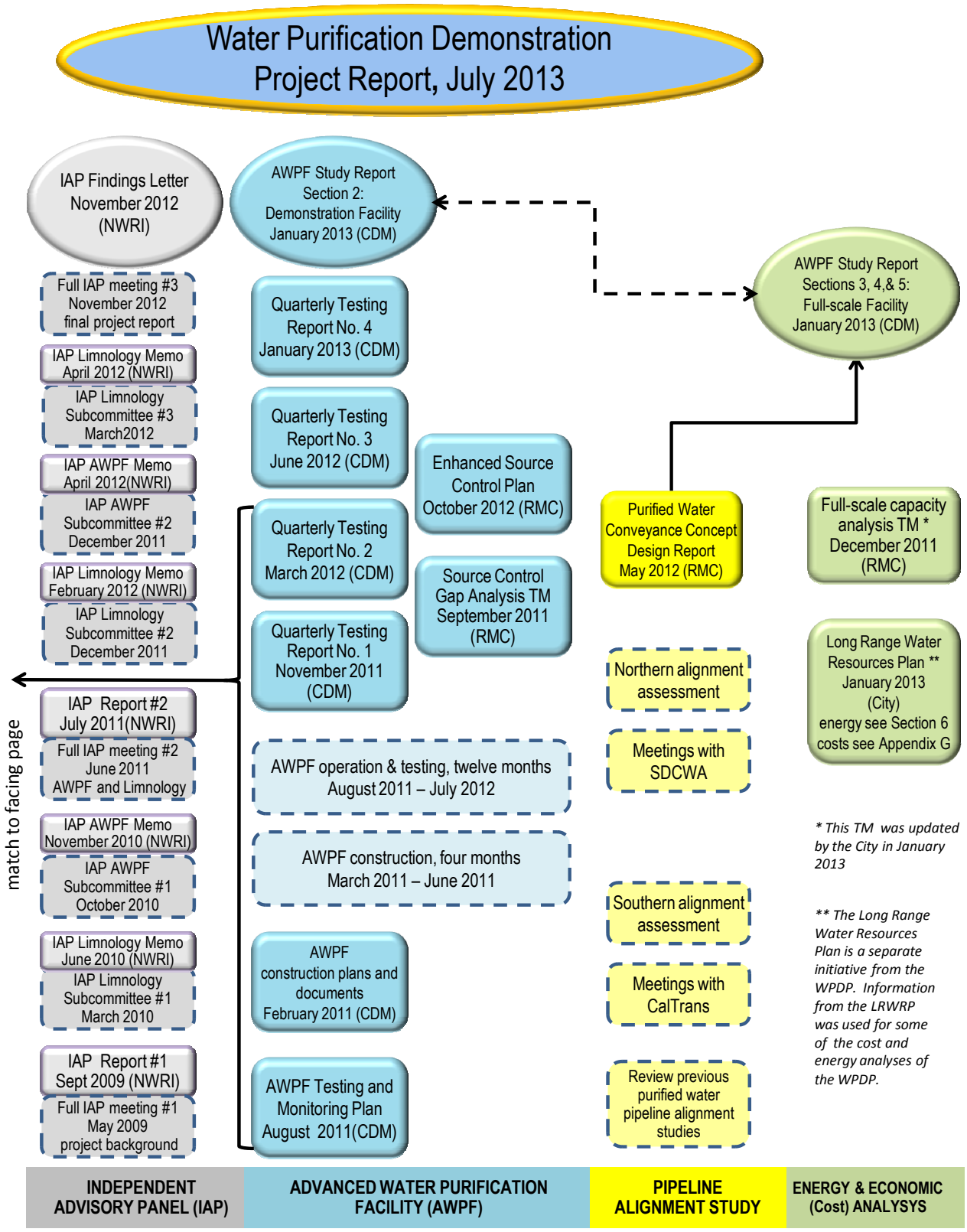
Figure A-3: Key tasks, meetings, reports, and outcomes of the Water Purification Demonstration Project, from project start in 2009 through project completion in 2013




Water Purification Demonstration Project Report, July 2013
IAP Findings Letter November 2012 (NWRI)
AWPF Study Report Section 2: Demonstration Facility January 2013 (CDM)
AWPF Study Report Sections 3, 4,& 5: Full-scale Facility January 2013 (CDM)
Full IAP meeting #3 November 2012 final project report
IAP Limnology Memo April 2012 (NWRI)
IAP Limnology Subcommittee #3 March2012
IAP AWPF Memo April 2012(NWRI)
IAP AWPF Subcommittee #2 December 2011
IAP Limnology Memo February 2012 (NWRI)
IAP Limnology Subcommittee #2 December 2011
IAP Report #2 July 2011(NWRI)
Full IAP meeting #2 June 2011 AWPF and Limnology
IAP AWPF Memo November 2010 (NWRI)
IAP AWPF Subcommittee #1 October 2010
IAP Limnology Memo June 2010 (NWRI)
IAP Limnology Subcommittee #1 March 2010
IAP Report #1 Sept 2009 (NWRI)
Full IAP meeting #1 May 2009 project background
match to facing page
Quarterly Testing Report No. 4 January 2013 (CDM)
Quarterly Testing Report No. 3 June 2012 (CDM)
Quarterly Testing Report No. 2 March 2012 (CDM)
Quarterly Testing Report No. 1 November 2011 (CDM)
Enhanced Source Control Plan October 2012 (RMC)
Source Control Gap Analysis TM September 2011 (RMC)
AWPF operation & testing, twelve months August 2011 – July 2012
AWPF construction, four months March 2011 – June 2011
AWPF construction plans and documents February 2011 (CDM)
AWPF Testing and Monitoring Plan August 2011(CDM)
Purified Water Conveyance Concept Design Report May 2012 (RMC)
Full-scale capacity analysis TM * December 2011 (RMC)
Long Range Water Resources Plan ** January 2013 (City) energy see Section 6 costs see Appendix G
Northern alignment assessment
Meetings with SDCWA
Southern alignment assessment
Meetings with CalTrans
Review previous purified water pipeline alignment studies
* This TM was updated by the City in January 2013
** The Long Range Water Resources Plan is a separate initiative from the WPDP. Information from the LRWRP was used for some of the cost and energy analyses of the WPDP.
INDEPENDENT ADVISORY PANEL (IAP)
ADVANCED WATER PURIFICATION FACILITY (AWPF)
PIPELINE ALIGNMENT STUDY
ENERGY & ECONOMIC (Cost) ANALYSYS

Summary of Findings

The Demonstration Project generated a substantial amount of data related to expected performance of a reservoir augmentation project at San Vicente Reservoir. Major findings of the Demonstration Project are summarized in the following discussion by project component. Each Demonstration Project component is described in further detail later in this Project Report.

Demonstration Advanced Water Purification Facility

The City operated a demonstration-scale Advanced Water Purification Facility (AWP Facility) to gather information on water quality, equipment reliability, regulatory requirements, capital and operating cost, and energy consumption that could be expected if a full-scale advanced water purification facility (full-scale AWP facility) were constructed. Additional benefits included verifying accuracy of online monitoring equipment, optimizing process cost, conducting public tours, and securing regulatory approval.

The AWP Facility was designed, installed, operated, and tested between September 2010 and July 2012. Start-up of the AWP Facility occurred over a one-and-a-half month period (mid-June 2011 through the end of July 2011), and facility testing spanned the following year (August 2011 through July 2012). Although the testing period is complete, the AWP Facility continues to operate for public tours (refer to Section E of this report) and to gather additional equipment performance data.

The Demonstration Facility was installed and operated to produce and test purified water.

The AWP Facility was designed in accordance with the industry-standard multiple barrier approach for water purification processes established by CDPH in the Groundwater Replenishment Reuse Draft Regulation (CDPH, 2011). The major process components were membrane filtration, reverse osmosis, and ultraviolet (UV) disinfection/advanced oxidation.

Key findings from the AWP Facility include:

<u>Monitoring</u>

- Daily testing to identify potential breaches in the membrane filtration units
- Continuous measurement of total organic carbon (TOC) and conductivity to demonstrate that the reverse osmosis system was performing as expected
- Continuous UV reactor power level monitoring to confirm UV lamp operations
- Daily monitoring of hydrogen peroxide dose and continuous flow confirmation to demonstrate that the target hydrogen peroxide dose was achieved

This daily and continuous testing was conducted throughout the 12-month testing period. This extensive monitoring showed that the AWP Facility equipment met the intended treatment performance on a continuous basis and was reliable throughout the operational period.

Comprehensive Water Quality Testing

- Comprehensive water quality testing at the AWP Facility included more than 9,000 tests of the purified water at various points in the treatment process and for 342 different constituents.
- Water quality of the purified water was compared to regulatory limits, verifying that purified water met all applicable water quality standards.

This comprehensive water quality testing shows that the purified water produced at the AWP Facility is pure, approaching distilled water quality. For example, the total dissolved solids (TDS, a measure of salt content) in the purified water is about 15 milligrams per liter (mg/L), compared to TDS in San Diego's source and drinking water of about 500 mg/L. As a second example, the TOC (a measure of carbon that is bound in organic molecules) in the purified water is about 0.1 mg/L compared to TOC of 3.0 mg/L in San Diego's source water and 2.5 mg/L in San Diego's drinking water (City of San Diego, 2012a, City of San Diego, 2012g).

San Vicente Reservoir Study

Supplementing local water sources with purified water is a practice that is gaining wide-ranging support, due in part to projects such as the Orange County Groundwater Replenishment System (GWRS). Although water purification technology is widely recognized as capable of making recycled water into purified water that is drinkable, the regulatory community requires that purified water be retained in an environmental buffer, such as a groundwater basin or a surface water reservoir, prior to being blended into a drinking water system. Retaining purified water in an environmental buffer is considered an additional public health protection feature since it provides dilution by blending the purified water with other water sources and adequate retention time by holding the purified water prior to its release to a drinking water treatment plant. It should be noted that purified water is the best quality water supply available to San Diego. Introducing purified water into San Vicente Reservoir and blending it with lesser quality raw water sources could improve the overall water quality in San Diego's drinking water system.

San Vicente Reservoir is capable of providing environmental buffer features required by regulatory agencies.

San Vicente Reservoir could serve as a highly effective environmental buffer because, in addition to having sufficient storage available to accommodate fluctuating purified water flows throughout the year, it has unique characteristics that would assist in meeting regulatory requirements. Specifically, its large capacity and other natural characteristics, described in detail in Section C of this report, would allow the reservoir to retain the purified water for a substantial period of time before delivery to a municipal drinking water treatment plant such as the Alvarado Water Treatment Plant for final treatment.

To clearly demonstrate the potential reliability characteristics provided by San Vicente Reservoir, a three-dimensional hydrodynamic computer model of the reservoir was set up, including retention time and dilution components as well as a water quality component. The model was used in conjunction with both the Regional Board and CDPH, whose feedback was important to this process due to regulatory requirements for dilution, retention, and water quality conditions. Model set up and validation were also reviewed by the Demonstration Project's IAP, which formed a subcommittee specifically to work closely with the City and its consultants to review and comment on the various scenarios and data.

For the San Vicente Reservoir Study, 18 separate runs of the three-dimensional hydrodynamic model were performed. From these model runs, the project team - with input from the IAP - selected eight modeling scenarios for further assessment and analysis. These modeling scenarios were selected because they represent the full range of operational conditions that a reservoir augmentation project at San Vicente Reservoir could encounter, ranging from average water supply and demand conditions to extreme drought conditions when water demand would be higher than average and natural water levels (water surface level) within the reservoir would be lower than average. The reservoir model also tested four potential locations where purified water could enter San Vicente Reservoir to determine if the location of the purified water's entrance into the reservoir had an impact on water quality, retention, or dilution. Lastly, the reservoir model took into consideration the San Vicente Dam Raise Project, which will more than double the size of the reservoir. The model was used to simulate water movement through the enlarged reservoir. Table A-3 summarizes the eight model scenarios evaluated. The modeling results were provided in five "sets" of modeling runs and captured the expected result of adding purified water to San Vicente Reservoir under the anticipated operating conditions.

More detailed information on the completed modeling runs is provided in Section C, Table C-1 and the Flow Science reports cited in the References section of this report.

Table A - 3: Summary of Model Scenarios Evaluated

No.	Operating Scenario Evaluated
1	**Base Case – Design Inlet Location:** simulated reservoir conditions under median expected storage and normal expected operations with purified water inlet simulated at the Design Inlet Location, shown on Figure C-2.
2	**Base Case – Existing Aqueduct Inlet Location:** simulated reservoir conditions under median expected storage and normal expected operations, with purified water inlet simulated at the Existing Aqueduct Inlet Location, shown on Figure C-2.
3	**Base Case – New Aqueduct Inlet Location:** simulated reservoir conditions under median expected storage and normal expected operations, with purified water inlet at the New Aqueduct Inlet Location, shown on Figure C-2.
4	**Base Case – Barona Arm Inlet Location:** simulated reservoir conditions under median expected storage and normal expected operations with purified water inlet simulated at the Existing Barona Arm Inlet Location, shown on Figure C-2.
5	**No Purified Water Additions:** simulated reservoir conditions similar to Base Case, except there are no purified water additions and an equal reduction in reservoir outflow.
6	**Extended Drought – Design Inlet Location:** simulated reservoir conditions in a hypothetical two-year drought where a large and constant volume of water is withdrawn monthly from the reservoir without importing additional water to refill the reservoir. Purified water inlet was simulated at the Design Inlet Location, shown on Figure C-2.
7	**Extended Drought – New Aqueduct Inlet Location:** simulated reservoir conditions in a hypothetical two-year drought where a large and constant volume of water is withdrawn monthly from the reservoir without importing additional water to refill the reservoir. Purified water inlet was simulated at the New Aqueduct Inlet Location, shown on Figure C-2.
8	**Emergency Drawdown:** simulates reservoir conditions in a hypothetical emergency drawdown situation.

Key findings from the San Vicente Reservoir Study include:

- The addition of purified water into San Vicente Reservoir would not affect natural hydrologic characteristics of the reservoir, seasonal stratification, or mixing. This finding demonstrates that the addition of purified water would not impede the natural blending and retention in the reservoir.
- Dilution and retention of purified water in San Vicente Reservoir would constitute a substantial environmental barrier, sufficient to meet regulatory requirements.
- For all anticipated reservoir operating scenarios and purified water inlet locations, the reservoir would dilute the purified water at all times by at least a factor of 200 to one prior to conveying to the drinking water treatment plant.

- The addition of purified water would not affect water quality in San Vicente Reservoir. The dam raise and reservoir expansion, which is independent of the Demonstration Project, will improve overall water quality in the reservoir by reducing nutrients that cause water quality issues, and the addition of purified water will not change these improvements. In addition, purified water would reduce the salt concentration in the reservoir and improve drinking water quality.

Regulatory Coordination

Prior to moving forward with implementation, the City's reservoir augmentation project at San Vicente Reservoir would require approval by CDPH and the Regional Board. Neither CDPH nor the Regional Board has specific regulations in place for reservoir augmentation projects. A key objective of the Demonstration Project was to work with these regulatory agencies to establish the project features and operating requirements that would ensure public health protection, enabling approval of the City's reservoir augmentation project at San Vicente Reservoir.

Coordination with applicable regulatory agencies was a critical component of the Demonstration Project.

CDPH has authority to approve reservoir augmentation projects on a case-by-case basis. An additional goal of the Demonstration Project was to facilitate concept approval from CDPH for a reservoir augmentation project at San Vicente Reservoir. The City submitted a proposal to CDPH in March 2012 that presented specific public health protections provided by a reservoir augmentation project at San Vicente Reservoir and summarized technical study results obtained throughout the Demonstration Project and validated by the IAP (City of San Diego, 2012d). The City's proposal, provided in Appendix A, articulated how a reservoir augmentation project at San Vicente Reservoir would provide a robust, multiple barrier approach fundamental to public health protection by incorporating the following elements:

- **Enhanced source control** to prevent potential contaminants from entering the wastewater stream
- **Control of pathogens** (potential disease-causing organisms such as viruses, bacteria, protozoa, and fungi) through the use of existing recycled water treatment and implementation of advanced water purification processes
- **Control of nitrogen compounds** through implementation of advanced water purification processes

- **Reliable removal of regulated contaminants and constituents of emerging concern**, achieved through implementation of an advanced water purification process and monitoring plan focused on removal and frequent measurement of these constituents
- **Reliability and redundancy** to meet regulatory requirements and to prevent purified water from entering San Vicente Reservoir if necessary
- **Monitoring and response plan** designed to detect any unexpected operational issues at the full-scale AWP facility or source water contamination before the purified water reaches San Vicente Reservoir

Based on the multiple barrier approach outlined in the City's proposal, CDPH sent the City a Concept Approval Letter for a reservoir augmentation project at San Vicente Reservoir on September 7, 2012 (Appendix B).

The City also convened a series of meetings with the Regional Board throughout the Demonstration Project that focused on clarifying the Regional Board's regulatory framework for permitting a reservoir augmentation project at San Vicente Reservoir. On October 12, 2011, the Regional Board adopted Resolution No. R9-2011-0069 (provided as Appendix C), which documented the Regional Board's support for a reservoir augmentation project at San Vicente Reservoir. The resolution also established that the Regional Board would regulate the City's project at San Vicente Reservoir through an NPDES permit. In August 2012 the City submitted to the Regional Board a document entitled *Proposed Regional Water Quality Control Board Compliance Approach,* provided as Appendix D (City of San Diego, 2012e). This document summarizes the City's potential reservoir augmentation project at San Vicente Reservoir, identifies key permitting issues, and proposes a regulatory pathway that the Regional Board could follow to approve a full-scale project at San Vicente Reservoir. The Regional Board, working together with the EPA, reviewed the City's submittal and acknowledged in a February 2013 letter that an NPDES permit could be issued for a reservoir augmentation project at San Vicente Reservoir based on the City's preferred regulatory pathway. That letter, provided in Appendix E, also acknowledged both the Regional Board's and EPA's strong support for the City's efforts in considering a full-scale reservoir augmentation project at San Vicente Reservoir.

Key findings from the regulatory coordination effort include:

- The combination of advanced water purification technology and San Vicente Reservoir conditions would provide the necessary safeguards to make reservoir augmentation feasible from a regulatory perspective.
- Regulatory acceptance of the City's Demonstration Project was validated through a Concept Approval letter from CDPH and a Resolution of Support and Letter of Concurrence from the Regional Board.

Public Outreach and Education

The public outreach and education program for the Demonstration Project was a continuation of outreach efforts that started with the Water Reuse Study, building on the foundation laid during that

study. A strategic outreach plan was developed at the outset of the Demonstration Project to guide the continuation of this program. Throughout the duration of the Demonstration Project, the City sought to ensure that information was presented in a clear, understandable, and accessible way to residents in all areas of the City. Information about the Demonstration Project was also provided through a variety of formats including direct contact with individuals, written and electronic materials, traditional and social media, group presentations, community events, and tours of the AWP Facility. Additional information on the public outreach and education program for the Demonstration Project can be found in the companion CD, which is Appendix H of this report. The following outreach activities were completed as part of the Demonstration Project:

- Developed the outreach plan
- Conducted research, including one-on-one stakeholder interviews
- Produced informational materials
- Assembled a speakers bureau composed of project team members and Public Utilities Department staff
- Created a presentation about the project for community groups
- Requested community group recommendations from City Council members to contact for presentation opportunities
- Conducted project presentations to community organizations, internal staff, the City's Independent Rates Oversight Committee (IROC) and Natural Resources & Culture Committee (NR&C)
- Participated in industry conferences
- Developed an email list database of individuals interested in the project
- Distributed eUpdates and electronic newsletters to interested parties
- Participated in community events
- Provided project information to a broad group of media representatives and outlets
- Compiled quarterly metrics reports and analyzed them to guide future outreach activities
- Launched the Urban Water Cycle Tour program, which culminated in AWP Facility tours
- Invited elected officials and project stakeholders to visit the AWP Facility when it began operation in mid-2011
- Developed informational materials, such as a virtual tour video, project white papers and a tour brochure
- Established a social media presence online using Facebook, Twitter, and YouTube
- Implemented continuous improvements in the AWP Facility tours based on feedback from tour guests
- Continuously enhanced the community presentations based on attendee feedback

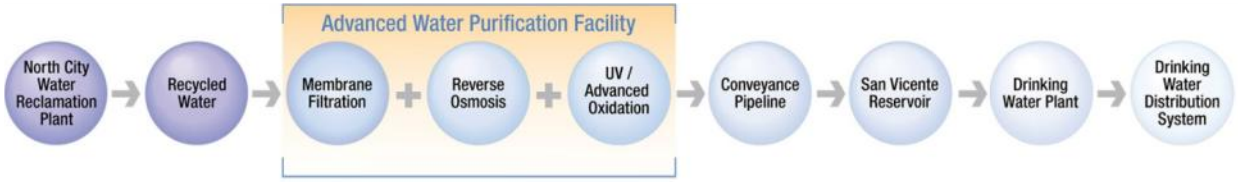
Key findings from the public outreach effort include:

- Feedback from more than 3,200 individuals who have toured the AWP Facility shows that providing an opportunity to tour the facility increases understanding about water purification processes.
- Survey research shows a steady increase from 2004 (26 percent) to 2011 (68 percent) to 2012 (73 percent) in City residents who favor using advanced treated recycled water as an addition to the City's drinking water supply.

Full-Scale Project Considerations

Potential implications of a full-scale project need to be well understood before a decision to implement such a project can be made. Full-scale project components evaluated during the Demonstration Project included source control enhancement, North City Water Reclamation Plant (North City) operations, full-scale AWP facility construction, pipeline system construction, environmental and regulatory permitting, economic and energy implications, and public outreach. Figure A-4 presents the components of a full-scale reservoir augmentation project at San Vicente Reservoir.

Figure A - 4: Components of a Multiple Barrier Reservoir Augmentation Project at San Vicente Reservoir



Full-scale project considerations include the following.

- **Source Control Enhancement:** The first barrier in the City's multiple barrier approach to water purification is source control, which is the prevention of contaminants from entering the wastewater stream processed at North City. The City already implements a robust Industrial Waste Control Program (IWCP) to protect wastewater treatment processes, recycled water quality, and coastal ocean resources as required by the Point Loma Wastewater Treatment Plant (Point Loma) discharge permit (refer to Section F for more information). The IWCP includes a pretreatment program for the City of San Diego and each of the 15 Participating Agencies, as well as other source control programs. Despite the extensive program currently in place, CDPH requires heightened vigilance and inclusion of residential and commercial programs in systems in which the purified water end product would enter the drinking water system. Orange County Sanitation District (OCSD) has implemented an enhanced source control program to support the GWRS. The City has reviewed that program and concluded that the following components would be appropriate

enhancements to the City's existing IWCP, should the City pursue reservoir augmentation at San Vicente Reservoir.

  - Develop a Chemical Inventory Program and Geographic Information System (GIS) Tracking system, which is an expanded industrial and commercial discharger chemical inventory database linked to discharger locations that are tracked using GIS software
  - Implement a Pollutant Prioritization Program, which would involve prioritizing pollutants through sampling, characterizing constituents of emerging concern (CECs) at the full-scale AWP facility, and determining if pollutants can be controlled through targeted source control for individual dischargers or commercial sectors
  - Perform an annual Local Limits Evaluation, which would consider including additional pollutants of concern on North City's list of local limits, and potentially lowering the limit of pollutants already on the list

- **North City Water Reclamation Plant Operations:** The IAP noted that North City already has key reliability features, including conservative operating criteria and flow equalization, to support a reservoir augmentation project at San Vicente Reservoir.
- **Full-Scale AWP Facility and Pipeline System Components:** The City evaluated construction considerations for a potential full-scale AWP facility with a capacity of 18 mgd and an estimated average production of 15 mgd, including facility components; production capacity; site location and layout; system controls, reliability, and redundancy; and full-scale AWP facility costs. Average production (15 mgd) is expected to be slightly lower than maximum treatment capacity (18 mgd) because production will vary throughout the year due to routine maintenance requirements and seasonal fluctuations in recycled water demand. During periods of low recycled water demand, full production capacity maybe attained, while in months of peak recycled water demand, it will be less than capacity, averaging approximately 15 mgd on a year-round basis. The City completed a conceptual design study for the purified water pipeline system that would be needed to transport water from a full-scale AWP facility (located at North City) to San Vicente Reservoir. This conceptual design study reviewed potential pipeline alignments and pump station specifications. Capital costs for full-scale AWP facility and pipeline system construction, which reflect data and information developed as part of the Demonstration Project, are estimated to be approximately $370 million, with annual operations and maintenance costs estimated to be approximately $16 million per year. This corresponds to a unit cost of approximately $2,000/ AF. This estimate is consistent with the 2012 LRWRP, which estimated that a full-scale reservoir augmentation project at San Vicente Reservoir would cost approximately $2,100/AF, including initial capital and annual operating costs (and energy). This would result in an increase of approximately $6.87 to an average monthly residential water bill. However, the project would also result in approximately $1,000/AF in avoided wastewater costs, resulting in a net cost of approximately $1,000/AF. Projected costs are described in further detail in the AWP Facility and Pipeline System Costs portion of Section F.

- **Environmental and Regulatory Permitting:** The Demonstration Project documented the regulatory requirements associated with a reservoir augmentation project at San Vicente Reservoir. Required regulatory documentation would likely include an Environmental Impact Report (EIR) and an Environmental Impact Statement (EIS); CDPH permitting, which would include developing an Engineering Report, convening three CDPH-led public hearings to comply with Section 116551 of the Health and Safety Code - Augmentation of Source with Recycled Water, issuing CDPH Findings of Fact, and amending the City's Water Supply Permit by CDPH to acknowledge a change of source water; and Regional Board permitting, which would include issuing a tentative permit, holding a public hearing, and issuing the formal permit.
- **LRWRP Energy Analysis:** Energy usage was estimated for a reservoir augmentation project at San Vicente Reservoir through development of the City's draft 2012 LRWRP, which provides the City with a water resources strategy to meet future water needs through 2035. The full-scale reservoir augmentation project at San Vicente Reservoir evaluated in development of the draft 2012 LRWRP would require approximately 2,500 kilowatt hours per acre-foot (kWh/AF) of energy, and would produce approximately 1.0 metric tons of greenhouse gases/AF. By comparison, imported water requires a range of 2,000 kWh/AF to 3,300 kWh/AF of energy, depending on the blend of water from the Colorado River or the Bay-Delta in Northern California, respectively. This corresponds to a range of 0.8 to 1.3 metric tons of greenhouse gases/AF (City of San Diego, 2012c). Since 2003, the blend delivered to the Water Authority has averaged approximately two-thirds Colorado River and one-third water from the Bay-Delta. Future imported water energy consumption will vary depending on actual blend. However, for practical purposes, the reservoir augmentation project at San Vicente Reservoir energy consumption is equivalent to that of imported water.
- **Public Outreach and Education Program:** The City has conducted extensive public outreach and education to make City residents aware of the potential implications and benefits of reservoir augmentation at San Vicente Reservoir. Should the City decide to move forward with a full-scale project, the interest level of the general population would be expected to increase and comprehensive outreach and education would need to continue. It is recommended that, should the City decide to move forward with a reservoir augmentation project at San Vicente Reservoir, the outreach activities conducted during the Demonstration Project be continued.

Summary of Findings

Table A-4 summarizes the Demonstration Project components and findings.

Table A - 4: Summary of Demonstration Project Findings

Project Component	Key Findings
Convene an Independent Advisory Panel	The IAP unanimously concluded that a reservoir augmentation project at San Vicente Reservoir would be a landmark project in the acceptance and furtherance of indirect potable reuse and would contribute to the City of San Diego's water portfolio.
Design, construct, and operate a demonstration-scale advanced water purification facility at the North City Water Reclamation Plant	The AWP Facility was designed, installed, operated, and tested between 2010 and 2012. Purified water produced at the AWP Facility reliably met applicable water quality standards.
Conduct a study of San Vicente Reservoir to establish residence time and water quality parameters and conditions of purified water in the reservoir	Addition of purified water into San Vicente Reservoir would not affect natural reservoir conditions and would meet regulatory requirements.
	San Vicente Reservoir would provide significant dilution of purified water.
	The addition of purified water would not impair existing conditions of San Vicente Reservoir, and could improve nutrient-related water quality issues.
Perform an energy and economic analysis	The estimated capital and annual operational and maintenance costs for a reservoir augmentation project at San Vicente Reservoir are $369 million and $15.5 million/year, respectively. This equates to approximately $2,000/AF, or an increase of approximately $6.87 to an average monthly household water bill. These costs are consistent with the City's draft 2012 LRWRP, which projected a reservoir augmentation project at San Vicente Reservoir to cost approximately $2,100/AF. In addition, the project would generate approximately $1,000/AF in avoided wastewater management costs.
	The reservoir augmentation project at San Vicente Reservoir would require approximately the same amount of energy and produce approximately the same amount of greenhouse gas emissions compared to imported water supplies.
	All three of the highest ranked portfolios in the 2012 LRWRP included a reservoir augmentation project at San Vicente Reservoir as a common resource option.

Project Component	Key Findings
Define the state's regulatory requirements for a full-scale reservoir augmentation project at San Vicente Reservoir	Results from the AWP Facility and reservoir studies provided evidence that the combination of advanced water purification technology and San Vicente Reservoir conditions would provide public health and environmental safeguards that would make reservoir augmentation feasible from a regulatory perspective. Regulatory participation in all IAP meetings and working groups addressing all technical aspects of reservoir augmentation conducted throughout the Demonstration Project enabled the regulators to establish specific guidelines and regulatory pathways to permitting a reservoir augmentation project. CDPH issued a Concept Approval Letter in September 2012 acknowledging that a reservoir augmentation project at San Vicente Reservoir would meet CDPH requirements. The Regional Board issued a letter in February 2013 concurring with the recommended permitting pathway for a reservoir augmentation project at San Vicente Reservoir.
Perform a pipeline alignment study	Conceptual design identified preferred pipeline alignments and estimated capital and annual operations and maintenance costs for the conveyance system to be $225 million and $3.4 million per year, respectively
Conduct a public outreach and education program	Survey research shows a steady increase from 2004 (26 percent) to 2011 (68 percent) to 2012 (73 percent) of City residents who favor using advanced treated recycled water as an addition to the City's drinking water supply.
	Feedback from individuals who have toured the AWP Facility shows that providing an opportunity to tour the facility increases understanding about water purification.

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