Colorado River Watershed Sanitary Survey

2015 Update

Metropolitan Water District of Southern California

December 2016

This page intentionally left blank

Colorado River Watershed Sanitary Survey
2015 Update

Metropolitan Water District of Southern California

This page intentionally left blank

Preface

Metropolitan Water District of Southern California (Metropolitan) was created in 1928 by an act of the California State Legislature to provide supplemental water to the coastal plain of Southern California. Metropolitan is a consortium of 26 cities and water districts providing drinking water to over 19 million people in its 5,200-square mile service area, which covers parts of Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties.

Metropolitan imports water from two sources: the Colorado River through the Colorado River Aqueduct and from Northern California via the State Water Project's California Aqueduct. California's Surface Water Treatment Rule—Title 22, Article 7, Section 64665 of California Code of Regulations—requires that every public water system treating surface water conduct a comprehensive sanitary survey of its watershed(s) every five years. This report presents the findings of the 2015 update to the Colorado River Watershed Sanitary Survey. The initial sanitary survey was completed in 1996, with updates completed in 2001, 2005, and 2010.

Metropolitan has assumed the responsibility for completing a watershed sanitary survey of the Colorado River (Metropolitan's Whitsett Intake near Parker Dam), the Colorado River Aqueduct, Lake Mathews, Diamond Valley Lake, and Lake Skinner for its member agencies. This report summarizes the results of that survey.

This page intentionally left blank

Project Team

Sun Liang, Ph.D., P.E. – Project Director

Mickey Chaudhuri, P.E. – Project Manager

Maria T. Lopez, P.E. – Project Lead

Project Review and Technical Contributors

Evelyn Bautista

Eric Crofts

Carrie Guo, Ph.D.

Susan Hogan

Stephen Hubbard

Nancy Lieu

Paul McCormick, Ph.D.

Stephen Reynolds

Paul Rochelle, Ph.D.

Mic Stewart, Ph.D.

Suzanne Teague

Tae Yun, P.E.

This page intentionally left blank

Table of Contents

Figures

Tables

Acronyms

Note: This list includes select acronyms frequently used throughout the document.

A

ADEQ......... *Arizona Department of Environment Quality*
AFO .... *animal feeding operation*
CAFO .... *concentrated animal feeding operation*
AMPAC .... *American Pacific Corporation*
ARRA *American Recovery and Reinvestment Act of 2009*

B

BLM............................ *U.S. Bureau of Land Management*
BMP .... *best management practice*

C

CAL FIRE..... *California Department of Forestry and Fire Protection*
CAP .... *Central Arizona Project*
CCDDB .... *Cajalco Creek Dam and Detention Basin*
CCWRD .... *Clark County Water Reclamation District*
CDPH .... *California Department of Public Health*
CEC .... *constituents of emerging concern*
CEQA .... *California Environmental Quality Act*
CERCLA......... *Comprehensive Environmental Response Compensation and Liability Act*
CFR.................................. *Code of Federal Regulations*
CRA .... *Colorado River Aqueduct*
CRWSS........ *Colorado River Watershed Sanitary Survey*
CT... *contact time*
CWA... *Clean Water Act*
CWS .... *community water system*

D

DOC .... *dissolved organic carbon*
DVL... *Diamond Valley Lake*
DWSAP .... *Drinking Water Source Assessment and Protection Program*

E

EDC .... *endocrine disrupting compound*

F

FBR .... *fluidized bed reactor*
FPA .... *flavor profile analysis*

G

GWUDIS . *groundwater supply under direct influence of surface water*

H

HAA5 .... *sum of five regulated haloacetic acids*

I

IESWTR...... *Interim Enhanced Surface Water Treatment Rule*
ISB... *in-situ bioremediation*

L

Lake Mead NRA ... *Lake Mead National Recreation Area*
LID .... low impact development
LT2ESWTR .... *Long Term 2 Enhanced Surface Water Treatment Rule*
LUST......................... *leaking underground storage tank*
UST .... *underground storage tank*

M

MAF .... million acre-feet
MCL
MCLG .... *maximum contaminant level goal*
SMCL........... *secondary maximum contaminant level*
MGD .... *million gallons per day*
MIB *2-methylisoborneol*
MRDL .... *maximum residual disinfectant level*
MRDLG ..... *maximum residual disinfectant level goal*
MRL...................................... *minimum reporting limit*
MS4 .... *municipal separate storm sewer systems*
MSHCP......... *multiple species habitat conservation plan*

N

ND .... *non-detect*
NIPDWR .... *National Interim Primary Drinking Water Regulations*
NL .... *notification level*
NPDES. *National Pollution Discharge Elimination System*
NSDWR *National Secondary Drinking Water Regulations*

O

OEHHA .... *Office of Environmental Health Hazard Assessment*
OEL................................. *operational evaluation level*
OWC......................... *organic wastewater contaminant*

P

PAR .... *photosynthetically active radiation*
PCE .... *tetrachloroethene*
PCS .... *potential contaminant source*
PHG .... *public health goal*
PWS .... *public water system*

R

RCDEH. *Riverside County Department of Environmental Health*
RCRA .... *Resource Conservation and Recovery Act*
RCRPOSD..... *Riverside County Regional Park and Open Space District*
RCTLMA....... *Riverside County Transportation and Land Management Agency*
RL... *response level*

RWQCB .... *Regional Water Quality Control Board*

S

SDWA .... *Safe Drinking Water Act*
SPME .... *solid phase microextraction*
SRP .... *soluble reactive phosphorus*
SUVA .... *specific ultraviolet light absorbance*
SWMP .... *Storm Water Management Program*
SWP .... *State Water Project*
SWRCB .... *State Water Resources Control Board*
SWTR .... *Surface Water Treatment Rule*

T

THM .... *trihalomethane*
TTHM .... *total trihalomethanes*
TKN .... *total Kjeldahl nitrogen*
TMDL .... *total maximum daily load*
TON .... *threshold odor number*
TSS .... *total suspended solids*

U

UCMR
UCMR 1 .... *Unregulated Contaminant Monitoring Regulation 1*
USEPA .... *U.S. Environmental Protection Agency*
USFWS .... *U.S. Fish and Wildlife Service*
USGS .... *U.S. Geological Survey*

W

WMWD .... *Western Municipal Water District*
WQMP .... *Riverside County Water Quality Management Plan for Urban Runoff, Santa Ana River Region and Santa Margarita River Region*
WWTP .... *wastewater treatment plant*

Executive Summary

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Executive Summary

Objectives

This report presents the findings of the 2015 update for the Colorado River Watershed Sanitary Survey (CRWSS 2015 Update). Metropolitan Water District of Southern California (Metropolitan) has assumed the responsibility for completing this watershed sanitary survey, which covers portions of the Colorado River (above Metropolitan's Whitsett Intake near Parker Dam), Colorado River Aqueduct (CRA), Lake Mathews, Diamond Valley Lake, and Lake Skinner, on behalf of its member agencies. The period for this update is from January 2011 through December 2015. The initial watershed sanitary survey was completed in 1996; and in accordance with the California Surface Water Treatment Rule (SWTR)—Title 22, Article 7, Section 64665 of California Code of Regulations (California Title 22)—updates must be developed at least every five years thereafter. Previous updates covered years 1996–2000, 2000–2004, and 2005–2010. The 2015 update covers a five-year period (2011–2015).

The CRWSS 2015 Update includes an assessment of source water quality monitoring data, a review of watershed land uses and potential contaminant sources (PCSs), an evaluation of compliance with surface water regulations for Metropolitan's water treatment plants, and a review of key watershed management activities. In addition, a discussion on findings and recommendations is provided to guide future source water protection efforts. This Executive Summary is presented in two main sections: 1) *Colorado River Watershed Review*, which discusses key watershed management activities and the PCS findings as they pertain to each of the Colorado River system watershed areas; and 2) *Water Quality Review*, which discusses source water quality findings and treated water quality compliance with drinking water regulations for Metropolitan's water treatment plants that treat Colorado River water.

The CRWSS 2015 Update presents comprehensive information (i.e., in-depth discussions, data tables and analyses, figures, and reference maps) organized in the following areas.

- Overview of major reservoirs along the Colorado River and Metropolitan's service area, study purpose and conduct, summary of previous watershed sanitary survey updates, and status of previous sanitary survey recommendations
- Overview of the physical and hydrologic characteristics of the watersheds that comprise the study area
- Description of Metropolitan's monitoring programs, summary of raw water quality data, and an evaluation of selected key constituents
- Vulnerability assessment of Metropolitan's Colorado River system watershed areas for the nine potentially contaminating sources (PCSs) selected for the 2015 update
- Updates to current and anticipated drinking water regulations and Metropolitan's water treatment plants' capability for compliance with these regulations
- Key watershed management efforts for the Colorado River watershed study area and

Metropolitan's activities and involvement
- Summary of principal findings and a comprehensive list of recommendations

Considering the length and comprehensive nature of the CRWSS 2015 Update, this Executive Summary is intended to provide a thorough overview of the full report.

Colorado River Watershed Review

The Colorado River's northernmost tributary headwaters are in Wyoming (the Green River) and the river's headwaters are in Colorado. The river travels approximately 1,400 miles from the Rocky Mountains to its outlet into the Gulf of California in Mexico. The Colorado River watershed covers seven basin states including Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California and supplies drinking water for over 35 million people including Metropolitan's service area. Metropolitan imports Colorado River water from its Whitsett Intake facility at Lake Havasu and conveys it through the Colorado River Aqueduct (CRA), which terminates at Lake Mathews.

The CRWSS 2015 Update covers the geographical regions and watersheds for the Colorado River, upstream of Whitsett Intake, and for Metropolitan's facilities, which convey and store Colorado River supplies to Metropolitan's service area. The watershed areas discussed in the update are the Upper Colorado River (i.e., above Glen Canyon Dam), Lake Mead (i.e., below Glen Canyon Dam to Hoover Dam), Lake Mohave and Lake Havasu, Colorado River Aqueduct, Lake Mathews, Diamond Valley Lake, and Lake Skinner. Discussions for the Upper Colorado River and Lake Mead watersheds are limited to the key watershed management activities that Metropolitan has engaged in to protect source water quality. The update focuses primarily on the watersheds near Metropolitan's intake (i.e., below Hoover Dam) and the downstream CRA system, as these watersheds will potentially have the greatest impact on water quality at Metropolitan's water treatment plants. The near-intake zone concept, an accepted practice by DDW, was defined as the watersheds for Lake Mohave and Lake Havasu downstream to Metropolitan's terminal reservoirs.

Key Watershed Management Activities

There are several key watershed management activities within Metropolitan's source waters. Metropolitan's involvement in these watershed management efforts has had a positive impact on protecting source water quality for the Colorado River and Metropolitan's downstream watersheds. Although the focus of the key watershed management activities discussion is on the 5-year reporting period (2011–2015), updates through the writing of this report are included for completeness.

Colorado River Stakeholder Partnerships

Metropolitan engages in a number of stakeholder partnerships with external partners to collaborate on various Colorado River water quality and watershed management issues. These stakeholder partnerships include: Colorado River Basin Salinity Control Forum, Clean Colorado River Sustainability Coalition, Lake Mead Water Quality Forum, Lake Mead Ecosystem Monitoring Workgroup, Lower Colorado River Water

Quality Partnership (Partnership), Nevada Environmental Response Trust Stakeholder Group, and Topock Stakeholder Forums. Metropolitan participates in regular meetings with these stakeholder groups and undertakes various activities such as sharing information on Colorado River water quality, monitoring cleanup of contaminated areas, and supporting the overall protection of the Colorado River. As appropriate, Metropolitan also sends joint letters with the Partnership to respond to water quality issues.

Colorado River Basin Salinity Control Program

Salinity in the Colorado River is an important water quality issue being addressed by the Colorado River Basin Salinity Control Forum (Forum) through the implementation of salinity control measures. In October 2014, the Forum completed and adopted its thirteenth triennial review of the salinity standards and Plan of Implementation for Colorado River salinity control. The Forum, which is comprised of representatives from the seven basin states (Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California), attributes an approximate 100 mg/L TDS (total dissolved solids) reduction for the Colorado River to Forum activities. Some of the salinity control projects coordinated between the Forum and federal agencies have included improved irrigation practices, rangeland management for non-point source control, and deep-well brine injection.

Metropolitan is committed to reducing salinity concentrations in southern California's water supplies through ongoing collaboration with the Forum and other pertinent agencies. In addition to serving on the Forum during the reporting period, Metropolitan contributed approximately $2.7 million per year to the Lower Basin Development Fund, which is 35 percent of the total funds required for cost sharing from the lower basin states. Metropolitan does not pay directly to the Basin States Program, but rather funds are collected based on a 2.5 mills per kilowatt-hour levy on California and Nevada purchases of hydropower generation from Hoover Power Plant. Along with federal appropriations, the funding is used for salinity control projects.

Metropolitan is also working with the Forum, U.S. Bureau of Reclamation (USBR) and the Southern California Salinity Coalition (SCSC) to update the 1999 Salinity Management Plan, which includes an update of the Salinity Economic Impact Model (SEIM) used for preparing the Forum's water quality standards triennial report. The SEIM estimates economic damages caused by salinity and potential benefits of salinity control in the Colorado River. On June 1, 2012, SCSC convened a workshop to identify current salinity challenges and potential solutions to salinity management issues in southern California. In September 2012, USBR hired a consultant that completed a literature review of previous modeling references used in the development of the SEIM. Metropolitan worked with the Forum, SCSC, and USBR to expand the SEIM to account for damages in other reaches in the lower Colorado River. In January 2016, the Colorado River Basin Salinity Control Advisory Council approved funding for the model update to supplement USBR's resources. USBR plans to award a contract for updating the SEIM in 2017. Metropolitan will continue to provide support to update the SEIM while completing the 1999 Study update.

Uranium Mill Tailings Removal near Moab, Utah

A 16 million-ton pile of uranium mill tailings was left along the banks of the Colorado River near Moab, Utah. The tailings pile, located approximately 750 feet from the west bank of the Colorado River, is remains from a decommissioned mining corporation that ceased operation in 1984. Moving the pile offsite is critical to prevent the potential for a catastrophic flood event to wash the mill tailings directly into the Colorado River. In addition, the presence of the uranium mill tailings pile adjacent to the Colorado River impacts the public's confidence in the safety and reliability of the river as a source of drinking water supplies. In March 2008, $108 million was directed to the Moab Uranium Mill Tailings Remediation Action (UMTRA) project under the American Recovery and Reinvestment Act (ARRA) of 2009 to accelerate initial tailings removal. In April 2009, the U.S. Department of Energy (USDOE) began removing the tailings by rail to a disposal site located approximately 30 miles north of Moab in Crescent Junction, Utah.

In January 2016, USDOE achieved a significant milestone with removal of half of the original 16 million tons of tailings and as of November 2016, more than 8.4 million tons of the tailings pile has been removed. USDOE continues to maintain project progress on tailings removal while responding to critical project needs, such as implementing site safety measures and shifting resources to necessary equipment repairs and disposal cell expansion. Due to federal budget cuts, tailings removal has reduced from approximately 2 million tons annually (with ARRA funds) to between 600,000 and 900,000 tons annually. An increase in federal funding is needed to meet USDOE's targeted completion date for full removal of the tailings pile by 2025. The total cost of the remediation efforts is anticipated to be approximately $1 billion.

Metropolitan continues to advocate for expeditious removal of the tailings pile and monitor uranium levels in Colorado River water. Over the years, Metropolitan has sent letters to the Secretary of Energy and Congressional delegates advocating for increased funding to maintain effective and timely cleanup of the UMTRA site to ensure long-term protection of the Colorado River. USDOE continues to regularly inform Metropolitan of the UMTRA project remediation progress and project challenges.

Energy Exploration and Development

An increasing demand for energy is driving various energy development activities in the Colorado River basin including interests in hydraulic fracturing, uranium exploration near Grand Canyon, and activation of abandoned mines. The development of these energy resources make the Colorado River vulnerable to non-point source pollution, which could result from surface disturbance during construction of production facilities, underground mining and extraction, and wastewater discharge. In recent years, federal and state agencies have proposed various legislation to regulate the surge in energy development interests and address environmental impacts.

Metropolitan routinely monitors for uranium in its source waters and is not aware of any exceedances of regulated levels of uranium as a result of mining operations. However, Metropolitan recognizes that uranium mining in areas near the Colorado River can have impacts on the public's confidence in the safety and reliability of this water supply due to the potential for uranium mining operations to impact drinking water quality. During the reporting period, Metropolitan sent various letters commenting on energy exploration and development activities including a 2011 Partnership letter on BLM's draft EIS for the proposed Northern Arizona Proposed Withdrawal project which continued to advocate for close federal oversight over mining claims to ensure Colorado River water quality protection; a 2013 Partnership letter on the USDOE's Draft Programmatic EIS for the USDOE Uranium Leasing Program; and in March 2015, Metropolitan responded to the Grand Canyon Trust's letter regarding the issue of inactive mines in northern Arizona. In addition, following the Gold King Mine spill, the Partnership agencies sent a letter to USBR and U.S. Geological Survey in October 2015 requesting an improvement of the Lake Powell Water Quality Monitoring Program. The USBR established a workgroup, including the Partnership, to enhance Lake Powell's monitoring program to better manage and respond to upstream water quality issues.

Perchlorate Remediation in Henderson, Nevada

As a result of past disposal practices at two chemical manufacturing facilities in Henderson, Nevada, two large perchlorate plumes are located in close proximity to the Las Vegas Wash and Lake Mead. Since early 2007, perchlorate loading as measured in the Las Vegas Wash has typically been between 50 and 100 lbs/day. Several remediation efforts have been undertaken at the two sites, referred to as the Tronox (now Nevada Environmental Response Trust or NERT) and American Pacific Corporation or AMPAC (now Endeavour) sites, respectively, which have reduced perchlorate levels at Metropolitan's Whitsett Intake at Lake Havasu from 0.009 mg/L in 1998 to typically less than .002 mg/L since 2006. In January 2009, Tronox filed for Chapter 11 bankruptcy protection citing significant environmental liabilities taken on from its predecessor. The bankruptcy settlement resulted in the formation of the NERT, which has been given ownership and responsibility for site cleanup as of February 14, 2011, with Nevada Division of Environmental Protection (NDEP) providing regulatory project oversight. In April 2014, Tronox reached a $5.15 billion settlement with its predecessors which awarded approximately $1.1 billion, directed to NERT, to clean up the former Tronox site. The settlement, which represents one of the largest environmental recoveries in history, went into effect in January 2015 and helps to ensure adequate funds are available for site cleanup and protection of the downstream Colorado River.

During the reporting period, NERT completed several improvements to optimize the current treatment system including refurbishment of the fluidized bed reactors (FBRs) and critical repairs to various process equipment. NERT also began operating additional extraction wells to maximize groundwater extraction and completed improvements to convert the GW-11 pond to an equalization basin. Through June 2016, remedial efforts at the Tronox/NERT site have removed an estimated 4,125 tons of perchlorate. This has resulted in over 90 percent reduction of perchlorate entering the Colorado River.

NERT is currently conducting remedial investigations for long-term soil and groundwater cleanup, while NDEP is initiating a regional investigation of downstream perchlorate contaminated areas to further reduce loading into Las Vegas Wash. Current efforts involve a soils investigation of former perchlorate production buildings at the site and a groundwater and surface water investigation near the Las Vegas Wash. In addition, NERT has commenced field studies of various remedial technologies, which include soil flushing and bioremediation, to assist with determining the final remedy. NERT anticipates completing the remedial investigations in 2020, followed by a feasibility study report in 2021 containing an evaluation of multiple remedial alternatives. Construction of the final remedy is expected to begin in 2022 with full cleanup anticipated to take several decades.

In June 2012, the former AMPAC site shut down the in-situ bioremediation (ISB) system and, in September

2012, started FBR treatment (similar to the Tronox/NERT FBR system) to increase perchlorate destruction rates. In 2012, AMPAC also expanded its extraction system to include five deep extraction wells in the Auto Mall area, closer to the source area, which allowed for treatment of higher perchlorate loading. Effective December 14, 2015, Endeavour assumed full responsibility for conducting and completing the perchlorate remediation activities. Endeavour's full-scale FBR system now removes approximately 1,000 lbs/day of perchlorate compared to the ISB system, which only removed between 30 and 50 lbs/day.

Metropolitan is actively engaged in the perchlorate cleanup efforts. Metropolitan participates in regular meetings with NDEP and NERT to stay informed of remedial progress and budgetary issues, and provide input. Metropolitan also participates in site visits to review the current remediation performance and discuss planned remedial project efforts. Metropolitan reviews all pertinent project documents to provide input on the development of the long-term remedial plan. In May 2013, Metropolitan, through the Partnership, submitted a comment letter on the 2012 *Remedial Investigation and Feasibility Study (RI/FS) Work Plan for the Nevada Environmental Response Trust Site*. In 2013, Metropolitan, on behalf of NERT and stakeholders, also commissioned a third-party expert review of the RI/FS Work Plan to assist with assessment of perchlorate conditions at the site, and to evaluate and identify remediation alternatives.

Metropolitan continues to monitor perchlorate levels at several Colorado River sites and within its service area. Levels remain well below the MCL. Metropolitan will continue to be engaged with USEPA and other stakeholders as a draft federal MCL for perchlorate is developed.

Wastewater Management in the Las Vegas Valley

Las Vegas Valley wastewater treatment plants discharge tertiary treated wastewater effluent into Las Vegas Wash. Phosphorus loads from wastewater treatment plants can potentially negatively impact source waters by stimulating algal growth in downstream reservoirs and conveyance systems. Metropolitan collaborates with Las Vegas wastewater dischargers through various stakeholder forums including the Ecosystem Monitoring Workgroup. In addition, during the reporting period, Metropolitan reviewed the 5-year NPDES permit renewals which continue to include provisions to protect the ecological systems and beneficial uses of the Las Vegas Wash, Boulder Basin of Lake Mead, and the Colorado River system downstream of Hoover Dam. Metropolitan submitted a joint review letter through the Partnership in March 2015 and acknowledged that optimized treatment and year-round phosphorus removal at the treatment plants is a key contribution to the long-term protection of downstream uses of the Colorado River in terms of phosphorus loading. In recent years, the plants have optimized their treatment processes with biological nutrient removal to achieve greater phosphorus removal and nitrogen reduction. Metropolitan will continue to track performance of the wastewater treatment plants with respect to phosphorus discharges and expects future water quality issues to be successfully addressed through collaborative processes between the dischargers and key stakeholders.

Las Vegas Wash Stabilization Program

Years of growth in the Las Vegas Valley has increased the amount of treated effluent, groundwater, urban runoff, and storm flows into Las Vegas Wash. This has resulted in increased erosion of the wash and the transport of sediment to Lake Mead. With support from multiple stakeholders, Southern Nevada Water Authority (SNWA) has been managing the Las Vegas Wash Stabilization Program. The program includes the construction of 22 erosion control structures along the wash to slow the stream flow and provide favorable conditions for restoring habitat along the wash. Since 1999, 19 structures have been built; during the reporting period, 8 weir structures were completed including Homestead, Lower Narrows, DU Wetlands No. 1, Duck Creek Confluence, Upper Narrows, Archery, Silver Bowl, and Three Kids Weirs. Completion of these erosion control structures is also critical to minimize the potential for future mobilization of subsurface perchlorate-laden geologic formations. However, the construction of weirs involves dewatering and temporarily discharging groundwater to Las Vegas Wash that has higher levels of perchlorate than what is currently contained in wash surface flows. Dewatering discharges were modeled to assess impacts at both the SNWA and Metropolitan intakes to determine the optimal dewatering discharge and operating period to minimize any downstream impacts. NDEP issues an NPDES permit to regulate perchlorate in dewatering discharges; actual discharges have been well below permitted levels.

In April 2016, NDEP issued a Finding and Order requiring NERT to provide an Engineering Evaluation/ Cost Analysis (EE/CA) that evaluates the cost, feasibility, schedule, and permitting requirements treating groundwater extracted during SNWA's construction dewatering for the Historic Lateral and Sunrise Weirs, which are under influence of the NERT perchlorate plume. NDEP and NERT are currently coordinating installation of a perchlorate treatment system to manage and treat groundwater extracted during construction of the weirs, which is expected to begin in June 2017.

SNWA closely coordinates weir construction activities with Metropolitan, provides regular reports on perchlorate concentrations and loadings during dewatering, provides copies of quarterly reports, which are submitted to NDEP. In September 2016, Metropolitan reviewed and commented on documentation provided by NDEP and NERT regarding the proposed treatment system for the groundwater extracted during dewatering for the weir construction. Overall, Metropolitan strongly supports the Las Vegas Wash Stabilization Program, which is improving water quality in Lake Mead and controlling long-term perchlorate loading.

Chromium-6 Remediation at PG&E's Topock Gas Compressor Station

An important remediation effort is underway in the watershed for a chromium-6 plume from the PG&E Topock Gas Compressor Station located near Needles, California. PG&E is complying with a regulatory cleanup process subject to state and federal oversight from the Department of Toxic Substances Control (DTSC) and the U.S. Department of the Interior (DOI), respectively. In 2004, PG&E began implementing interim measures to control the flow of groundwater away from the Colorado River and to remove total chromium from the groundwater. In conjunction with DOI, DTSC finalized the Notice of Remedy Selection in January 2011. Also in January 2011, an environmental impact report was certified to determine any significant impacts resulting from the proposed remedial action.

The selected remedy involves installation of an in-situ bioremediation system with freshwater flushing. The In Situ Reactive Zone (IRZ) technology would use injection and extraction wells to continuously mix the contaminated plume groundwater with nutrient-added water to promote the reduction of chromium-6 to chromium-3. In addition, extraction wells near the Colorado River would act as a barrier to prevent contamination from reaching the river and additional injection wells located around the plume would inject fresh water and groundwater to push the plume toward the IRZ. PG&E prepared the final design based on the selected Final Remedy in November 2015. In April 2015, DTSC determined that a Subsequent Environmental Impact Report (SEIR) would have to be prepared to evaluate potential environmental impacts based on new design details, such as the installation of the freshwater wells in the final design. DTSC anticipates releasing the draft SEIR in January 2017 for public review. The final design would be approved when the SEIR is certified. Project construction is estimated for completion in 2022 after which the operations and monitoring phase is anticipated to take approximately 30 years or more.

Metropolitan participates in the Consultative Workgroup, Clearinghouse Task Force, and Topock Leadership Partnership meetings to provide consultation and recommendations on the remediation project. Since becoming involved in August 2003, Metropolitan has reviewed numerous work plans and technical data and has provided letters and technical memoranda to review and comment on the progress of the cleanup effort. Overall, Metropolitan supports the remediation plan and will continue participating in the stakeholder process to maintain progress and ensure long-term protection of the Colorado River. Metropolitan also conducts regular monitoring for chromium-6 at various locations upstream and downstream of the PG&E Topock Gas Compressor site. Chromium-6 has typically been at non-detect levels (< 0.00003 mg/L) in the Colorado River downstream of the site.

Lake Mathews Watershed Planning and Management

In addition to efforts along the Colorado River, Metropolitan engages in local watershed management efforts, working with local agencies to develop and implement water quality improvement plans. The Drainage Water Quality Management Plan (DWQMP) was completed in the early 1990s through a partnership between Metropolitan, County of Riverside, and Riverside County Flood Control and Water Conservation District (RCFCWCD). The DWQMP was developed to protect the quality of water in Lake Mathews by taking a regional approach to managing runoff in the watershed. Metropolitan's construction of the Cajalco Creek Dam and Detention Basin in 2001 was a key element of the DWQMP and has been effective in removing sediment and attached pollutants from entering Lake Mathews.

Metropolitan, in conjunction with RCFCWD and County of Riverside, initiated a Lake Mathews watershed study in 2008. The Lake Mathews Watershed Water Quality Improvement Study, which was completed in December 2012, evaluated constituents such as total nitrogen, total phosphorus, sediment, and fecal coliform. The study also included modeling of various future development scenarios and evaluated DWQMP BMP water quality management strategies and low-impact development (LID) requirements. The watershed study results can be used to help manage existing uses and guide future development and stormwater management practices in the watershed. The results also assist Metropolitan and partnering agencies in reviewing development proposals and other projects within the watershed to ensure protection of Lake Mathews. This watershed-wide assessment and model provides an effective planning tool that evaluates the impacts of watershed development on Metropolitan's source water quality. During the reporting period, Metropolitan was involved with reviewing proposed developments to evaluate potential water quality impacts to Lake Mathews. Metropolitan coordinated closely with the RCFCWCD and the County of Riverside to provide input during the planning and approval process for the Boulder Springs-Dailey Ranch housing development. Metropolitan was also involved with reviewing the Cajalco Road Widening and Realignment Alternative Project and provided input to the County on the impacts to Metropolitan's facilities within the proposed project's road alternatives.

Potential Contaminant Sources

The CRWSS 2015 Update includes an evaluation of various point and non-point contaminant sources, referred to as PCSs, for five watershed areas – Lake Mohave and Lake Havasu watersheds, Colorado River Aqueduct, Lake Mathews watershed, Lake Skinner watershed, and Diamond Valley Lake watershed. The PCSs include 1) *Erosion, Urban and Stormwater Runoff*, 2) *Recreation*, 3) *Municipal and Industrial Dischargers*, 4) *Spills*, 5) *Landfills*, 6) *Leaking Underground Storage Tanks*, 7) *Septic Systems*, 8) *Agriculture,* and 9) *Fires*. As with the key watershed management activities discussion, updates through the writing of this report summarizing discussions regarding regulatory oversight of PCSs and key studies that are relevant to the contaminant source are included for completeness.

Lake Mohave and Lake Havasu Watersheds

Lake Mohave is a long and narrow reservoir formed by Davis Dam on the Colorado River, which defines the border between Nevada and Arizona. The lake is a 1,818,000 acre-feet capacity reservoir and lies near Laughlin, Nevada and Bullhead City, Arizona. The lake and adjacent lands forming its shoreline are part of the Lake Mead National Recreation Area administered by the National Park Service. Lake Havasu is a 648,000 acre-feet capacity reservoir behind Parker Dam on the Colorado River, on the border between California and Arizona.

The Lake Mohave and Lake Havasu watersheds include the Colorado River from Hoover Dam to Parker Dam through the tri-state region of Arizona, Nevada, and California. The watersheds drain multiple alluvial valleys, but do not have a major tributary upstream of Metropolitan's Whitsett Intake. The Bill Williams River, which enters Lake Havasu between Whitsett Intake and Parker Dam, can potentially impact Metropolitan's intake water quality during very large storm events. The majority of the land use in the watershed is rangeland.

The Colorado River through the Lake Mohave and Lake Havasu watersheds is susceptible to PCSs related to recreational activities. In this desert reach, the Colorado River attracts both local and vacationing users to boating, camping, hiking, and other recreational activities. To ensure protection of Colorado River water quality, federal agencies such as National Park Service, U.S. Coast Guard, and Bureau of Land Management provide oversight and regulations to manage recreational uses. Metropolitan reviews water quality data, published by multiple agencies, to monitor the impacts of the ongoing recreational activities.

Metropolitan includes its Colorado River monitoring data on SNWA's Lower Colorado River Water Quality Database. This online regional database allows member-only access and contains data from multiple federal, state, and local agencies that monitor Colorado River water quality. The database also allows stakeholders, including Metropolitan, to track historical water quality changes at key locations along the lower Colorado River. Several studies conducted by multiple agencies are also ongoing to assess water quality issues relevant to the lower Colorado River. The Lake Mead Ecosystem Monitoring Workgroup provides a forum for discussing and sharing various water quality studies.

The general watershed area has minimal development and municipalities have populations less than 100,000. The existing development is concentrated in close proximity to the Colorado River and most of the cities rely on septic systems for wastewater treatment. The groundwater, which can contain high nitrate levels due to septic tanks, has the potential to degrade the river water quality. In recent years, Lake Havasu City and Bullhead City have constructed sewer collection systems and reduced the number of septic systems by more than 75 percent in their respective cities.

Metropolitan also stays informed and participates in ongoing monitoring and clean-up efforts for areas of concern. This includes reviewing groundwater monitoring data for the Needles Sanitary Landfill, tracking progress on initial efforts to clean up a chromium-6 groundwater plume at the McCulloch site, and actively participating in the PG&E Topock Gas Compressor Station chromium-6 remediation process. A long-term remedial alternative has been selected for the Topock site and PG&E completed design in 2015. Construction is expected to start in 2017 after completion of a subsequent environmental review, and would be completed in 2022.

Metropolitan also tracks spills and is included in the Lower Colorado River Geographic Response to receive spill notifications as an affected downstream water utility. USBR has been designated as the lead response agency and is coordinating with CCRSCo members to ensure an effective notification process with all members.

Colorado River Aqueduct

The CRA spans 242 miles of desert and mountain ranges between Metropolitan's Whitsett Intake on Lake Havasu and Lake Mathews in Riverside County, California. The CRA system includes the San Diego Canal, which delivers water to San Diego County from a junction structure located approximately 25 miles east of the CRA terminus at Lake Mathews. Although the aqueduct and its associated facilities were designed to keep most local runoff out, a few areas of the aqueduct may receive drainage, especially during flood events. Public access to open-channel sections of the CRA system is not allowed and frequent and routine ground and aerial surveillance help protect the system from unauthorized entry.

This region, which includes a long reach of the CRA and San Diego Canal, consists of open barren lands and is primarily susceptible to potential spills from transportation vessels or contaminated runoff from concentrated animal feeding operations (CAFOs). Spills on vehicle and railroad crossings over the CRA would directly flow into the aqueduct and impact water quality. Metropolitan stays informed on reported spill activity. In addition, the prevalence of dairies along the San Diego Canal could have a potential impact on CRA water quality. Metropolitan will continue to stay informed on related regulatory efforts.

Since LACSD is no longer pursuing the Eagle Mountain Landfill, the Eagle Mountain Pumped Storage project is the only project of interest that is proposed in the Eagle Mountain area of the CRA. Metropolitan will continue to track progress for this project to ensure protection of the CRA. Metropolitan also began preliminary work with DWR on a Perris Dam active seepage recovery project which would recover dam seepage water and discharge it to the CRA. Future CRWSS updates would include discussion of this project if it moves forward.

Although not a direct threat to public health, the introduction of quagga mussels to the lower Colorado River watershed is also noted. Quagga mussels were discovered in Lake Mead in January 2007 and rapidly spread throughout the lower Colorado River and Metropolitan's CRA system. Although its introduction into drinking water supplies does not typically result in violation of drinking water standards, invasive mussel infestations can adversely impact aquatic environments used as sources of drinking water. This includes a potential for clogging of intakes and raw water conveyance systems and a long-term potential for rendering lakes more susceptible to deleterious algae blooms. Metropolitan has implemented control measures to address quagga mussel proliferation such as the installation of chlorination facilities within its CRA system.

Lake Mathews Watershed

Lake Mathews is the terminal reservoir for the CRA and is located in western Riverside County approximately 10 miles southwest of the city of Riverside. The lake is surrounded by the 5,100-acre Lake Mathews Multiple Species Reserve. Lake Mathews has a capacity of 182,000 acre-feet and receives a limited amount of local runoff water in addition to Colorado River water. The watershed is drained primarily by Cajalco Creek, which is intermittent, flowing only during storm events or in the presence of agricultural runoff.

Lake Mathews watershed includes large community developments in the unincorporated areas of Corona, Woodcrest, Lake Elsinore, and Riverside. Lake Mathews does not offer recreational opportunities; hence, the primary potential impact to source water quality is related to the development growth in the watershed area. Over half of the watershed is developed with residential, commercial, or industrial improvements while the remaining watershed primarily encompasses open space and agricultural land uses.

Significant efforts have been undertaken to ensure the protection of Lake Mathews' water quality. Previous efforts include the development of the Drainage Water Quality Management Plan (DWQMP), which provided recommendations for large scale best management practices (BMPs) located along Cajalco Creek and other watershed tributary drainages. Regional BMPs, such as flood control and sedimentation facilities, have been constructed by, or with support from, Metropolitan. In addition, Metropolitan provides ongoing services to support the Lake Mathews Multiple Species Habitat Conservation Plan in protecting the Multiple Species Reserve buffer that surrounds Lake Mathews.

Riverside County continues to implement their 2010 MS4 Permit, which mandates low impact development (LID) BMPs and requires significant development projects to complete water quality management plans (WQMPs) to identify applicable BMPs. Metropolitan, in cooperation with Riverside County Flood Control and Water Conservation District and the County of Riverside, completed the Lake Mathews Watershed Study in 2012 and developed a watershed model to evaluate the effects of development and various BMPs on runoff pollutant loading into the lake.

During the reporting period, Riverside County also adopted General Plan documents containing policies to protect Lake Mathews. Based on the Riverside County General Plan, development in the watershed will continue to increase. A proposed transportation project within the watershed is Riverside County's Cajalco Road Widening project which will improve Cajalco Road between Interstate 215 and Temescal Canyon, south of Lake Mathews. Also, a proposed large housing development in the watershed is the Boulder Springs-Dailey Ranch development project, located east of Lake Mathews and along Cajalco Road. Metropolitan will work with project stakeholders to ensure that water quality impacts are minimized through stormwater management practices and other development requirements.

Diamond Valley Lake Watershed

Diamond Valley Lake is located near Hemet with an 810,000-acre-foot capacity. The lake can be filled with SWP or Colorado River water through the inlet/outlet tower or with SWP water through the secondary inlet. Since the discovery of quagga mussels in Colorado River water in 2007, Diamond Valley Lake has only been filled with SWP water. Diamond Valley Lake's contributing watershed area is limited to the ephemeral drainage areas from the hills surrounding the reservoir. Approximately half of the watershed consists of vacant land and the other half is the lake itself, which offers recreational uses.

The watershed is unique in that Metropolitan owns and manages the watershed area surrounding the lake. The surrounding property does not have urban development, but the lake is open to public use for fishing, boating, hiking, and other non-body contact recreational uses. Metropolitan leases areas around the lake for marina operations and related recreational facilities. Since the lake is primarily susceptible to PCSs from these recreational activities, Metropolitan has developed Boating Rules and Regulations for Diamond Valley Lake.

Metropolitan has developed a Recreational Activity Plan (RAP), which has been approved by DDW, to promote and operate recreational facilities within the Diamond Valley Lake area while protecting water quality. This includes the 6-mile long North Hills Trail (for hiking and equestrian use), which is primarily outside the watershed, but connects two 5-acre trailheads at the northwest and northeast ends of the lake. The watershed's aesthetic and recreational opportunities have appealed to developers interested in expanding recreational uses. During the reporting period, Metropolitan extended the boat launch ramp which was exposed under low lake levels due to drought conditions. Metropolitan also began efforts to upgrade the marina restroom facilities. Metropolitan will continue to be involved with recreational planning efforts to minimize the potential for water quality impacts and will amend the RAP as necessary.

Lake Skinner Watershed

Lake Skinner is located in Riverside County near Temecula and serves as a regulatory storage reservoir for the Robert A. Skinner Water Treatment Plant (Skinner). The lake has a storage capacity of 44,000 acre-feet and the major sources of water for the reservoir are the Colorado River and the California State Water Project (SWP). Lake Skinner receives very little local runoff compared to the amount of water imported to the lake.

The watershed is primarily drained by Tucalota Creek, Rawson Canyon Creek, and Middle Creek, which are ephemeral streams, flowing only after prolonged or heavy rains. A majority of the watershed is vacant land, designated for open space and recreation including the Southwestern Riverside County Multi-Species Reserve (Reserve) and Lake Skinner Recreation Area. Residential land use accounts for approximately a third of the watershed and the majority of residences are ranches or hobby farms, defined as properties with ten horses or less.

Metropolitan allows multiple recreational opportunities in the Lake Skinner area including boating, trails, and park space. Water quality impacts to the lake are minimized through boating guidelines and agreements with Riverside County Regional Park and Open Space District for oversight of the recreational elements. An equestrian trail exists along the perimeter of the Lake Skinner Recreational Area and within the watershed. Trail use has been minimal during the CRWSS 2015 Update period and riding is not permitted during the rainy season. The approximate 13,700-acre Reserve occupies a portion of the watershed and provides a buffer for development. Metropolitan coordinates with the Reserve on vegetation management practices to ensure water quality protection.

Outside of the lake area, the majority of the watershed is vacant land and the primary threat to water quality is due to the horse corrals on private properties. Although there are a number of equestrian and bovine related businesses in the Lake Skinner watershed, there are a greater number of hobby farms. Many of these properties and horse corrals do not have adequate BMPs in place to ensure protection of downstream water quality. Local resource conservation districts do not specifically outreach to individual property owners but do provide educational outreach covering best management practices for the general ranch community within the Lake Skinner watershed at local events. Metropolitan will continue to evaluate watershed conditions and work with local agencies and other stakeholders to develop and implement water quality improvement and protection plans to minimize impacts from existing properties and future development growth in the area.

Summary of Watershed Threats

The greatest potential threat to source water quality would result from the *Erosion, Urban and Stormwater Runoff*, *Recreation*, and *Municipal and Industrial Discharges* PCSs. These PCSs are of particular concern because of their ability to directly contribute pollutants to source waters based on their occurrence in the watershed or in consideration of high urban growth and development anticipated in some watersheds.

The *Erosion, Urban and Stormwater Runoff* PCS is a concern in the Lake Mathews and Lake Skinner watersheds where future development growth can increase the threat of runoff pollution into the lakes. The *Recreation* PCS is a concern due to existing and future recreational activities that may directly contaminate source waters. While recreational use is more prevalent along the shoreline of the Colorado River in the Lake Mohave and Lake Havasu watersheds, there are also existing and proposed recreational opportunities at Diamond Valley Lake and Lake Skinner. The *Municipal and Industrial Discharges* PCS is a concern in the watersheds along the Colorado River due to the large volume of wastewater discharges in the Las Vegas Valley, as well as contaminated sites near the Colorado River associated with past industrial discharge practices. Significant remediation efforts are underway at these sites, which include the uranium mill tailings pile near Moab, Utah; hexavalent chromium contaminated groundwater near Needles, California; and perchlorate contaminated groundwater in Henderson, Nevada.

Water Quality Review

The CRWSS 2015 Update involves a compilation of source water quality monitoring data between 2011 and 2015. Water quality monitoring programs were developed in compliance with California Title 22 regulations. The following constituents of concern were selected for evaluation in the CRWSS 2015 Update: various inorganic compounds (i.e., aluminum, boron, chromium-6, perchlorate, total dissolved solids [TDS], nutrients [total phosphorus and nitrate]), radionuclides (i.e., uranium, radium, gross alpha and gross beta emitters, strontium-90, and tritium), turbidity, organic compounds (i.e., total organic carbon [TOC], *N*-nitrosodimethylamine [NDMA], and pharmaceuticals and personal care products [PPCPs]), and microbiological constituents (i.e., coliforms and pathogens).

In addition to source water, regulations also require monitoring of Metropolitan's finished water for general mineral constituents, general physical parameters, trace metals, pesticides, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), synthetic organic compounds (SOCs), disinfection byproducts (DBPs), DBP precursors, asbestos, and radiological constituents. Finished water is monitored at Metropolitan's water treatment plants. The CRWSS 2015 Update presents information for three of Metropolitan's five water treatment plants, which treat varying blends of Colorado River water and SWP water and discusses their compliance with federal and state drinking water regulations.

Metropolitan maintains a proactive monitoring program, which extends beyond that required by the regulations for source water and finished water quality. Monitoring is often conducted more frequently than required. In addition, Metropolitan monitors several constituents of interest, which are not currently regulated due to source water concerns and for compliance with anticipated regulations.

Source Water Quality Findings

A summary is provided below on the findings for each of the constituents or class of constituents (inorganic, radionuclides, turbidity, organic, and microbiological), referred to as constituents of interest in this report. Source water data is monitored at Whitsett Intake on Lake Havasu, San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, Diamond Valley Lake, and influents to Metropolitan's water treatment plants. Some constituents may be monitored in reaches between Hoover Dam and Whitsett Intake due to specific source water concerns.

Inorganic Compounds

Inorganic compounds are naturally occurring mineral elements that are typically dissolved into groundwater and surface water flows from erosion of rock and soil formations containing the minerals. However, some of the inorganic compounds that were selected as constituents of interest were introduced by human activities and at elevated levels may be a source water quality concern.

Aluminum

Aluminum was selected for evaluation as it is on U.S. Environmental Protection Agency's (USEPA's) Drinking Water Contaminant Candidate List (CCL) and Metropolitan's water treatment plants use aluminum sulfate (alum) for coagulation, which may contribute to aluminum in the finished water effluent. Aluminum has a primary standard of 1 mg/L and a secondary aesthetics-based standard of 0.2 mg/L. Concentrations in Colorado River source waters are typically low with levels well below the secondary standard. However, in the spring rainy season, heavy precipitation produces runoff which may introduce sediments containing aluminum into the source waters. This results in a temporary increase in aluminum levels, which return to normal after storm flows subside.

Boron

Boron was selected for evaluation as it is on USEPA's CCL list and based on Metropolitan's member agencies' concerns. Boron is an unregulated chemical with a DDW notification level of 1 mg/L. Concentrations were found to be stable and well below the DDW notification level.

Chromium-6

Chromium-6 was selected for evaluation as it is a regulated constituent, has contaminated groundwater near the Colorado River, and based on member agencies' concerns. Metropolitan became aware of a groundwater plume of chromium-6 near the Pacific Gas and Electric (PG&E) Topock Gas Compressor Station in 2003. California adopted a drinking water standard for chromium-6 of 0.010 mg/L effective on July 1, 2014. USEPA is currently conducting human health assessments for chromium-6 and will determine whether to regulate chromium-6 in drinking water beyond the current regulations for total chromium. Median source water concentrations were low (less than 0.0001 mg/L) along the CRA and terminal reservoirs. Immediately downstream of the PG&E Topock Gas Compressor site, chromium-6 levels have been low, with a maximum detection level of 0.00006 mg/L at the sampling point above the railroad bridge.

Perchlorate

Perchlorate was selected for evaluation as it is a regulated constituent and was detected in the Colorado River in 1997, resulting from a groundwater plume that flowed into Lake Mead via Las Vegas Wash in Henderson, Nevada. Perchlorate has a California maximum contaminant level (MCL) of 0.006 mg/L. On February 1, 2015, OEHHA published the updated perchlorate PHG of 0.001 mg/L. Over the reporting period, the median concentration for all source water monitoring sites was low with a maximum value of 0.0016 mg/L below Davis Dam in September 2013, at Whitsett Intake in March 2015, and at the San Jacinto Tunnel West Portal in April 2015. Perchlorate levels at Whitsett Intake have been typically less than 0.002

mg/L since 2006. Since perchlorate was first discovered, source water sampling at Las Vegas Wash shows a 90 percent decrease in perchlorate loading over time as a result of the groundwater remediation efforts.

TDS

TDS was selected for evaluation as it is an important constituent to Metropolitan and its member agencies and affects a variety of sectors. High salinity water increases scaling potential, can reduce agricultural crop yields, limit groundwater recharge efforts, and can reduce the marketability and usability of reclaimed water. TDS and sulfate have a secondary MCL and are regulated based on aesthetics, rather than a health hazard, at a range of concentrations. Water with TDS lower than the recommended level (500 mg/L) is considered desirable for a high degree of customer acceptance; concentrations ranging to the upper contaminant level (1,000 mg/L) are acceptable if it is neither reasonable nor feasible to provide more suitable waters. TDS ranging to the short-term contaminant level (1,500 mg/L) is acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources.

The Colorado River Basin Salinity Control Forum has recommended numeric standards for TDS of 723 mg/L below Hoover Dam, 747 mg/L below Parker Dam, and 879 mg/L at Imperial Dam. Metropolitan has a Salinity Management Policy with a goal of achieving a running annual average (RAA) of 500 mg/L TDS for treated waters, which is typically accomplished by blending higher TDS Colorado River water with State Water Project (SWP) water. Overall, TDS in the Colorado River has cycled up and down over multiple years depending on hydrology in the Colorado River Basin, and showed a slight declining trend during the reporting period. Median TDS concentrations along the CRA were above the recommended level of 500 mg/L. Since sulfate is the primary component of TDS in Colorado River water, sulfate trends are similar to TDS trends; median sulfate levels along the CRA were below the recommended sulfate level of 250 mg/L. Metropolitan's current strategy of blending Colorado River water with SWP water has proven to be effective when sufficient SWP supplies are available. Due to low SWP allocation and drought conditions during the reporting period, the maximum TDS levels in source waters exceeded the target goal of 500 mg/L, with the exception of Diamond Valley Lake, which was not filled with Colorado River water due to quagga mussel concerns.

Nutrients

Total phosphorus was selected for evaluation as it is the primary limiting nutrient for algal growth in Colorado River water. Nitrate was also evaluated due to potential impacts of septic systems along the lower Colorado River. Nutrients are naturally occurring in aquatic ecosystems, but when present in excess may result in taste and odor production, nuisance algal blooms, excessive macrophyte (aquatic plant) growth, toxin production, increased TOC levels, and shortened filter runs at treatment plants. Total phosphorus is the limiting nutrient controlling cyanobacteria and algal growth in the Colorado River system. Therefore, Metropolitan has an active interest in levels of phosphorus loading from the wastewater treatment plants in the Las Vegas Valley. Total phosphorus has no primary or secondary MCL. The Nevada Administrative Code has established a 0.05 mg/L beneficial use standard and 0.02 mg/L anti-degradation standard for the Colorado River below Hoover Dam. Nitrate has a primary MCL of 10 mg/L (as nitrogen). Total phosphorus in the Colorado River is relatively stable around 0.010 mg/L, but with periodic spikes during storm events. For nitrate, median source water concentrations were low (less than 0.5 mg/L as nitrogen) at the sampled locations.

Radionuclides

Radionuclides can come from natural or man-made elements that can give off radiation as they decay from unstable forms of atoms into more stable atoms. Radionuclides were evaluated because the Colorado River is vulnerable to contamination from upstream sources related to the uranium mill tailings pile near Moab, Utah. The radionuclides evaluated in the CRWSS 2015 Update are uranium, radium, gross alpha and gross beta emitters, strontium-90, and tritium. The following results for radionuclides were observed during the reporting period:

- Gross alpha levels in the source waters were consistently below the MCL of 15 pCi/L. Gross alpha activity (minus the uranium activity) has an MCL of 15 pCi/L.
- Uranium levels in the source waters were consistently below the California MCL of 20 pCi/L. The USEPA MCL for uranium is 0.03 mg/L (27 pCi/L).
- The combined radium was less than the state detection limit for purposes of reporting (DLR) of 0.5 pCi/L and the individual quarterly results of radium-226 and radium-228 were less than 1 pCi/L for all the monitoring locations. The USEPA and California MCLs for radium are set as the sum of radium-226 and radium-228 at 5 pCi/L.
- Gross beta activities in the source waters and treated waters were well below the screening level of 50 pCi/L. Exceeding the screening level of 50 pCi/L for gross beta would trigger a requirement for further testing to characterize the water.
- Strontium-90 activities were below the California DLR of 2 pCi/L. Strontium-90 has an MCL of 8 pCi/L.
- Tritium activities were below the California DLR of 1,000 pCi/L. Tritium has an MCL of 20,000 pCi/L.

Turbidity

Turbidity was evaluated because it is a regulated constituent used to evaluate the efficiency and effectiveness of water treatment processes and is a general indicator of water quality. Some sources of turbidity include erosion and sediment transport during storm events, waste discharges, and runoff from watersheds. Turbidity requirements are regulated under California's Surface Water Treatment Regulations (Chapter 17, California Title 22) and the Federal Interim Enhanced Surface Water Treatment Rule (IESWTR). With the exception of one month, when turbidity spiked to 6.8 NTU at Lake Skinner, source water turbidity data from 2011–2015 were less than 4 NTU for all monitoring locations.

Organic Compounds

Organic compounds can be either naturally occurring compounds, such as TOC, or synthetic chemical compounds, such as volatile organic compounds (VOCs) that contain carbon. Select organic compounds were evaluated due to potential source water quality concerns.

TOC

TOC was evaluated since it is a DBP precursor regulated under the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rules and is known to be present in Colorado River water. Decayed plant material and organics from wastewater are potential sources of TOC and can be contributed from the general watershed, urban and agricultural runoff, and wastewater. The D/DBP Rules have enhanced coagulation requirements for finished water and compliance is now determined on a locational basis rather than on a distribution system-wide basis. Median TOC levels within the CRA system ranged between 2.56 and 3.00 mg/L. The highest measurement of TOC in the source water sampling was 4.30 mg/L measured at San Jacinto Tunnel West Portal in August 2014, likely caused by significant runoff in upstream watersheds.

NDMA

NDMA was evaluated as it is a potential carcinogen that may be regulated by USEPA and DDW in the foreseeable future. Wastewater treatment plant effluent and agricultural runoff can contribute organic material into source waters, which react to form NDMA at water treatment plants. USEPA placed NDMA in the Unregulated Contaminant Monitoring Regulation 2 (UCMR 2) and on the Contaminant Candidate List 3 (CCL3) and draft CCL4. DDW has not established an MCL for NDMA, but has a notification level of 100 ng/L and recommends that occurrences of NDMA in treated water supplies at concentrations greater than 100 ng/L be included in the utility’s annual Consumer Confidence Report. In December 2006, the Office of Environmental Health Hazard Assessment (OEHHA) set a public health goal of 3 ng/L for NDMA. Metropolitan ceased monitoring its source waters (at treatment plant influents) in 2011 since all plant influent samples were non-detect, indicating that NDMA is primarily formed as a disinfection byproduct and is not present in the source water.

PPCPs

PPCPs were evaluated as the occurrence and fate of PPCPs has emerged as an issue for source water quality and as a subject of public concern. PPCPs are comprised of several chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, and cosmetics. Some PPCPs, together with other organic wastewater contaminants (OWCs) such as pesticides and polycyclic aromatic hydrocarbons (PAHs), are known or suspected to be endocrine disrupting compounds. Currently, there are no regulatory requirements for PPCPs. Metropolitan’s PPCP monitoring program found PPCPs and OWCs at low ng/L levels in source water samples; much lower than applicable MCLs and orders of magnitude lower than therapeutic doses, which are in milligrams per dose. Though these levels of PPCPs and OWCs may affect the aquatic environment and wildlife, the impact on human health is widely considered insignificant [28] [29].

Microbiological Constituents

Coliforms

Coliforms were evaluated because they are indicative of the general microbial quality of water. Principal sources of potential fecal contamination include runoff (i.e., stormwater, urban, and agricultural), body contact recreation, wastewater discharges, and migratory bird deposits. In March 2008, California Title 22 required monthly reporting to DDW of total coliform and fecal coliform or *E. coli* levels in the raw water entering the treatment plants. Metropolitan initially monitored all three constituents but discontinued fecal coliform monitoring in 2010. The primary indicator of the microbial quality of water is *E. coli* for Metropolitan's source waters; total coliform levels may provide general trending of the microbial quality of water. The median *E. coli* levels were low (< 10 per 100 mL) for Metropolitan's source waters. The median total coliform levels were slightly higher than levels reported in the CRWSS 2010 Update. This may be partially due to the switch in analytical method in 2006 from multiple-tube-fermentation (MTF) to membrane filtration using MI medium (MF-MI). In the summers of 2013, 2014, and 2015, monthly total coliform levels were observed to be lower at Diemer and Weymouth plants possibly due to chlorination for quagga mussel control at Lake Mathews.

Pathogens

Cryptosporidium and *Giardia* were selected for evaluation since the original CRWSS. *Giardia* and viruses are regulated under the SWTR, which requires a minimum of 3-log and 4-log reduction at water treatment plants, respectively. *Cryptosporidium* is regulated under the IESWTR, requiring 2-log reduction, and under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), with a potential requirement for additional treatment determined by its source water concentration. Metropolitan's pathogen monitoring program includes monthly monitoring of water treatment plant influents for *Giardia* and *Cryptosporidium*. Between 2011 and 2015, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples. *Giardia* was detected once, at a concentration of 1 cyst per 10 L, in the Weymouth plant influent sample collected in September 2011. Beginning in April 2015, monthly monitoring of treatment plant influents was mandated and reported under the LT2ESWTR Round 2 monitoring. The Round 2 monitoring will continue through March 2017. As required by LT2ESTWR, *Cryptosporidium* concentrations, turbidity, and *E. coli* concentrations were monitored. In 2015, *Cryptosporidium* oocysts were not detected in any of the treatment plant influents receiving Colorado River water.

Water Treatment Plant Evaluations

Metropolitan owns and operates three water treatment plants (Robert B. Diemer, Robert A. Skinner, and F. E. Weymouth) that treat varying blends of Colorado River water and SWP water. The water treatment plants are subject to compliance with state and federal drinking water regulations.

Metropolitan complied with all existing primary drinking water regulations including those revised or added since the CRWSS 2010 Update. These drinking water regulations include the National Primary Drinking Water Regulations; Phases I, II, and V Standards; Total Coliform Rule; Surface Water Treatment Rule (SWTR); Lead and Copper Rule; Stage 1 D/DBP Rule; Interim Enhanced Surface Water Treatment Rule (IESWTR); Radionuclides Rule; Filter Backwash Recycling Rule; Arsenic Rule; Long Term 2 Enhanced SWTR; and Stage 2 D/DBP Rule.

As the primacy agency, California is required to adopt USEPA's MCLs under each rule by reference or make them more stringent. Primacy agencies can also add their own MCLs for constituents deemed to pose a threat to public health but do not yet have federal MCLs; therefore, California Title 22 includes more regulated constituents. None of the regulated primary constituents were detected at any level of concern in the effluent from the three water treatment plants.

A summary of Metropolitan's compliance with current and anticipated drinking water regulations is presented below.

Compliance with Existing Drinking Water Regulations

The following drinking water regulations were promulgated prior to the review period for this CRWSS update. New regulations that became effective during the current review period are discussed under Compliance with New Drinking Water Regulations below.

National Primary Drinking Water Standards

USEPA regulated 22 constituents in 1976 under the National Interim Primary Drinking Water Regulations (NPDWR), the first set of standards after the creation of the Safe Drinking Water Act. Newer, more stringent regulations between 1986 and 2013 have superseded the NPDWR and added more MCLs for a total of 91 regulated constituents collectively referred to as primary standards. Primary standards are health-related, legally enforceable standards that apply to public water systems. For the period under review, there were two detected constituents in Metropolitan's water treatment plant effluents with unchanged standards from the original list of 22 regulated constituents – fluoride and nitrate. Fluoride occurs naturally in raw water supplies, but it is also added to treated water. Nitrate occurs naturally in groundwater and surface waters can also have nitrate associated with the use of fertilizers or from animal and human waste. Other detected constituents on the list of primary standards are addressed below under their respective newer rules.

The federal MCL for fluoride is 4 mg/L. California's MCL for fluoride is 2.0 mg/L. In April 2015, DHHS recommended that water systems adjust their fluoride content to 0.7 mg/L, as opposed to temperature-dependent optimal levels ranging from 0.7 mg/L to 1.2 mg/L based on scientific evidence provided by CDC. The 0.7 mg/L optimal level aims to provide the benefits of fluoridation while minimizing effects of dental fluorosis (teeth discoloration) in children. DDW is consulting with public water systems to amend individual permits to reference CDC's recommended optimal level of 0.7 mg/L, which corresponds with the existing control range of 0.6 mg/L to 1.2 mg/L; 80 percent or more of daily fluoride samples collected in a month must fall within this range. Fluoride concentration in each water treatment plant's effluent is maintained within the optimal range, with a maximum of 1.0 mg/L in the period covered by this report.

Both the federal and California MCL for nitrate is 10 mg/L (as nitrogen). Metropolitan collects monthly water samples at the treatment plant effluents for nitrate (as nitrogen). Nitrate (as nitrogen) concentrations for this reporting period ranged from < 0.4 to 0.6 mg/L at each water treatment plant.

Aluminum, regulated as a primary standard in California and used in the treatment process as a coagulant, was also detected in the water treatment plant effluents. California's MCL for aluminum is 1 mg/L. USEPA has a secondary MCL of 0.2 mg/L, but no primary MCL. Compliance is based on running annual average (RAA). For individual samples collected monthly at each water treatment plant effluent, aluminum concentrations ranged from < 0.050 to 0.340 mg/L at each water treatment plant.

Secondary Standards

National Secondary Drinking Water Regulations (NSDWR) regulate contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. USEPA recommends secondary standards to water systems, but does not require systems to comply. The secondary drinking water regulations are intended as guidelines for the states; however, DDW enforces secondary MCLs. All constituents complied with their respective secondary MCLs as RAA except at the Skinner plant and Weymouth plant where the threshold odor number (TON) was higher than the recommended secondary MCL of 3 TON.

Aluminum, which has a secondary MCL of 0.2 mg/L, ranged from < 0.050–0.340 mg/L at the effluents of the treatment plants with the highest single treatment plant RAA of 0.167 mg/L at Diemer plant. Specific conductance and total dissolved solids (TDS) vary from year to year, mostly because of the blending of CRW and SWP water, but they are always below the upper limits of their respective consumer acceptance range of 1,600 µS/cm and 1,000 mg/L. Treated water specific conductance ranged from 370–1,080 µS/cm and TDS ranged from 214–668 mg/L. The availability of SWP supplies has decreased in recent years due to drought conditions and Delta pumping restrictions. Under low SWP allocations, Metropolitan has increased its reliance on higher salinity CRW to meet water demands. As a result, the plant effluent TDS at the Diemer, Skinner, and Weymouth plants has increased, primarily exceeding 500 mg/L since April 2013 and reflecting CRW salinity levels under no blend conditions.

A secondary MCL requires the water to be noncorrosive. At the treatment plant effluents, the saturation index is always maintained in the positive range, as a distribution system corrosion control measure, with a target finished water pH ≥ 8.0. Saturation index ranged from 0.05 to 0.94.

In addition to TON, Metropolitan voluntarily conducts weekly aesthetic evaluations of both odor and flavor using the flavor profile analysis (FPA) method. FPA is employs a panel of highly trained sensory assessors. The Skinner plant effluent exceeded the recommended secondary MCL of 3 TON in April 2008 and quarterly samples were collected until the 1st quarter of 2012 when the running annual average (RAA) for TON was at or below 3 TON. An intensive investigation was conducted to determine the source and cause for increased TON, but no sources were found and the event dissipated naturally. In April 2013, the Weymouth plant effluent exceeded the recommended secondary MCL of 3 TON and quarterly samples were collected until the 2nd quarter of 2014 when the RAA for TON was at or below 3 TON. There were no significant treatment or water quality changes during this period and no specific cause was identified for the increase in TON. During this period, the FPA did not indicate any odor events. In addition, the elevated TON did not extend to Skinner's or Weymouth's distribution system, and there were no consumer complaints. Annual sampling resumed in April 2015 and the TON was below 3 TON at Diemer, Skinner, and Weymouth treatment plants.

Phase I, II, and V Standards

A combined total of 57 constituents are regulated under Phase I, II, and V Standards. Three constituents, barium, fluoride and nitrate, were detected at maximum levels of 0.139 mg/L, 1.0 mg/L, and 0.6 mg/L, respectively, which is well below their respective MCLs of 1 mg/L, 2 mg/L, and 10 mg/L.

Total Coliform Rule

Under the Total Coliform Rule, no more than 5.0 percent of the samples collected from the distribution system during the month can be positive for total coliform bacteria. During the period under review, twenty positive total coliform samples were collected from the distribution system with the highest monthly total coliform positive of 0.5 percent occurring in 2012. In 2012 total coliform positive samples occurred in the distribution system in January, April, and May at one out of 674, one out of 656, and four out of 741, respectively. The positive total coliform samples were traced to the Willits Pressure Control Structure which was disinfected. On any occasion when a routine total coliform sample tests positive, three repeat samples from the same location are collected and tested for coliforms. The process is repeated until all repeat samples are total coliform negative. With the exception of discovering the source of contamination for the 2012 positive total coliform samples, the reason for other positive coliform bacteria results was not apparent. There was no total coliform MCL violation.

Surface Water Treatment Rule

Constituents under the SWTR that apply to the water treatment plants are *Giardia*, turbidity, Legionella, viruses, and disinfectant residual. Compliance under the SWTR is based on treatment techniques (TTs) instead of MCLs. The Diemer, Weymouth, and Skinner plants comply with the TT requirements of the SWTR and always achieve the turbidity requirements and the CT (disinfectant concentration multiplied by contact time) requirements for 3-log (99.9%) reduction for *Giardia* and 4-log (99.99%) reduction for viruses. USEPA indicates that if *Giardia* and viruses are removed or inactivated according to the TTs in the SWTR, Legionella will be controlled; therefore, no limit is set for Legionella. The SWTR also requires that disinfectant residual entering the distribution system must not fall below 0.2 mg/L for more than 4 hours during any 24-hour period. Metropolitan's target for chlorine residual entering the distribution system from the treatment plants is 2.5 mg/L and it did not fall below 0.2 mg/L at any time in any of the plant effluents during this CRWSS review period. Metropolitan complies with turbidity requirements, which were made more stringent under the IESWTR as discussed below.

Metropolitan showed that total coliform enumeration is a poor indicator for pathogens in Metropolitan's water supply sources. DDW agreed that source water weekly *E. coli* median levels that do not exceed 100 MPN per 100 mL would support the 3-log reduction for *Giardia* and 4-log reduction for viruses.

Lead and Copper Rule

Sampling under Lead and Copper Rule is conducted at taps in homes and other buildings; therefore, Lead and Copper Rule does not directly apply to water treatment plant effluents. However, corrosivity of water leaving the treatment plants could impact the level of lead and copper in the distribution system and customer taps. A plant effluent target pH ≥ 8.0 is maintained at each of the three water treatment plants to achieve a positive saturation index as a corrosion control measure in the distribution system and the plumbing system of homes and buildings served. Neither lead nor copper was detected at the effluent of the Diemer, Skinner, or Weymouth plants.

Stage 1 and Stage 2 Disinfectants/Disinfection Byproducts Rules

In December 1998, USEPA promulgated the Stage 1 D/DBP Rule which became effective in February 1999 and required large systems to be in compliance by January 2002. DDW adopted the Stage 1 D/DBP Rule in April 2005 and it became effective on June 17, 2006. Stage 1 D/DBP Rule consists of maximum residual disinfectant levels (MRDLs) for disinfectants, TTs to control DBP precursors, and MCLs for DBPs. Chlorine, chloramines, and chlorine dioxide are covered under the rule as alternative disinfectants for the control of DBP formation. The MCLs for DBPs resulting from chlorination are 0.080 mg/L for total trihalomethanes (TTHMs) and 0.060 mg/L for the five regulated haloacetic acids (HAA5). Metropolitan uses chloramines as its secondary disinfectant. Metropolitan has complied with Stage 1 D/DBP Rule since its inception in 2002.

USEPA finalized the Stage 2 D/DBP Rule in January 2006 and DDW adopted the Stage 2 D/DBP Rule, effective June 21, 2012. Under Stage 2 D/DBP Rule, compliance with the MCLs is based on the average of four individual quarterly DBP measurements collected at a given location, referred to as locational running annual average (LRAA). Metropolitan completed and submitted the Initial Distribution System Evaluation (IDSE) Report to DDW on September 27, 2006. The Disinfectant/Disinfection Byproducts Compliance Plan was last updated on December 20, 2013. The plan requires monitoring at 50 locations for Stage 1 and Stage 2 D/DBP Rules; the locations covered by each of Metropolitan's treatment plants were approved by DDW in 2009. Metropolitan had already been monitoring the 50 locations under Stage 1 D/DBP Rule, prior to Stage 2 compliance beginning in April 2012 and results have shown that Metropolitan complies with the LRAA of TTHM (0.080 mg/L) and HAA5 (0.060 mg/L) for each monitoring location under Stage 2 D/DBP Rule. The highest TTHM LRAA at the core locations for the Diemer, Skinner, and Weymouth plants were 0.052 mg/L, 0.024 mg/L, and 0.061 mg/L, respectively. The highest HAA5 LRAA at the core locations for the Diemer, Skinner, and Weymouth plants were 0.027 mg/L, 0.007 mg/L, and 0.034 mg/L, respectively. To further ensure compliance with the Stage 2 D/DBP Rule, Metropolitan implemented ozone disinfection at the Skinner plant in October 2010 and Diemer plant in July 2015, and is in the process of constructing ozone facilities at the Weymouth plant.

Metropolitan began using chlorine to control the proliferation of quagga mussels in the CRA, the Lake

Skinner outlet conduit, and at the Lake Mathews headworks or outlet tower in July 2007. Since 2007, Metropolitan has used the Step 2 method for compliance due to the effects of chlorinated CRW. During the reporting period, the Step 2 method was used at Diemer, Skinner, and Weymouth plants until the 3rd quarter of 2011 for Skinner plant and the 2nd quarter of 2015 for Diemer plant, following ozone treatment. With ozone treatment, Diemer and Skinner plants use the 40/30 Alternative Compliance Criteria which does not require achievement of specified TOC removals when TOC LRAA < 4.0 mg/L, alkalinity > 60 mg/L, TTHM LRAA ≤ 0.040 mg/L and HAA5 LRAA ≤ 0.030 mg/L.

Bromate formation is associated with ozone treatment because ozone reacts with bromide to form bromate. During the reporting period, the bromate level ranged ND–0.012 mg/L with the highest RAA of 0.0065 mg/L for Skinner plant. The detection limit for purpose of reporting is 0.001 mg/L while the MCL is 0.010 mg/L as a RAA. Monitoring for Diemer plant began in July 2015 when ozone went online, and bromate levels have not been detectable (< 0.001 mg/L).

Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rules

USEPA finalized the LT1ESWTR in January 2002, applicable to public water system serving fewer than 10,000 persons, and the LT2ESWTR in January 2006. DDW adopted both LT1ESWTR and LT2ESWTR, effective on July 1, 2013. One of the major provisions of the LT2ESWTR was required source water monitoring for *Cryptosporidium*, *E. coli*, and turbidity.

For Schedule 1 systems, such as Metropolitan, the start of the two-year monitoring period for LT2ESWTR was October 2006. Metropolitan completed Round 1 monitoring under the LT2ESWTR in 2008. Pathogen monitoring at the plant influents between 2006 and 2008 indicated that the Diemer, Skinner, and Weymouth plants fall into Bin 1 classification as *Cryptosporidium* was not detected in any samples over the 24-month period. Therefore, the plants do not require additional actions under the LT2ESWTR. The LT2ESWTR Round 2 monitoring began in April 2015 for the treatment plants. During the period covered by this report, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples. During the period from April 2015 to December 2015, monthly monitoring of treatment plant influents was mandated and reported under the LT2ESWTR Round 2 monitoring. The Round 2 monitoring will continue through March 2017. As required by the LT2ESTWR, *Cryptosporidium* concentrations, turbidity, and *E. coli* concentrations are being monitored.

Interim Enhanced Surface Water Treatment Rule

The IESWTR grants 2.0-log *Cryptosporidium* removal credit for systems with conventional or direct filtration water treatment plants provided turbidity requirements are met under the combined filter effluent (CFE) requirements of the IESWTR (≤ 0.3 NTU in 95 percent of samples based on 15-minute sampling intervals and never to exceed 1 NTU). The plants achieved 100-percent compliance with the IESWTR requirements based on 5-minute sampling intervals. The maximum 95th-percentile CFE turbidity of 0.10 NTU occurred at the Skinner plant in July 2015.

Radionuclides Rule

Gross alpha, gross beta, and uranium have MCLs of 15 pCi/L, 4 mrem/yr, and 20 pCi/L, respectively. Detected radionuclides at the Diemer, Skinner, and Weymouth plants are well below their respective MCLs. Gross alpha has a detection limit of 3 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from < 3 to 5.0 pCi/L. Gross beta has a detection limit of 4 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from < 4–6.5 pCi/L. Uranium has a detection limit of 1 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from 1.2–2.8 pCi/L.

Filter Backwash Rule

The FBRR requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes be returned to a location such that all processes of a system's conventional or direct filtration including coagulation, flocculation, sedimentation (conventional filtration only), and filtration are employed.

Weymouth, Diemer, and Skinner plants have WWRPs that treat filter backwash water, sludge thickener supernatant, and liquids from dewatering processes and return the reclaimed water to the plant influent prior to any treatment in compliance with the FBRR. In addition, DDW established goals that no more than 10 percent of the total plant flow should come from washwater return and that the WWRP effluent turbidity should be less than 2.0 NTU. Metropolitan strives to achieve these goals at its treatment plants. For the December 2015 FBRR form submitted to DDW, the average recycled water turbidities were 0.41 NTU, 0.54 NTU, and 0.73 NTU at the Diemer, Skinner, and Weymouth plants, respectively. The average recycled water flows were 1.2 percent, 13.4 percent, and 2.3 percent at the Diemer, Skinner, and Weymouth plants, respectively.

Arsenic Rule

The federal arsenic MCL, originally set at 0.050 mg/L under NPDWR, was revised to 0.010 mg/L effective January 23, 2006; DDW adopted the federal MCL effective November 28, 2008. For this reporting period, the maximum arsenic concentration at each of the Diemer and Weymouth plant effluents was 0.003 mg/L, which is well below the MCL. Arsenic was not detected in the Skinner plant effluent at the DLR value of 0.002 mg/L.

Perchlorate

California's MCL for perchlorate is 0.006 mg/L, effective October 2007. USEPA has no MCL for perchlorate at this time. Prior to the MCL development, perchlorate was detected at 0.004 mg/L and 0.005 mg/L at the Diemer and Skinner plants, respectively, during California UCMR monitoring in 2004. This is attributed to contamination of CRW via Las Vegas Wash at that time. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants at the DLR of 0.004 mg/L during this reporting period.

Compliance with New Drinking Water Regulations

A number of MCLs, public health goals (PHGs), notification levels (NLs), and other requirements have been revised or added since the CRWSS 2010 Update was completed. They are summarized below along with Metropolitan's compliance with the new regulations.

Chromium-6

On July 27, 2011, OEHHA established the PHG for chromium-6 at 0.00002 mg/L. As of July 1, 2014, the California MCL for chromium-6 is 0.010 mg/L. Chromium-6 levels at the plant effluents were between 0.00004 mg/L and 0.00016 mg/L. The elevated chromium-6 at the Diemer, Skinner, and Weymouth plants was most likely caused by blending of other source waters, most notably from pump-in programs along the California SWP system.

Stage 2 Disinfectants and Disinfection Byproducts Rule

Compliance with the Stage 2 D/DBP Rule is discussed above under *Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule*.

Long Term 2 Enhanced Surface Water Treatment Rule

Compliance with the LT2ESWTR is discussed above under *Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rule*.

New Public Health Goals

Five PHGs (perchlorate, chlorobenzene, endothall, hexachlorocyclopentadiene, silvex, and trichlorofluoromethane) were revised and one new PHG (chromium-6) was added during this review period. No new or revised PHG during this CRWSS update period has any impact on the operations at the Diemer, Skinner, and Weymouth plants.

On April 24, 2014, OEHHA finalized the revised PHGs as 0.070 mg/L for chlorobenzene, 0.094 mg/L for endothall, 0.002 mg/L for hexachlorocyclopentadiene, 0.003 ng/L for silvex, and 1.3 mg/L for trichlorofluoromethane. On February 1, 2015, OEHHA published the updated perchlorate PHG of 0.001 mg/L based on new research that focused on the effects of perchlorate on infants. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected (ND; < 0.0001 mg/L) in the plant effluents at the Diemer, Skinner, or Weymouth plants during this reporting period based on the USEPA Method 332.

New Notification Levels

During this report period, there were no NLs that have been revised or added. NLs are established either in response to actual contamination of drinking water supplies or in anticipation of possible contamination. Chemicals for which notification levels are established may eventually be regulated by MCLs. There was no actual contamination, or threat of contamination, to Colorado River water by any chemical that has a notification level during this reporting period.

Compliance with Anticipated Drinking Water Regulations

The safety of drinking water supplies is an ongoing priority for public health regulatory officials. As such, federal and state regulatory agencies continue to revise existing regulations and propose new regulations as potential contaminants are identified. Metropolitan continues to evaluate compliance with these anticipated regulations and does not foresee any significant impacts.

Fluoride

On April 27, 2015, the U.S. Department of Health and Human Services (DHHS) announced a final recommendation of 0.7 mg/L to replace the current recommended range of 0.7 to 1.2 mg/L of fluoride in treated drinking water. This updated recommendation is based on USEPA and DHHS scientific assessments to balance the benefits of preventing tooth decay while limiting any unwanted health effects. These scientific assessments will also guide USEPA in making a determination of whether to lower the maximum amount of fluoride allowed in drinking water, which is set to prevent adverse health effects. USEPA is currently reviewing both the primary and secondary standards for fluoride but has not established a timeline for releasing the final recommended fluoride level for drinking water. As the primacy agency, DDW will adopt any new fluoride MCL set by USEPA or set a more stringent fluoride MCL. Metropolitan will make necessary adjustments at each of the water treatment plants to feed fluoride at the level recommended in the future. No impact is expected.

NDMA

Neither USEPA nor DDW has established an MCL for *N*-nitrosodimethylamine (NDMA) at this time. In 2002, DDW set NDMA notification and response levels of 10 ng/L and 300 ng/L as RAA. OEHHA set a PHG of 3 ng/L for NDMA in December 2006. USEPA added NDMA to UCMR 2 in 2007 and included it on the CCL3 in 2009 and the draft CCL4 in 2015. Metropolitan began voluntarily sampling NDMA on a quarterly basis in 2005 and completed a special monitoring under UCMR 2 in 2008. Since 2014, Metropolitan has conducted voluntary NDMA monitoring at treatment plant effluents and representative distribution system locations twice per year. During this reporting period, NDMA did not exceed 10 ng/L as RAA at any monitoring location.

Under voluntary monitoring, the Diemer plant effluent had an NDMA peak concentration of < 2 ng/L and Diemer's distribution system had NDMA concentrations ranging from < 2 to 5.5 ng/L. The Skinner plant effluent had an NDMA peak concentration of 6.5 ng/L and Skinner's distribution system had NDMA concentrations ranging from 2 to 11 ng/L. The Weymouth plant effluent had an NDMA peak concentration of 2.5 ng/L and Weymouth's distribution system had NDMA concentrations ranging from < 2 to 6.7 ng/L. Metropolitan's compliance strategy will be based on the future MCL.

Perchlorate

California's MCL for perchlorate is 0.006 mg/L, effective October 2007. USEPA has no MCL for perchlorate at this time. A revised perchlorate MCL may be established in the future in response to the January 7, 2011, revised draft perchlorate PHG of 0.001 mg/L by OEHHA. Perchlorate was detected at 0.004 mg/L and 0.005 mg/L at the Diemer and Skinner plants, respectively, during California UCMR monitoring in 2004. This is attributed to contamination of CRW via Las Vegas Wash at that time. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants at the DLR of 0.004 mg/L during this reporting period.

PPCPs

As discussed under the *Summary of Source Water Quality Review* above, Metropolitan's PPCP monitoring program found PPCPs and OWCs at low ng/L levels in source water samples.

1,2,3-TCP

DDW has recommended an MCL for 1,2,3-TCP of 0.000005 mg/L. Metropolitan completed compliance monitoring under the UCMR regulation and continues to conduct internal monitoring of 1,2,3-TCP. 1,2,3-TCP has not been detected in any samples. Metropolitan will begin compliance monitoring for 1,2,3-TCP after the drinking water standard is adopted.

Strontium

USEPA proposes to reduce the Health Reference Level for strontium from 4.2 to 1.5 mg/L. In addition to monitoring for gross alpha, gross beta, and uranium, as discussed under the Radionuclides Rule section, Metropolitan also monitored for strontium during the reporting period. The strontium levels in Diemer, Skinner, and Weymouth plant effluents were between 0.4 and 1.2 mg/L, below the proposed Health Reference Level of 1.5 mg/L.

Key Recommendations

The following is a comprehensive list of 24 recommendations developed based on the findings of the CRWSS 2015 Update and grouped by watershed. Many recommendations are a continuation from previous sanitary surveys as the source water issue is ongoing and requires continued engagement from Metropolitan. The recommendations marked with an asterisk (*) are a continuation or adaptation of previous recommendations from the CRWSS 2010 Update. These recommendations may be associated with a long-term activity or an activity that has evolved into a new but related effort.

Overall Colorado River Basin

1. *Participate in the Colorado River Basin Salinity Control Program and related efforts addressing salinity management in Metropolitan supplies**
   Metropolitan will continue to serve on the Colorado River Basin Salinity Control Forum, as representatives of California, and participate in the Forum Workgroup to support funding and implementation of salinity control projects, and completion of the program's triennial review.

2. *Complete the Salinity Management Plan Study Update**
   Metropolitan will collaborate with USBR, SCSC, and the Forum to complete the Salinity Management Plan Study Update, which will include an update of the economic impact model used by the Forum to assess Colorado River salinity impacts.

3. *Participate with the Lower Colorado River Water Quality Partnership**
   Metropolitan will continue to actively participate with SNWA and CAP to monitor Colorado River water quality issues of mutual interest and develop strategies and management actions to ensure source water protection.

4. *Track uranium exploration and other energy development activities**
   Metropolitan will continue to track uranium exploration and other energy development activities throughout the Colorado River Basin to ensure measures are taken to protect the water quality of the Colorado River.

5. *Comment on regulatory development for perchlorate and chromium-6**
   Metropolitan will track the federal regulatory processes for perchlorate and chromium-6 and the California regulatory progress on the perchlorate MCL, which is currently under review; coordinate with regulators, trade organizations, and other water utilities; and comment as appropriate in the drinking water standard setting process.

Upper Colorado River Watershed

6. *Support expeditious removal of the uranium mill tailings pile near Moab, Utah**
   Metropolitan will continue to support the efforts of USDOE in cleanup of the mill tailings site, advocating for continued and increased federal funding for expeditious removal of the tailings pile to ensure protection of downstream drinking water uses.

7. *Participate in the Lake Powell Water Quality Monitoring Work Group*
   Metropolitan will continue to participate in monthly work group meetings, led by USBR to review and discuss Lake Powell water quality data.

Lake Mead Watershed

8. *Continue to track performance of Las Vegas Valley wastewater treatment plants**
   Metropolitan will continue to coordinate with Las Vegas area wastewater dischargers, review and comment, as necessary, on NPDES permit renewals, and track phosphorus discharges from the wastewater treatment plants to ensure protection of downstream drinking water uses.

9. *Continue to track NDEP's progress on development of a Nutrient Criteria Strategy for the State of Nevada**
Metropolitan will track Nevada's Nutrient Criteria Strategy, an effort being pursued by NDEP in cooperation with USEPA Region IX with the end goal of improving Nevada's existing nutrient criteria.

10. *Continue to participate in Lake Mead Water Quality Forum's Ecosystem Monitoring Workgroup**
Metropolitan will continue to participate in the Ecosystem Monitoring Workgroup, formed to enhance multi-agency cooperation on ecosystem monitoring for Lake Mead and Colorado River watersheds.

11. *Continue to track and engage with stakeholders on perchlorate remediation efforts in Henderson, Nevada**
Metropolitan will continue to coordinate with NDEP, NERT, and other key Colorado River stakeholders to monitor and provide input on the remedial investigations and efforts related to the Tronox/NERT and Endeavour perchlorate plumes.

Lake Mohave and Lake Havasu Watersheds

12. *Continue to review groundwater monitoring data for the Needles Sanitary Landfill**
Metropolitan will continue to review the monitoring data for the Needles Sanitary Landfill. Although current groundwater monitoring indicates that contaminants are below MCLs for drinking water, there has been an increase in tetrachloroethene (PCE) at one of the site's monitoring wells (N-4).

13. *Continue to support the efforts of CCRSCo**
Metropolitan will continue to participate in and support CCRSCo's efforts to protect the water quality of the Colorado River, including working with USBR on the spill notification process and supporting CCRSCo's development of a watershed plan with funding from a USBR WaterSMART grant to enhance watershed planning efforts for the lower Colorado River.

14. *Continue to participate in advisory groups for chromium-6 remediation at the Topock Gas Compressor Station**
Metropolitan will continue to coordinate with the lead regulatory agencies and PG&E and actively participate in various workgroups to support efforts to remediate the chromium-6 groundwater plume adjacent to the Colorado River near Needles, California. In addition, Metropolitan will review the Subsequent EIR, groundwater model improvements, and decommissioning of IM-3 facilities during construction, anticipated in 2019, to ensure protection of Colorado River water quality.

15. *Track ADEQ's progress on remediating the chromium-6 contamination at the former McCulloch corporation facilities*
Metropolitan will track and support ADEQ's efforts to clean up the McCulloch contaminated groundwater site near Lake Havasu. ADEQ is in the preliminary phase of developing a remedial action plan for the project and will be engaging stakeholders in future project reviews.

16. *Continue to track on-going water quality studies in the Lake Mohave and Lake Havasu watersheds**
Metropolitan will track a number of lower Colorado River-related water quality studies over the next five years. Notably, USBR's ongoing Lower Colorado River Contaminant Monitoring Program and ADEQ's proposed increase in beach monitoring.

Colorado River Aqueduct

17. *Continue to track the progress of the Eagle Mountain Pumped Storage Project**
Metropolitan will continue to track the proposed Eagle Mountain Pumped Storage Project and participate in the design review process to ensure protection of the CRA.

18. *Assess water quality effects of a potential Perris Dam seepage recovery project*
Metropolitan is currently investigating a project with DWR to recover seepage water from Lake Perris while assuring protection of CRA water quality. If the project moves forward, Metropolitan will provide an assessment in future CRWSS updates.

Lake Mathews Watershed

19. *Continue to coordinate with Riverside County Flood Control and Water Conservation District on development reviews**
Metropolitan will coordinate closely with RCFCWCD on development proposals that could impact water quality within the Lake Mathews Watershed including the Boulder Springs-Dailey Ranch development project. As appropriate, Metropolitan would recommend the application of the Lake Mathews watershed model to evaluate the effectiveness of proposed stormwater treatment options in protecting Lake Mathews' water quality.

20. *Continue to track progress of the Cajalco Road Widening project and evaluate potential impacts to Lake Mathews**
Metropolitan will continue to track the status of the Cajalco Road Widening and Safety Enhancement project, evaluate potential impacts to Lake Mathews based on the proposed alignments and provide input into the environmental review process.

Diamond Valley Lake Watershed

21. *Continue to be involved in long-term recreational plans for Diamond Valley Lake**
Metropolitan will continue to assess recreational and other development proposals to ensure that any new facilities within the Diamond Valley Lake watershed are consistent with existing permitted activities and are protective of water quality. Metropolitan will update the Recreational Activity Plan, as needed, to reflect recreational improvements.

Lake Skinner Watershed

22. *Develop a Lake Skinner Source Water Protection Plan**
Metropolitan has assessed various watershed activities with potential to impact Lake Skinner water quality as included in this CRWSS update. Metropolitan will develop a source water protection plan for the Lake Skinner watershed to further assess and document watershed activities and provide actions, policies, and practices necessary to ensure protection of Lake Skinner water quality.

23. *Consider improvements to water quality and flow monitoring for Lake Skinner tributaries**
Metropolitan will consider developing a monitoring framework to obtain data to better evaluate

watershed pollution threats. Additional data is needed to better understand the hydrologic and water quality characteristics within the Lake Skinner watershed. Information could be used to develop a watershed model, as may be recommended in the Lake Skinner Source Water Protection Plan.

24. *Identify and prioritize parcels for potential future land acquisition or conservation easements**
    Metropolitan previously acquired several properties within the Lake Skinner watershed for water quality protection. Metropolitan will evaluate the potential for future land acquisition and/or conservation easements and, if determined feasible, will rank properties based on their potential to impact lake water quality.

1 Introduction

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Chapter 1 Introduction

This report presents the findings of the 2015 update for the Colorado River Watershed Sanitary Survey (CRWSS). Metropolitan Water District of Southern California (Metropolitan) has assumed the responsibility for completing this watershed sanitary survey, which covers portions of the Colorado River (above Metropolitan's Whitsett Intake near Parker Dam), the Colorado River Aqueduct (CRA), Lake Mathews, Diamond Valley Lake, and Lake Skinner, on behalf of its member agencies. The period for this update is from January 2011 through December 2015. The initial watershed sanitary survey was completed in 1996 [1]; and in accordance with the California Surface Water Treatment Rule (SWTR)—Title 22, Article 7, Section 64665 of California Code of Regulations (California Title 22)—updates must be developed at least every five years thereafter. Previous updates were for years 1996–2000, 2000–2004, 2005-2010 [2] [3] [4].

California Senate Bill 162 established the California Department of Public Health (CDPH) within the existing Health and Human Services Agency and statutorily transferred certain responsibilities from the California Department of Health Services to the new CDPH, effective July 1, 2007. On July 1, 2014, CDPH's Drinking Water Program was transferred to the State Water Resources Control Board's new Division of Drinking Water (DDW). Due to the reorganization of the State's drinking water programs, original reference documents and correspondence created prior to July 1, 2014 will reference DDW, irrespective of activities completed under DDW's predecessors' authority.

Background

Metropolitan's Service Area and Water Supplies

Metropolitan is a public agency organized in 1928 by a vote of the electorates of 11 cities located in southern California. The agency was enabled by the Metropolitan Water District Act, which was passed into law by the California Legislature. Metropolitan was formed "for the purpose of developing, storing, and distributing water" to the residents of southern California. **Figure 1-1** provides an overview of Metropolitan's service area and member agencies across the southern California coastal plain. A detailed list of Metropolitan's member agencies and communities served can be found in **Table 1-1**. Metropolitan's service area extends about 200 miles along the Pacific Ocean from the city of Oxnard on the north to the international boundary with Mexico on the south, and it reaches as far as 70 miles inland from the coast. The total area served is nearly 5,200 square miles and it includes portions of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties.

Metropolitan imports and distributes water from the Colorado River through its CRA and from the Sacramento-San Joaquin River Delta through the State Water Project (SWP) (**Figure 1-2**). The focus of this update is the Colorado River watershed. Several major dams control river flow throughout the Colorado River watershed. The Navajo Dam regulates the San Juan River and the Green River is controlled by the Fontenelle and Flaming Gorge dams. The Gunnison River has three major dams: Crystal, Morrow Point, and Blue Mesa. Glen Canyon Dam forms Lake Powell and controls most of the Colorado River flow above Lee's Ferry. Hoover Dam forms Lake Mead and provides most of the storage and regulation for the lower Colorado River Basin. Lake Mohave is formed by Davis Dam and Lake Havasu by Parker Dam. Lake Havasu serves as the forebay for Metropolitan's CRA and the Central Arizona Project intakes. Several other dams along the river between Lake Havasu and Mexico serve primarily as diversion structures for irrigation projects. A brief overview of each reservoir can be found later in this chapter.

The SWP, built and operated by the California Department of Water Resources, consists of 700 miles of canals and pipelines, 34 storage facilities, 20 pumping plants, 4 pumping-generating plants, and 5 hydroelectric power plants [5]. Metropolitan is one of 29 agencies throughout California that have contracted to receive water from the SWP. Deliveries to Metropolitan through the California Aqueduct began in 1973.

Metropolitan's water distribution system consists of 830 miles of pipeline, five water treatment plants, 12 reservoirs (including the four on the CRA system – Gene Wash, Copper Basin, Iron Mountain, and Eagle Mountain), 16 hydroelectric power recovery plants, and numerous regulating structures. In addition to treated water, Metropolitan delivers untreated Colorado River water to several agencies in its service area. Agencies in Metropolitan's service area that currently treat Colorado River water are listed in **Table 1-2**. Eastern Municipal Water District and Western Municipal Water District of Riverside County have treated Colorado River water in the past, but are not currently doing so. The water sales for fiscal year 2014–2015 were 1.91 million-acre-feet of water [6].

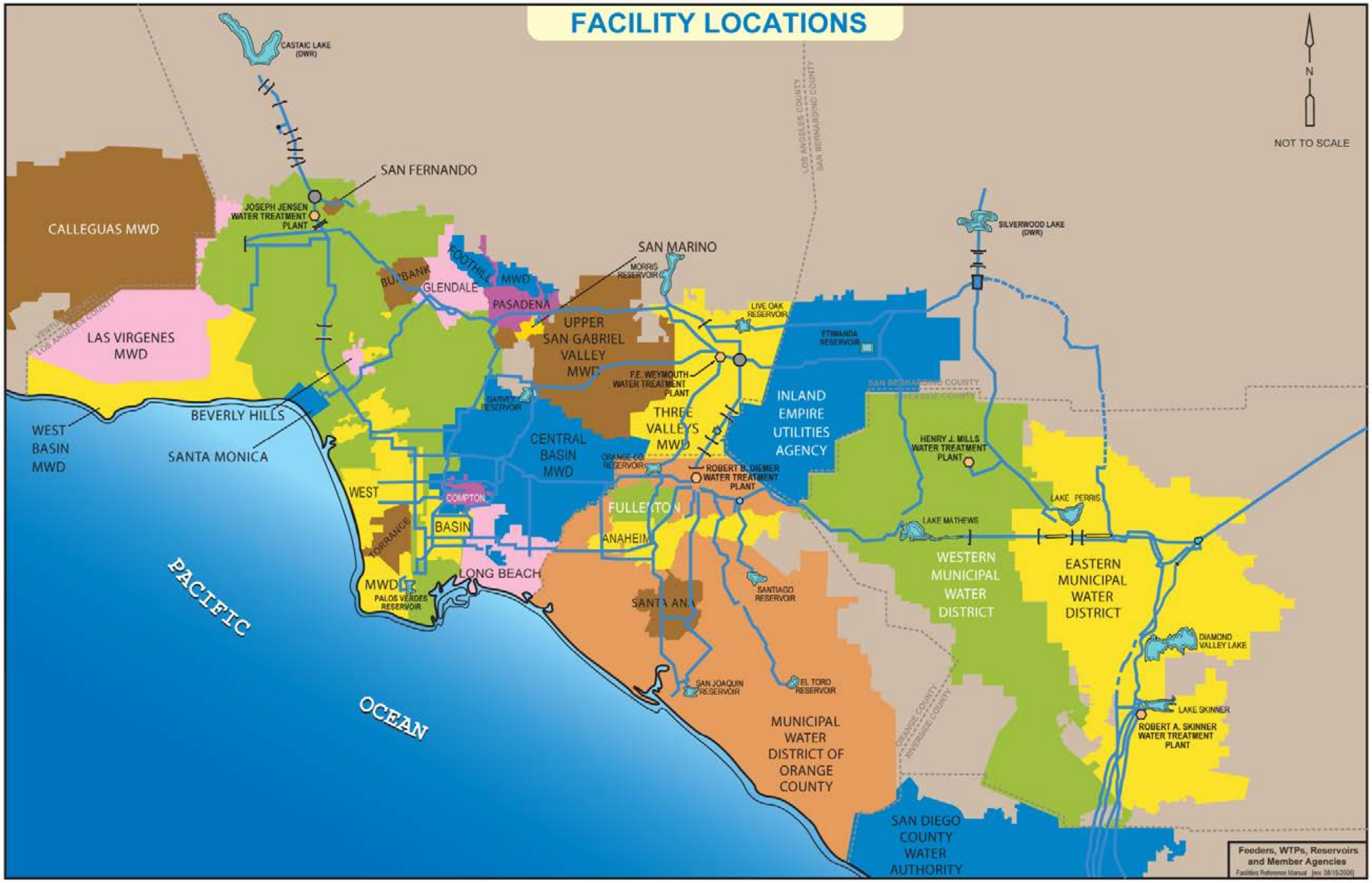


Figure 1-1. Map of Metropolitan's Member Agencies, Facilities, and Distribution of Colorado River Water and State Project Water

Figure 1-2. Southern California's Imported Water Resources

Table 1-1. Metropolitan's Member Agencies and the Communities Served

Municipal Water Districts (11)		Member Cities (14)			County Water Authorities (1)
Calleguas	Orange County	Anaheim	Glendale	San Marino	San Diego
Central Basin	Three Valleys	Beverly Hills	Long Beach	Santa Ana	
Foothill	Upper San Gabriel Valley	Burbank	Los Angeles	Santa Monica	
Inland Empire		Compton	Pasadena	Torrance	
Eastern	West Basin	Fullerton	San Fernando		
Las Virgenes	Western				

Cities Within Member Agency Jurisdictions

Calleguas MWD
- Camarillo
- Camarillo Heights
- Fairview
- Lake Sherwood Valley
- Las Posas
- Moorpark
- NAWS Point Mugu
- NCBC Port Hueneme
- Oak Park
- Oxnard
- Port Hueneme
- Santa Rosa Valley
- Simi Valley
- Somis
- Thousand Oaks

Central Basin MWD
- Artesia
- Bell
- Bellflower
- Bell Gardens
- Cerritos
- Commerce
- Cudahy
- Downey
- East Los Angeles
- Florence
- Hawaiian Gardens
- Huntington Park
- La Habra Heights
- Lakewood
- La Mirada
- Lynwood
- Maywood
- Montebello
- Norwalk
- Paramount
- Pico Rivera
- Santa Fe Springs
- Signal Hill
- South Gate
- South Whittier
- Vernon
- Whittier

Foothill MWD
- Altadena
- La Cañada Flintridge
- La Crescenta
- Montrose

Inland Empire
- Chino
- Chino Hills
- Fontana
- Montclair
- Ontario
- Rancho Cucamonga
- Upland

Eastern MWD
- Good Hope
- Hemet
- Homeland
- Juniper Flats
- Lakeview
- Mead Valley
- Menifee
- Moreno Valley
- Murrieta
- Murrieta Hot Springs
- Nuevo
- North Canyon Lake
- Perris
- Quail Valley
- Romoland
- San Jacinto
- Sun City
- Temecula
- Valle Vista
- Winchester

Las Virgenes MWD
- Agoura
- Agoura Hills
- Calabasas
- Chatsworth
- Hidden Hills
- Lake Manor
- Malibu Lake
- Monte Nido
- Westlake Village
- West Hills

MWD of Orange County
- Aliso Viejo
- Brea
- Buena Park
- Capistrano Beach
- Corona Del Mar
- Costa Mesa
- Coto De Caza
- Cypress
- Dana Point
- Fountain Valley
- Garden Grove
- Huntington Beach
- Irvine
- Laguna Beach
- Laguna Hills
- Laguna Niguel
- Laguna Woods
- La Habra
- Lake Forest
- La Palma
- Leisure World
- Los Alamitos
- Mission Viejo
- Monarch Beach
- Newport Beach
- Orange
- Placentia
- Rancho Santa Margarita
- San Clemente
- San Juan Capistrano

MWD of Orange County (cont.)
- Seal Beach
- Stanton
- Tustin
- Tustin Foothills
- Villa Park
- Westminster
- Yorba Linda

Three Valleys MWD
- Azusa
- Charter Oak
- Claremont
- Covina
- Covina Knolls
- Diamond Bar
- Glendora
- Industry
- La Verne
- Pomona
- Rowland Heights
- San Dimas
- So. San Jose Hills
- Walnut
- West Covina

Upper San Gabriel Valley MWD
- Arcadia
- Avocado Heights
- Baldwin Park
- Bradbury
- Citrus
- Covina
- Duarte
- El Monte
- Glendora
- Hacienda Heights
- Industry
- Irwindale
- La Puente
- Mayflower Village
- Monrovia
- Rosemead
- San Gabriel
- South El Monte
- South Pasadena
- South San Gabriel
- Temple City
- Valinda
- West Covina
- West Puente Valley

West Basin MWD
- Alondra Park
- Carson
- Culver City
- El Segundo
- Gardena
- Hawthorne
- Hermosa Beach
- Inglewood
- Ladera Heights
- Lawndale
- Lennox
- Lomita

West Basin MWD (cont.)
- Malibu
- Manhattan Beach
- Marina Del Rey
- Palos Verdes Estates
- Rancho Palos Verdes
- Redondo Beach
- Rolling Hills
- Rolling Hills Estates
- Ross-Sexton
- Topanga Canyon
- West Athens
- West Hollywood

Western MWD of Riverside County
- Bedford Heights
- Canyon Lakes
- Corona
- Eagle Valley
- El Sobrante
- Jurupa
- Lake Elsinore
- Lake Mathews
- March AFB
- Murrieta
- Norco
- Riverside
- Rubidoux
- Temecula
- Temescal Canyon
- Woodcrest

San Diego County Water Authority
- Alpine
- Bonita
- Bonsall
- Camp Pendleton
- Carlsbad
- Casa De Oro
- Chula Vista
- Del Mar
- El Cajon
- Encinitas
- Escondido
- Fallbrook
- Lakeside
- La Mesa
- Lemon Grove
- Mount Helix
- National City
- Oceanside
- Pauma Valley
- Poway
- Rainbow
- Ramona
- Rancho Santa Fe
- San Diego
- San Marcos
- Santee
- Solana Beach
- Spring Valley
- Valley Center
- Vista

Table 1-2. Member Agencies Treating Colorado River Water

Metropolitan Member Agencies	Sub-agencies
City of Anaheim	N/A
Inland Empire Utilities Agency	City of Ontario
Municipal Water District of Orange County	East Orange County Water District; Irvine Ranch Water District; Moulton Niguel Water District; Santa Margarita Water District; Trabuco Canyon Water District
San Diego County Water Authority	City of Escondido; City of Oceanside; City of Poway; City of San Diego; Helix Water District; Olivenham Municipal Water District; Ramona Municipal Water District; Santa Fe Irrigation District; Sweetwater Authority
Western Municipal Water District of Riverside County	City of Corona; Elsinore Valley Municipal Water District

Lakes and Reservoirs within the Study Area

The physical characteristics of the major reservoirs on the Colorado River and CRA system are shown in **Table 1-3**. The following sections discuss each lake individually. **Chapter 2** contains additional hydrologic information for the lakes and watershed characteristics.

Table 1-3. Physical Characteristics of Major Reservoirs along the Colorado River and Colorado River Aqueduct System

Reservoir	Capacity	Maximum Elevation*	Water Source
Colorado River System			
Lake Powell	27,215,000 AF	3,711 ft	Colorado River
Lake Mead	27,620,000 AF	1,229 ft	Colorado River
Lake Mohave	1,818,000 AF	647 ft	Colorado River
Lake Havasu	646,200 AF	450 ft	Colorado River
Colorado River Aqueduct			
Gene Wash	6,300 AF	1,037 ft	Colorado River
Copper Basin	22,000 AF	1,026 ft	Colorado River
Southern California Reservoirs			
Lake Mathews	182,000 AF	1,390 ft	Colorado River
Diamond Valley Lake	810,000 AF	1,756 ft	Blend of Colorado River and State Water Project**
Lake Skinner	44,000 AF	1,479 ft	Blend of Colorado River and State Water Project

AF = acre-feet
* Above mean sea level
** Only State Water Project water has been used to fill Diamond Valley Lake since the discovery of quagga mussels in Colorado River water in 2007.

Lake Powell

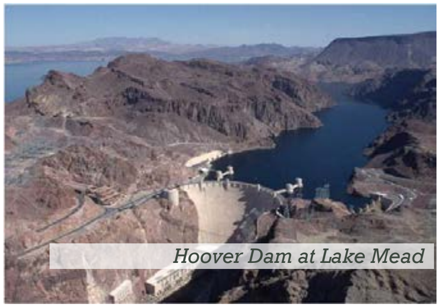
Lake Powell is the major storage reservoir on the Colorado River serving the Upper Basin states of the Colorado River Compact (Colorado, Utah, Wyoming, and New Mexico). The Compact specifies that the Upper Basin states are to provide a minimum annual flow of 7.5 million acre-feet to the Lower Basin states (Arizona, Nevada, and California). Lake Powell is the second largest man-made reservoir in the United States behind Lake Mead, storing up to approximately 27,200,000 acre-feet of water when full and having a retention time of approximately 3 years. Lake Powell began filling in 1963 after the Glen Canyon Dam was completed and reached full capacity for the first time in 1980. The U.S. Department of Interior, Bureau of Reclamation (USBR), manages the lake.

Glen Canyon Dam at Lake Powell

Lake Powell straddles the border between Utah and Arizona (predominantly in Utah). Through the creation of Lake Powell, Glen Canyon National Recreation Area was established in 1972. The Glen Canyon National Recreation Area is public land managed by the National Park Service and is available to the public for recreational purposes. It lies in parts of Garfield, Kane, and San Juan counties in southern Utah, and Coconino County in northern Arizona. The northern limits of the lake extend at least as far as the Hite Crossing Bridge.

Lake Mead

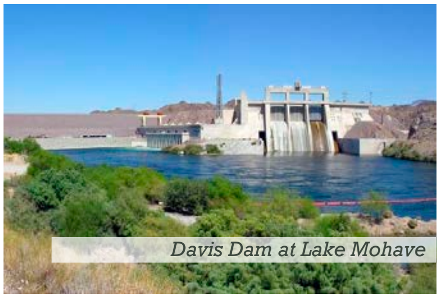
Lake Mead is the largest reservoir in the United States. It is located on the Colorado River about 30 miles southeast of Las Vegas, Nevada, in the states of Nevada and Arizona. Formed by water impounded by the Hoover Dam, it extends 112 miles behind the dam, holding up to approximately 27,600,000 acre-feet of water. Lake Mead is part of the Boulder Dam Recreation Area established in 1936 and administrated by the National Park Service. The name was changed to the Lake Mead National Recreation Area in 1964, this time including Lake Mohave and the Shivwits Plateau under its jurisdiction. Both lakes and the surrounding area offer year-round recreation options.



Hoover Dam at Lake Mead

Lake Mohave and Lake Havasu

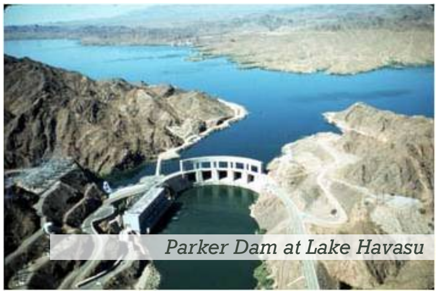
Lake Mohave is a long and narrow reservoir formed by Davis Dam on the Colorado River, which defines the border between Nevada and Arizona. The lake lies at an elevation of 647 feet near Laughlin, Nevada and Bullhead City, Arizona—about 67 miles downstream from Hoover Dam. The lake and adjacent lands forming its shoreline are part of the Lake Mead National Recreation Area administered by the National Park Service. Lake Mohave has a storage capacity of 1,818,000 acre-feet and water from Lake Mohave flows into Lake Havasu.



Davis Dam at Lake Mohave

Lake Havasu is a 646,000 acre-feet-capacity reservoir behind Parker Dam on the Colorado River, on the border between California and Arizona. The concrete-arch Parker Dam was built by USBR between 1934 and 1938. The lake's primary purpose is to store water for pumping into two aqueducts: the Central Arizona Project and the CRA.

Colorado River Aqueduct



Parker Dam at Lake Havasu

The CRA, which was completed in 1941, spans 242 miles of desert and mountain ranges between Metropolitan's intake (Whitsett Intake) on Lake Havasu and Lake Mathews. The aqueduct consists of 92 miles of tunnel, 55 miles of cut-and-cover conduit, 63 miles of open lined canal, 28 miles of inverted siphons, one mile of open unlined canal into Lake Mathews, and two miles of transportation reservoirs. The aqueduct is primarily open lined canal and cut-and-cover conduit where it crosses alluvium, with inverted siphons across drainage channels. Tunnels were used through the mountain segments. The integrity of the CRA system requires routine inspection and maintenance programs.

Colorado River Aqueduct

Lake Mathews

Lake Mathews

Metropolitan constructed Lake Mathews in the 1930s as the terminal reservoir for the CRA. Lake Mathews is located in Riverside County within a semi-rural area that has low-density residential development in surrounding communities. The western and southern shores of the lake are part of the 5,100-acre Lake Mathews Multiple Species Reserve. Lake Mathews has a capacity of 182,000 acre-feet and primarily receives Colorado River water with a limited amount of local runoff water. The lake features three earth fill dams: Main Dam on the west side of the lake, Dike #1 on the northwest side, and Dike #2 to the west of Dike #1.

Recreational use of the lake is not allowed and there is no public access to Lake Mathews. Public access is limited to tours supervised by Metropolitan or the California Department of Fish and Wildlife.

Lake Skinner

Lake Skinner

Lake Skinner, created by Metropolitan in 1973 with the construction of an earth fill dam across Tucalota Creek, serves as a regulatory storage reservoir for the Robert A. Skinner Water Treatment Plant. The lake, which has a storage capacity of 44,000 acre-feet, is located near the city of Temecula in Riverside County. Lake Skinner receives varying levels of both Colorado River water and SWP water. Lake Skinner receives very little local runoff compared to the amount of water imported to the lake. The lake features the earth fill Skinner Dam on the west end of the lake, located at the Skinner plant.

As reported in the initial survey, most of the watershed is vacant land, with about a third designated for open space and recreation (i.e., land that will remain vacant), including the Southwestern Riverside County Multi-Species Reserve (Reserve) and Lake Skinner Recreation Area. In addition, Metropolitan and the Riverside County Parks and Open Space District continue to maintain limited recreational uses in the Lake Skinner Recreation Area, which consists of the lake and the surrounding Lake Skinner County

Park. Similar to Diamond Valley Lake, Lake Skinner is open to boating and fishing; however, body contact is not permitted.

Diamond Valley Lake

Diamond Valley Lake, is a man-made off stream reservoir located near Hemet. It is one of the largest reservoirs in southern California with an 810,000 acre-feet capacity. Upon completion of Diamond Valley Lake, southern California's surface water storage capacity nearly doubled with the lake providing additional water supplies for drought, peak summer, and emergency needs.

Diamond Valley Lake

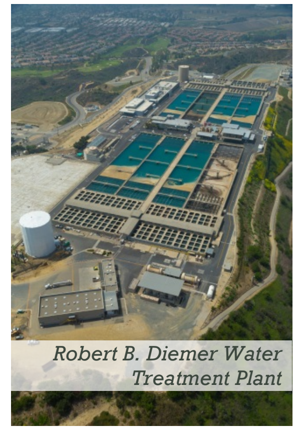
Diamond Valley Lake can be filled with Colorado River or SWP water through the inlet/outlet tower, and with SWP water through the secondary inlet. Filling of the lake began in 1999 by way of the inlet/outlet tower and was completed in 2003. Since the discovery of quagga mussels in Colorado River water in 2007, only SWP water has been used to fill Diamond Valley Lake. The lake features three earth fill dams: West Dam, East Dam, and Saddle Dam, which is located on the northwest side of the lake. Construction of the dams took advantage of nearby materials and was one of the largest earthworks projects in the United States. The lake is open to boating and fishing along with hiking and other recreational activities around the lake. Due to record low levels under drought conditions, boat launches were suspended in April 2015 and resumed in May 2016. Body contact is not permitted at Diamond Valley Lake.

Metropolitan's Water Treatment Facilities

Metropolitan has five water treatment plants, three of which routinely treat a blend of Colorado River water (the Robert B. Diemer [Diemer], Robert A. Skinner [Skinner], and F.E. Weymouth [Weymouth] water treatment plants) and water from the SWP. The other two (the Joseph Jensen [Jensen] and Henry J. Mills [Mills] water treatment plants) receive water only from the SWP. In an emergency, the Mills plant can receive Colorado River water through a pump-back facility. The water treatment plants are operated continuously, excluding occasional scheduled shutdowns or low flow conditions, and are staffed 24 hours per day. The plants provide conventional treatment (rapid mix, flocculation, sedimentation, filtration, and disinfection), while Skinner plant has direct filtration modules (excludes sedimentation). Pre-oxidation is currently done through either free chlorine (Weymouth plant) or ozone (Diemer, Jensen, Mills, and Skinner plants). Construction of ozonation facilities is underway at Weymouth plants and is expected to be completed in 2017. A brief discussion of the three blend plants follows.

Robert B. Diemer Water Treatment Plant

The Diemer plant is located in Yorba Linda, approximately 30 miles southeast of Los Angeles. It treats a blend of Colorado River water and SWP water. The plant provides full conventional treatment (i.e., rapid mix, coagulation, flocculation, sedimentation, filtration, and disinfection) with a design capacity of 520 million gallons per day (MGD). The Diemer plant switched to ozone as the primary oxidant in 2015.



Robert B. Diemer Water Treatment Plant

The Diemer plant provides treated water to the Central Pool of Metropolitan's distribution system through the Lower, Second Lower, and East Orange County feeders, as well as the Allen-McCulloch Pipeline. Diemer provides water to various communities including Anaheim, Brea, Buena Park, Capistrano Beach, Carson, West Carson, Cerritos, Costa Mesa, Cudahy, Cypress, Dana Point, Downey, El Toro, Florence, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, Inglewood, Irvine, Irwindale, La Mirada, La Habra, La Habra Heights, La Palma, Laguna Beach, Laguna Hills, Laguna Niguel, South Laguna, Lawndale, Long Beach, Los Alamitos, Los Angeles, Lynwood, Manhattan Beach, Marina Del Rey, Mission Viejo, Newport Beach, Norwalk, Orange, Palos Verdes Estates, Paramount, Placentia, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, Rossmoor, San Clemente, San Juan Capistrano, Santa Ana, Seal Beach, Signal Hill, Stanton, Torrance, Tustin, Tustin Foothills, Vernon, Villa Park, Westminster, Willowbrook, and Yorba Linda.

Robert A. Skinner Water Treatment Plant

Robert A. Skinner Water Treatment Plant

The Skinner plant is located in Winchester, approximately 14 miles southwest of Hemet and 10 miles northeast of Temecula, and treats a blend of SWP water and Colorado River water. The Skinner plant is operated as three separate water treatment plants. Plant 1, with a design capacity of 240 MGD, provides conventional treatment. Plant 2 is a 280 MGD direct filtration plant and Plant 3 is a 110 MGD conventional treatment plant. The Skinner plant switched to ozone as the primary oxidant in October 2010.

The Skinner plant provides treated water to the Eastern Municipal Water District, the Western Municipal Water District of Riverside County, and the San Diego County Water Authority. Communities served include: Alpine, Bonita, Bonsall, Camp Pendleton, Casa de Oro, Carlsbad, Castle Park, Chula Vista, Del Mar, El Cajon, Encinitas, Escondido, Fallbrook, Hemet, La Mesa, Lakeside, Lemon Grove, Leucadia, Mead Valley, Mount Helix, Murrieta Hot Springs, National City, Oceanside, Otay, Pauma Valley, Poway, Quail Valley, Rainbow, Ramona, Rancho California, Rancho Santa Fe, San Diego, San Jacinto, San Marcos, Santee, Solana Beach, Spring Valley, Temecula, Temescal, Valley Center, and Vista.

F.E. Weymouth Water Treatment Plant

F. E. Weymouth Water Treatment Plant

The Weymouth plant is located approximately 25 miles east of Los Angeles in La Verne. It treats a blend of Colorado River water and SWP water. The Weymouth plant provides conventional treatment with a design capacity of 520 MGD. Ozone facilities at the Weymouth plant are currently in construction and scheduled to be online in 2017.

The Weymouth plant provides treated water to the Central Pool of Metropolitan's distribution system through the Upper, Middle, and Orange County feeders. This includes the communities of Altadena, Arcadia, Anaheim, Artesia, Avocado Heights, Baldwin Park, Bell, Bell Gardens, Bellflower, Beverly Hills, Bradbury, Brea, Charter Oak, Chino, Citrus, Claremont, Commerce, Compton, Covina, Covina Knolls, Diamond Bar, East Los Angeles, El Monte, El Segundo, Florence, Fullerton, Gardena, Glendora, Good Hope, Green River, Hacienda Heights, Hawaiian Gardens, Hawthorne, Huntington Park, Industry, La Cañada Flintridge, La Crescenta, La Habra, La Puente, Ladera Heights, Lomita, Los Angeles, Maywood, Monrovia, Montclair, Montebello, Montrose, Norco, Ontario, Orange, Pasadena, Pomona, Rancho Cucamonga, Rosemead, Rowland Heights, San Dimas, San Gabriel, South San Gabriel, Santa Ana, Santa Fe Springs, South El Monte, South Gate, South Pasadena, Temple City, Walnut, West Covina, West Hollywood, West Puente Valley, Whittier, South Whittier, West Whittier, and Willowbrook.

Purpose of Study

This CRWSS 2015 Update fulfills the California SWTR requirement that the source watershed be surveyed at least once every five years. A watershed sanitary survey identifies potential sources of contamination in the watershed, evaluates source and treated water quality, and recommends watershed management activities that will protect and possibly improve source water quality. The CRWSS also serves as a governing document for Metropolitan's Source Water Protection Program.

In addition, Metropolitan strives to develop and implement comprehensive programs to ensure delivered water meets or surpasses all water quality regulations and objectives. Specific water quality-related core objectives and actions are identified in Metropolitan's Fiscal Year 2016/17 Water System Operations Business Plan [7] and include the following:

Key Performance Measures

- *Compliance with primary drinking water quality standards.* Deliver water that complies with all health-based water quality standards. Track all Level 1 and Level 2 Water Quality Action Level exceedances.
- *Control salinity.* Deliver water that meets water quality goals for salinity (when water supply conditions allow).
- *Water quality satisfaction.* Monitor and respond to all water quality taste-and-odor complaints reported by member agencies as an indicator of consumer satisfaction.
- *Water quality regulatory process*. Proactively engage in water quality regulatory process and provide comment to agency or industry groups on proposed regulations that affect Metropolitan and/or its member agencies.
- *Engage on source water protection.* Engage stakeholders on each recommendation from the 2015 Colorado River Watershed Sanitary Survey prior to next survey.

Conduct of Study

This update will focus on the watersheds below Hoover Dam with a few notable exceptions. In the 2000 and CRWSS 2005 Updates, the geographical areas "above Lake Mead" and "Lake Mead" (hereafter referred to as Upper Colorado River [i.e., above Glen Canyon Dam], Lake Mead [i.e., below Glen Canyon Dam to Hoover Dam]) were thoroughly evaluated for potential contaminant sources (PCSs). The CRWSS 2015 Update will focus on the following geographical regions and watersheds, consistent with the CRWSS 2010 Update: Lake Mohave and Lake Havasu, the CRA, Lake Mathews, Diamond Valley Lake, and

Lake Skinner. Metropolitan staff met with DDW on September 30, 2015, to initiate and discuss the approach for preparing the CRWSS 2015 Update.

The near-intake zone concept from DDW's Drinking Water Source Assessment and Protection Program (DWSAP) was utilized to evaluate PCSs for this update, as with the previous updates. The use of a near-intake zone focuses PCS evaluations on the watershed areas near the intake since these areas have the greatest potential to impact source water quality. The near-intake zone was defined as the watershed area for Lake Mohave and Lake Havasu downstream to the terminal reservoirs. Discussions for the Upper Colorado River and Lake Mead watersheds are linked to the key watershed management activities that Metropolitan has engaged in to protect source water quality.

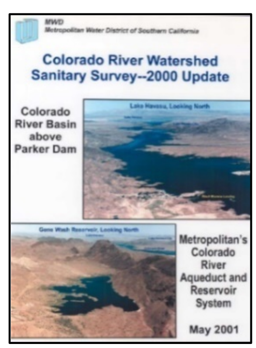
The project team consisted of Metropolitan staff. Water quality data and review of potential contaminant sources in this report covers the period from January 2011 through December 2015, with the exception of providing updates through the writing of this report for completeness in summarizing discussions regarding regulatory oversight of PCSs and key studies that are relevant to the contaminant source. The drinking water quality regulations and key watershed management activities are also presented as current as of the writing of this report. Information was obtained by contacting various agencies and through literature reviews, internal file reviews, internet research, and discussions with Metropolitan staff. Agencies and organizations contacted for information are listed in **Appendix A**.

Summary of Initial CRWSS (1996), 2000, 2005, and 2010 CRWSS Updates

The initial watershed sanitary survey was completed in 1996, and covered the period from 1990 through 1995. The CRWSS 2000 Update was completed in 2001, and covered the period from 1996 through 2000. The CRWSS 2005 Update was completed in 2006 and covered the period from 2000 through 2004. The CRWSS 2005 Update covered the Colorado River drainage area above Parker Dam as well as the CRA, Lake Mathews, Diamond Valley Lake, and Lake Skinner watersheds. The CRWSS 2010 Update, completed in March 2012, covered a six-year period (2005–2010) and covered the same regions as the CRWSS 2005 Update. For all CRWSS updates to date, the overall quality of the Colorado River water was characterized as good based on raw water quality data and evaluation of Metropolitan's water treatment plants' capability to comply with drinking water standards. Field inspections were conducted in the drainage area from Lake Mead to Parker Dam. In addition, information for this reach and the watershed above Lake Mead was collected from other agencies. No field inspections were performed above Lake Mead.

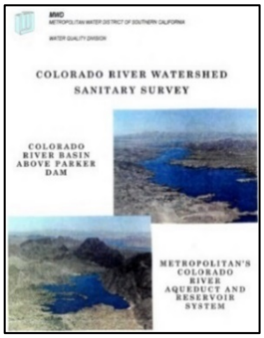
Summary of 1996 Initial Report Conclusions

Continued efforts to prevent water quality deterioration were deemed necessary. Close surveillance of recreational activities and wastewater discharges as well as increased coordination with the responsible governmental agencies in the watershed was recommended. A high degree of protection from contamination sources was provided for Lake Mathews, Lake Skinner, and the CRA.



The report identified wastewater discharges, recreational use, and animal populations as the most significant potential sources of contamination for the Colorado River system. These sources may contribute to the presence of microorganisms, organic chemicals, and nutrients in the watershed.

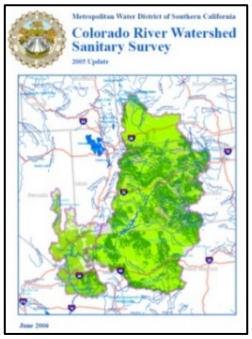
Summary of 2000 Update Report Conclusions



Recommendations stressed the importance of coordinating with regulatory agencies in the watershed, to continue tracking emerging issues in the watershed that may impact source water quality, along with additional sampling for pathogens, endocrine disruptors, pesticides, and polycyclic aromatic hydrocarbons (PAHs).

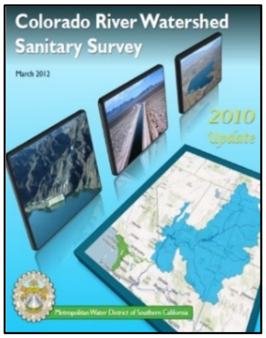
Of the nine contaminant sources identified, urban and storm runoff and recreation appeared to have the greatest potential to impact Metropolitan's source water quality in the Colorado River watershed. This was based on their presence in the watershed, the size of the sources compared to other sources, and the ability to directly contribute constituents of concern to the Colorado River.

Summary of 2005 Update Report Conclusions



Erosion/urban and stormwater runoff, recreation, and municipal and industrial dischargers were identified as having the greatest potential impact to Metropolitan's source water quality in the Colorado River watershed. In addition, the report introduced new issues and included discussions on perchlorate contamination in the Henderson, Nevada area; chromium-6 contamination near Topock, Arizona; and the development of an alternative discharge location into Lake Mead for treated wastewater from the Las Vegas Valley. Metropolitan would continue to actively engage in these and other watershed management efforts to ensure protection of the Colorado River.

Summary of 2010 Update Report Conclusions



Erosion/urban and stormwater runoff, recreation, and municipal and industrial dischargers were identified as having the greatest potential impact to source water quality. Although not a threat to public health, the report also noted the introduction of quagga mussels into the lower Colorado River system. The report included updates on ongoing cleanup activities including perchlorate contamination in the Henderson, Nevada area; chromium-6 contamination near Topock, Arizona; and uranium mill tailings near Moab, Utah. The report also introduced the issue of uranium exploration near Grand Canyon National Park.

Table 1-4 summarizes recommendations from the CRWSS 2010 Update as well as the current (2016) status for each. These include updates on the recommendations from the previous CRWSS updates, which were not fully addressed. Metropolitan received one recommendation from DDW for the CRWSS 2010 Update in a letter dated May 14, 2012 (**Appendix B**). DDW recommended that Metropolitan include an update on the effectiveness of chlorination facilities at Copper Basin and the outlets to Lake Mathews and Lake Skinner for quagga larval control. The ***Colorado River Aqueduct*** section in **Chapter 2** discusses the effectiveness of Metropolitan's Quagga Mussel Control Program, as approved by the California Department of Fish and Wildlife, for surveillance and quagga control activities.

Table 1-4. Summary of 2010 Report Recommendations and Current Status

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
1.	*Participate in the Colorado River Basin Salinity Control Program and related efforts addressing salinity management in Metropolitan supplies* Metropolitan will continue to serve on the Colorado River Basin Salinity Control Forum, as representatives of California, and participate in the Forum Workgroup to support funding and implementation of salinity control projects.	Metropolitan continues to serve on the Colorado River Basin Salinity Control Forum (CRBSCF) and provided support for the Program's 2014 Triennial Review. Metropolitan also contributed to updates of the USBR's Salinity Economic Impact Model (SEIM) for the lower Colorado River. **Chapter 6** provides an update on the Colorado River Basin Salinity Control Program. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing salinity management efforts.
2.	*Complete the Salinity Management Plan Study Update* Metropolitan will collaborate with USBR and SCSC to complete the Salinity Management Plan Study Update, which will include an update of the economic impact model used by the Colorado River Basin Salinity Control Forum to assess Colorado River salinity impacts.	Metropolitan continues to collaborate with USBR and SCSC to complete the Salinity Management Plan Study Update. In June 2012, the project partners held a workshop to revisit salinity challenges and identify potential solutions to salinity management issues in southern California. In addition, Metropolitan also collaborated with CRBSCF to provide input on further enhancements to the SEIM. Metropolitan will continue this recommendation in the CRWSS 2015 Update through completion of the Salinity Management Plan Study Update.
3.	*Participate with the Lower Colorado River Water Quality Partnership* Metropolitan will continue to actively participate with SNWA and CAP to monitor Colorado River water quality issues of mutual interest and develop strategies and management actions to ensure source water protection.	During the reporting period, the Lower Colorado River Water Quality Partnership submitted joint comment letters concerning uranium exploration in the Grand Canyon area; the Uranium Mill Tailing Remedial Action Project near Moab, Utah; Nevada Environmental Response Trust's Remedial Investigation and Feasibility Study Work Plan for the perchlorate remediation in Henderson, Nevada; U.S. Department of Energy's Uranium Leasing Program; wastewater discharges in Las Vegas Valley; and Lake Powell water quality monitoring. **Chapter 6** provides an update on Metropolitan's participation in Colorado River stakeholder partnerships including the Partnership. Metropolitan will continue this recommendation in the 2015 CRWSS due to ongoing Partnership collaborative efforts.
4.	*Track uranium exploration and other energy development activities* Metropolitan will continue to track uranium exploration and other energy development activities throughout the Colorado River Basin to ensure measures are taken to protect the water quality of the Colorado River.	Metropolitan continues to track energy development activities including ongoing uranium mining interests near the Grand Canyon. In May 2013, Metropolitan, through the Lower Colorado River Water Quality Partnership, commented on the U.S. Department of Energy's Uranium Leasing Program. In March 2015, Metropolitan responded to the Grand Canyon Trust regarding the issue of abandoned mines within watersheds tributary to the Grand Canyon and Colorado River. Following the Gold King Mine spill in August 2015, Metropolitan, through the Partnership, also sent a letter to USBR and USGS requesting an improvement of the Lake Powell Water Quality Monitoring Program. **Chapter 6** provides an update on energy development and exploration in the Colorado River watershed. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing energy development activities.

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
5.	*Comment on regulatory development for perchlorate and chromium-6* Metropolitan will track the federal and California regulatory processes for perchlorate and chromium-6; coordinate with regulators, trade organizations, and other water utilities; and comment as appropriate in the drinking water standard setting process.	In coordination with other water utilities and as part of the Association of California Water Agencies and California Municipal Utilities Association, Metropolitan actively tracked and commented on DDW's development of a chromium-6 MCL, which became effective in July 2014. Metropolitan continues to track the regulatory process for perchlorate as DDW considers a possible revision to the MCL, following the Office of Environmental Health Hazard Assessment's updated public health goal of 1 ppb in February 2015. In February 2011, USEPA announced its position to regulate perchlorate and it is anticipated to issue a proposed perchlorate rule in 2017. **Chapter 6** includes a discussion on activities related to perchlorate and chromium-6. Metropolitan will continue this recommendation in the CRWSS 2015 Update as the perchlorate MCL is under review.
6.	*Support expeditious removal of the uranium mill tailings pile near Moab, Utah* Metropolitan will continue to support the efforts of USDOE in cleanup of the mill tailings site, advocating for continued and increased federal funding for expeditious removal of the tailings pile to ensure protection of downstream drinking water uses.	Metropolitan continued to closely monitor cleanup operations related to the uranium mill tailings pile near Moab, Utah. In coordination with the Lower Colorado River Water Quality Partnership, Metropolitan submitted three joint letters (2011, 2013, and 2015) to USDOE advocating for continued and increased funding to expedite removal of the uranium mill tailings pile. **Chapter 6** provides an update on the uranium mill tailings removal. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing cleanup activities.
7.	*Continue to track performance of Las Vegas Valley wastewater treatment plants* Metropolitan will continue to coordinate with Las Vegas area wastewater dischargers to track phosphorus discharges from the wastewater treatment plants and ensure protection of downstream drinking water uses.	Metropolitan continued to track the performance of the Las Vegas Valley wastewater treatment plants, including ongoing year-round phosphorus removal and optimization of the wastewater treatment systems. In March 2015, Metropolitan through the Lower Colorado River Water Quality Partnership commented on Las Vegas Valley dischargers' NPDES renewal permit applications and emphasized that optimized treatment and year-round phosphorus removal at the treatment plants are key to the long-term protection of downstream uses of the Colorado River. **Chapter 6** provides an update on wastewater management in Las Vegas Valley. Metropolitan will continue this recommendation in the CRWSS 2015 Update.
8.	*Track NDEP's progress on development of a Nutrient Criteria Strategy for the State of Nevada* Metropolitan will track Nevada's Nutrient Criteria Strategy, an effort being pursued by NDEP in cooperation with USEPA Region IX, with the end goal of improving Nevada's existing nutrient criteria.	Metropolitan tracked NDEP's progress on development of a Nutrient Criteria Strategy. NDEP developed a Nutrient Criteria Strategy in February 2009 but has not progressed in the development of statewide nutrient criteria. NDEP continues to evaluate nutrient pollution issues and recently established nutrient criteria for the Lahontan and South Fork Reservoirs. NDEP is also in the process of finalizing nutrient criteria recommendations for wadeable streams. Metropolitan will continue this recommendation in the CRWSS 2015 Update.

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
9.	*Participate in the Lake Mead Water Quality Forum* Metropolitan joined the Lake Mead Water Quality Forum (LMWQF) in 2010 and will continue to participate in its quarterly meetings. Through the LMWQF, Metropolitan will coordinate with key stakeholders and stay apprised and provide input on key water quality issues for Lake Mead and the Colorado River.	Metropolitan continued to participate in the Lake Mead Water Quality Forum meetings. In August 2013, the Lake Mead Water Quality Forum decided to reduce their meeting frequency to meet only on an annual basis. Due to organizational changes, the Forum has not met since October 2014. However, the Lake Mead Ecosystem Monitoring Workgroup continues to provide a forum to share information on Lake Mead water quality. Metropolitan will continue this recommendation in the CRWSS 2015 Update as participation in the Lake Mead Water Quality Forum's Ecosystem Monitoring Workgroup.
10.	*Participate in Lake Mead Water Quality Forum's Ecosystem Monitoring Workgroup* Metropolitan will participate in the Ecosystem Monitoring Workgroup, recently formed to enhance multi-agency cooperation on ecosystem monitoring for Lake Mead and Colorado River watersheds.	Since its formation in 2012, Metropolitan has participated in quarterly Lake Mead Ecosystem Monitoring Workgroup discussions. The Workgroup has provided a platform for information exchange on topics related to protecting the ecosystems of Lake Mead, Lake Mohave and their interrelated components. Agencies share information on their respective efforts in water quality monitoring programs, habitat conservation programs, and ecological studies. Metropolitan will continue this recommendation in the CRWSS 2015 Update.
11.	*Continue to track and engage with stakeholders on perchlorate remediation efforts in Henderson, Nevada* Metropolitan will continue to coordinate with NDEP, NERT, and other key Colorado River stakeholders to monitor and provide input on the remediation efforts related to the Tronox and AMPAC perchlorate plumes.	In addition to participating in quarterly and annual stakeholder meetings, Metropolitan reviews and comments on pertinent project documents. In April 2014, Tronox reached a $5.15 billion settlement with its predecessors, which awarded approximately $1.1 billion, directed to NERT, to clean up perchlorate and other contaminants at the former Tronox site in Henderson. The project is in the Remedial Investigation/Feasibility Study phase with current focus on field investigations and treatability studies. Metropolitan will continue this recommendation in the CRWSS 2015 Update while a long-term remedial plan to accelerate cleanup is developed.
12.	*Continue to support the efforts of Colorado River Regional Sewer Coalition (CRRSCo)* Metropolitan will continue to participate in and support CRRSCo's efforts to obtain funding to enhance wastewater management practices along the Colorado River.	In 2012, CRRSCo changed its name to Clean Colorado River Sustainability Coalition (CCRSCo) and adopted revised bylaws in 2013 to focus on the protection and enhancement of the lower Colorado River through monitoring and analysis of water quality. Metropolitan continues to be a member of CCRSCo and has provided letters of support for CCRSCo to pursue grant funding to enhance watershed planning efforts for the lower Colorado River. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing CCRSCo efforts.

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
13.	*Develop notification protocols to track spills within the lower Colorado River Basin* Metropolitan will work with agencies such as CRRSCo members to consider opportunities for establishing notification protocols to obtain timely information regarding spills that may impact Colorado River water quality.	A Lower Colorado River Geographic Response Plan was developed through a collaborative effort between local, state, and federal government agencies in February 2014. The Plan serves as the principal guide for emergency preparedness when responding to oil and hazardous material emergencies along the lower Colorado River. USBR, designated as a lead responder for spill incidents, has included Metropolitan and CCRSCo members in the incident notification process. Metropolitan will not continue this recommendation in the 2015 CRWSS, but will track USBR's spill notification process through CCRSCo.
14.	*Continue to participate in advisory groups for chromium-6 remediation at the Topock Gas Compressor Station* Metropolitan will continue to coordinate with the lead regulatory agencies and PG&E and actively participate in the Consultative and Technical Workgroups to support efforts to remediate the chromium-6 groundwater plume adjacent to the Colorado River near Needles, California.	Metropolitan continues to participate in multiple stakeholder groups for the chromium-6 remediation at PG&E's Topock Gas Compressor Station. During the reporting period, Metropolitan reviewed and provided comments on the Final EIR, project design, and groundwater model development. The Final Design was completed in November 2015. Metropolitan also provided presentations to the Topock Consultative Workgroup on Metropolitan's source water quality program and emphasized the importance of implementing the groundwater treatment system to continue protecting Colorado River drinking water supplies. The preparation of a Subsequent EIR is currently underway and construction is anticipated to begin in 2017 Metropolitan will continue this recommendation in the CRWSS 2015 Update since the project involves a long-term remediation effort.
15.	*Investigate opportunities to enhance PPCP awareness and outreach within Lake Mohave and Lake Havasu watersheds* Metropolitan will contact municipal stakeholders to identify opportunities for enhancing PPCP awareness and outreach, such as recommending that Clark County Water Reclamation District's Pain in the Drain program be linked to Clark County's incorporated cities' websites.	Clark County's *Pain in the Drain* program has expanded over the past few years to include additional drug disposal locations, including a location in Laughlin, Nevada. Due to limited resources, Clark County's incorporated cities have not increased information regarding the *Pain in the Drain* program on their websites but have incorporated awareness of the program in their educational and outreach materials. Mohave County cities along the Colorado River have also incorporated drug disposal locations. Metropolitan will not continue this recommendation in the CRWSS 2015 Update.
16.	*Track ongoing water quality studies in the Lake Mohave and Lake Havasu watersheds* There are a number of water quality related studies, which Metropolitan should track over the next five years. Notably, the City of Lake Havasu's treated wastewater injection studies, BLM's Resources Management Plan for Lake Havasu, and USBR's Phase II Lower Colorado River Contaminant Monitoring Program.	Water quality studies are conducted to address multiple water quality objectives such as recreational uses. **Chapter 4** provides an update on water quality studies in the Lake Mohave and Lake Havasu watersheds. Metropolitan will continue this recommendation in the 2015 CRWSS due to ongoing water quality studies in the watersheds.

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
17.	*Metropolitan will continue to track the progress of Eagle Mountain area projects* Metropolitan will continue to track the proposed Eagle Mountain Pumped Storage Project and participate in the environmental review process to ensure protection of the CRA. In addition, Metropolitan will continue to track progress for Los Angeles County Sanitation Districts' proposed Eagle Mountain Landfill.	Los Angeles County Sanitation Districts is no longer pursuing the Eagle Mountain Landfill project. As such, Metropolitan will not continue to report on this project. Metropolitan continues to track the proposed Eagle Mountain Pumped Storage project and commented on the Federal Energy Regulatory Commission's license review process during the reporting period. Metropolitan will continue monitoring the Eagle Mountain Pumped Storage project in the 2015 CRWSS due to ongoing project activities.
18.	*Develop a Lake Mathews Watershed Model* Metropolitan, RCFCWCD, and the County of Riverside, will complete development of a dynamic watershed model for the Lake Mathews watershed. The model will estimate pollutant loads under future build out conditions and can be used to identify areas for optimal BMP deployment. Metropolitan and its partners will also seek opportunities to further refine the model with additional water quality and flow data.	The Lake Mathews Watershed Model, which was completed in 2012, evaluated constituents such as total nitrogen, total phosphorus, sediment, and fecal coliform. The model is being used to evaluate development proposals in the watershed with updated data as it becomes available. **Chapter 6** provides an update on the Lake Mathews Watershed Model. Metropolitan will continue to track development and apply the model when necessary but will not continue this recommendation in the CRWSS 2015 Update as the model is complete.
19.	*Complete the Lake Mathews Watershed - Water Quality Improvement Study* Metropolitan and its partners, RCFCWCD and County of Riverside, will complete the Lake Mathews Watershed - Water Quality Improvement Study. The study will provide an updated assessment of the current and future threat of runoff pollution into Lake Mathews and propose long-term solutions for protecting the lake based on the current regulatory, planning, and management environment.	The Lake Mathews Watershed Water Quality Improvement Study was completed in 2012. The study evaluated water quality management strategies and low-impact development requirements for various future development scenarios using the Lake Mathews Watershed Model. The watershed study and model provide an effective planning tool that evaluates the impacts of watershed development on Metropolitan's source water quality. **Chapter 6** provides an update on the Lake Mathews Watershed Study. Metropolitan will continue to track regulatory and development planning in the watershed but will not continue this recommendation in the CRWSS 2015 Update as the study is complete.
20.	*Coordinate with RCFCWCD on development reviews* Metropolitan will coordinate closely with RCFCWCD on development proposals that could impact water quality within the Lake Mathews Watershed. RCFCWCD is the principal agency responsible for review and acceptance of developer's project-specific WQMPs.	Metropolitan coordinated with RCFCWCD on development reviews including the proposed Boulder Springs-Dailey Ranch housing development and WQMP improvements to ensure protection of Lake Mathews water quality. **Chapter 4** provides an update on development reviews within the Lake Mathews Watershed. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing planning and development activities.
21.	*Track the status of the proposed Mockingbird Canyon Trail development* Metropolitan will continue to track the status of the proposed multi-purpose recreation trail development and provide input as needed to minimize any potential adverse impacts to Lake Mathews. The current proposed trail alignment would connect the Harford Springs Reserve in Gavilan Hills to the Mockingbird Canyon Archaeological site.	In 2014, development of the Mockingbird Canyon Trail development was put on hold due to limited resources. Metropolitan will not continue this recommendation in the CRWSS 2015 Update due to no project activity.

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
22.	*Track progress of the Cajalco Road Widening project and evaluate potential impacts to Lake Mathews* Metropolitan will track the status of the Cajalco Road Widening and Safety Enhancement project, evaluate potential impacts to Lake Mathews based on the proposed alignments and provide input into the environmental review process.	Metropolitan has been coordinating the Cajalco Road Widening project alignment with the project team to minimize environmental impacts to the Lake Mathews Multiple Species Reserve and water quality impacts within the watershed. **Chapter 4** provides an update on the Cajalco Road Widening project. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing planning activities.
23.	*Monitor gull roosting at Lake Mathews* Metropolitan will continue to monitor the intermittent presence of gulls at Lake Mathews and investigate whether there's a trend with *E. coli* levels at Lake Mathews outlet tower. If gull roosting persists, Metropolitan would investigate watershed sources, which may contribute to the presence of gulls.	Metropolitan noted an influx of gulls at Lake Mathews in January 2014 and February 2015 but was not able to confirm a watershed source. The nearby El Sobrante Landfill implements a full-time gull abatement program between October and April; no increase in gull presence was experienced in early 2014 or 2015. Metropolitan will not continue this recommendation in the CRWSS 2015 Update since *E. coli* levels have not corresponded with the intermittent presence of gulls at Lake Mathews. Metropolitan will, however, continue to monitor for gull activity and take action, if necessary, to mitigate any water quality issues.
24.	*Continue to be involved in long-term recreational plans for Diamond Valley Lake* Although slowed down as a result of the recent economic downturn, Metropolitan and outside entities continue to seek opportunities to develop additional recreational facilities within and adjacent to Diamond Valley Lake watershed. Metropolitan will continue to assess recreational and other development proposals to ensure that any new facilities within the watershed are consistent with existing permitted activities and are protective of Diamond Valley Lake water quality.	During the reporting period, Metropolitan amended the Recreational Activity Plan (RAP) to include changes to restroom facilities at the Diamond Valley Lake marina. Metropolitan continued to review recreational proposals including a feasibility analysis for expansion of the Diamond Valley Lake East Marina. Metropolitan will continue this recommendation in the CRWSS 2015 Update due to ongoing recreational and development proposals.
25.	*Develop a Lake Skinner Source Water Protection Plan* Metropolitan has developed a Draft Framework for a Lake Skinner Source Water Protection Plan and will follow up this watershed assessment to develop a source water protection plan for the Lake Skinner watershed.	Metropolitan will continue to develop a Lake Skinner Source Water Protection Plan. As discussed in **Chapter 4,** Metropolitan assessed watershed issues and potential contaminating threats as part of this CRWSS 2015 Update. Metropolitan will continue this recommendation in the CRWSS 2015 Update.
26.	*Consider improvements to water quality and flow monitoring for Lake Skinner tributaries* Additional data is needed to better understand the hydrologic and water quality characteristics within the Lake Skinner watershed. Metropolitan will consider developing a monitoring framework to obtain data to better evaluate watershed pollution threats.	Metropolitan installed flow monitoring equipment but was not able to collect stormwater data due to dry conditions. Metropolitan will continue this recommendation in the CRWSS 2015 Update.

No.	Recommendation from the 2010 CRWSS	Current Status (2016)
27.	*Consider development of a Lake Skinner Watershed Model* Based on the experience gained through the completion and use of the Lake Mathews Watershed Model, Metropolitan will consider development of a similar model for the Lake Skinner watershed. Once adequate hydrologic and water quality data are obtained for tributaries within the watershed, the development of a watershed model would allow Metropolitan to evaluate the potential water quality threats from existing and future development conditions and propose appropriate solutions.	Metropolitan will consider proceeding with developing a Lake Skinner Watershed Model as hydrologic and water quality data are available. Future modeling efforts will be evaluated during the development of the Lake Skinner Source Water Protection Plan. Metropolitan will not continue this recommendation in the CRWSS 2015 Update and will consider it in the development of the Lake Skinner Source Water Protection Plan.
28.	*Consider partnering with the local resource conservation district and/or other stakeholders for educational outreach to private ranches* Metropolitan will consider partnering with local agencies and/or organizations to implement an educational program for small ranches and hobby farms. The educational program could focus on several topics such as manure management, erosion control, fertilizer, and pesticide use and landscaping BMPs. Outreach on proper management of septic systems could also be included.	Metropolitan contacted local resource conservation districts to identify current educational outreach programs and found that their programs cover best management practices for the ranch community. Although the programs do not specifically outreach to private ranches, information is widely available to the general community. Metropolitan will not continue this recommendation in the CRWSS 2015 Update as general best management practices outreach information is currently available.
29.	*Identify and prioritize parcels for potential future land acquisition or conservation easements* Metropolitan previously acquired several properties within the Lake Skinner watershed for water quality protection. Metropolitan will evaluate the potential for future land acquisition and/or conservation easements and rank properties based on their potential to impact lake water quality.	Metropolitan has continued to consider acquisition of large parcels within the Lake Skinner watershed for water quality protection. In 2014, Metropolitan evaluated the acquisition of the Las Mañanitas Ranch Property, a 352-acre parcel located north of Lake Skinner, in partnership with Riverside County Parks and Open Space District; however, the acquisition was not feasible. Metropolitan will continue this recommendation in the CRWSS 2015 Update.

Report Organization

The format of the CRWSS 2015 Update has been organized into seven chapters, which present information pertaining to the watershed site characterization, source water quality data, potential contaminant sources, regulatory overview and compliance, key watershed management activities, and findings and recommendations.

Executive Summary

An executive summary for the CRWSS 2015 Update is provided.

Chapter 1 – Introduction

This chapter provides an overview of major reservoirs along the Colorado River from Lake Powell to Metropolitan's service area, describes the purpose of the CRWSS update, describes how the update was conducted, provides a summary of the 1996, 2000, 2005, and 2010 watershed sanitary survey updates and includes a description of the report organization.

Chapter 2 – Watershed Overview

This chapter provides an overview of the physical and hydrologic characteristics of the watersheds that comprise the study area for the CRWSS update. Changes in lake storage elevations and hydrologic characteristics reflect impacts of drought conditions during the reporting period.

Chapter 3 – Source Water Quality Data Review

This chapter provides a description of Metropolitan's monitoring programs, summary of raw water quality data, and an evaluation of selected key constituents. These constituents include various inorganic compounds (i.e., aluminum, boron, chromium-6, perchlorate, TDS, and the nutrients total phosphorus and nitrate), radionuclides (i.e., uranium, radium, and gross alpha and gross beta emitters), turbidity, organic compounds (i.e., TOC, NDMA, and PPCPs), and microbiological constituents (i.e., total coliform, *E. coli*, *Giardia*, and *Cryptosporidium*).

Chapter 4 – Potential Contaminant Sources

This chapter contains a vulnerability assessment of Metropolitan's Colorado River system watershed areas for the nine PCSs selected for the 2015 update. These include *Erosion/Urban and Stormwater Runoff, Recreation, Municipal and Industrial Dischargers, Spills, Landfills, Leaking Underground Storage Tanks, Septic Systems, Agriculture, and Fires*. The chapter is organized by watershed and, as applicable, the PCS discussion for each watershed evaluates the occurrence of the PCS, regulation and management oversight, pertinent studies and monitoring, a summary discussion, and key recommendations.

Chapter 5 – Surface Water Regulatory Compliance Evaluation

Chapter 5 provides an overview of current and anticipated drinking water regulations. This chapter also contains the evaluation of Metropolitan's water treatment plants' (that receive Colorado River water) capability to meet the SWTR, Interim Enhanced SWTR (IESWTR), Long Term 1 Enhanced SWTR (LT1ESWTR) and Long Term 2 Enhanced SWTR (LT2ESWTR), Stage 1 and Stage 2 Disinfectants/Disinfection Byproducts (D/DBP) Rule, Radionuclides Rule, and Arsenic Rule, as well as anticipated regulations for constituents such as NDMA.

Chapter 6 – Key Watershed Management Activities

This chapter discusses key watershed management efforts for the Colorado River watershed and Metropolitan's activities and involvement since the CRWSS 2010 Update.

Chapter 7 – Findings and Recommendations

This chapter consists of a summary of principal findings and a comprehensive list of new or updated recommendations from the CRWSS 2015 Update.

Appendices

Appendices include additional data, correspondence, figures, and other supporting information for the CRWSS 2015 Update. Appendices are included in electronic format.

2 Watershed Overview

This page intentionally left blank

Chapter 2 Watershed Overview

This chapter describes the watersheds for the Colorado River and Metropolitan's Colorado River Aqueduct (CRA) system and terminal reservoirs. The entire Colorado River watershed is depicted in **Figure 2-1**. The Colorado River watershed includes portions of seven states: Wyoming, Utah, Colorado, Nevada, New Mexico, Arizona, and California, as well as portions of Mexico. The river's northernmost tributary headwaters are in Wyoming (the Green River) and the river's headwaters are in Colorado. The river travels approximately 1,400 miles from the Rocky Mountains to its outlet into the Gulf of California in Mexico. The Colorado River watershed covers approximately 242,000 square miles (155 million acres) [8]. The Colorado River has been estimated to serve the drinking water needs of over 35 million people, and provide irrigation water for approximately 4 million acres in the United States [9]. The Colorado River also serves about 3 million people and 500,000 irrigated acres in Mexico [8].

Background

The Colorado River begins at an elevation of 10,000 feet in the Rocky Mountains of Grand County, Colorado and flows southwest into the Gulf of California in Mexico when its flow exceeds water demands and the reservoir system's storage capacity. It meanders southwest for 640 miles through the Upper Colorado River Basin (Upper Basin) to Lee's Ferry, the dividing point for the upper and lower portions of the Colorado River Basin. Major tributaries to the Colorado River within the Upper Basin include the Green River, the Gunnison River, and the San Juan River. The average annual natural flow of the Colorado River at the Lee's Ferry Gaging Station is approximately 15 million acre-feet (MAF) [10]. Natural flow represents an estimate of flows that would exist without human intervention. Recent climate change studies suggest that future average annual natural inflow could be less than 15 MAF [11].

Temperature in the Colorado River Basin ranges from -61 °F to over 120 °F. The northern portion experiences short, warm summers and long, cold winters and consists of high basins, valleys, and mountains. The southern reaches of the watershed are in semi-arid to desert regions with long, hot summers and mild winters. Rainfall averages 2.5 inches per year in the southern portion of the basin and 40 to 60 inches annually in the northern mountain areas [10]. The geology varies considerably throughout the watershed with igneous, sedimentary, and metamorphic rocks and alluvial deposits. The soils are consistent with the geologic formations of their area. Millions of years ago, much of the land within the Colorado River Basin was the bottom of a large inland sea. The sea evaporated leaving deposits of salts, which were formed into the soil and rock formations that make up the Colorado River Basin of today. These salts are carried to the Colorado River by natural erosion or man's activities.

Study Area

The CRWSS 2015 Update covers the following geographical regions and watersheds within the entire Colorado River watershed: Upper Colorado River (i.e., above Glen Canyon Dam), Lake Mead (i.e., below Glen Canyon Dam to Hoover Dam), Lake Mohave and Lake Havasu, Colorado River Aqueduct, Lake Mathews, Diamond Valley Lake, and Lake Skinner (**Figure 2-1**). This update focuses primarily on the watersheds near Metropolitan's Intake (i.e., below Hoover Dam), as these watersheds will potentially have the greatest impact on water quality. The near-intake zone concept, an accepted practice by DDW, was used in previous CRWSS updates. For the CRWSS updates, the near-intake zone was defined as the watersheds for Lake Mohave and Lake Havasu downstream to the terminal reservoirs.

It should be noted that the Bill Williams River joins the Colorado River between Metropolitan's Whitsett Intake and Parker Dam. Under certain circumstances the Bill Williams River has backed up past Whitsett Intake and impacted Lake Havasu. Since the Bill Williams River is located downstream of the Whitsett Intake, its watershed was not included in this evaluation. For simplicity, the CRWSS 2015 Update will reference these areas as Upper Colorado River, Lake Mead, Lake Mohave, and Lake Havasu watersheds, as appropriate. A relief map showing the boundaries for the upper Colorado River, Lake Mead, Lake Mohave, Lake Havasu, Lake Mathews, Diamond Valley Lake, and Lake Skinner watersheds is included as **Figure 2-2.**

Figure 2-1. Colorado River Watershed Including Tributaries

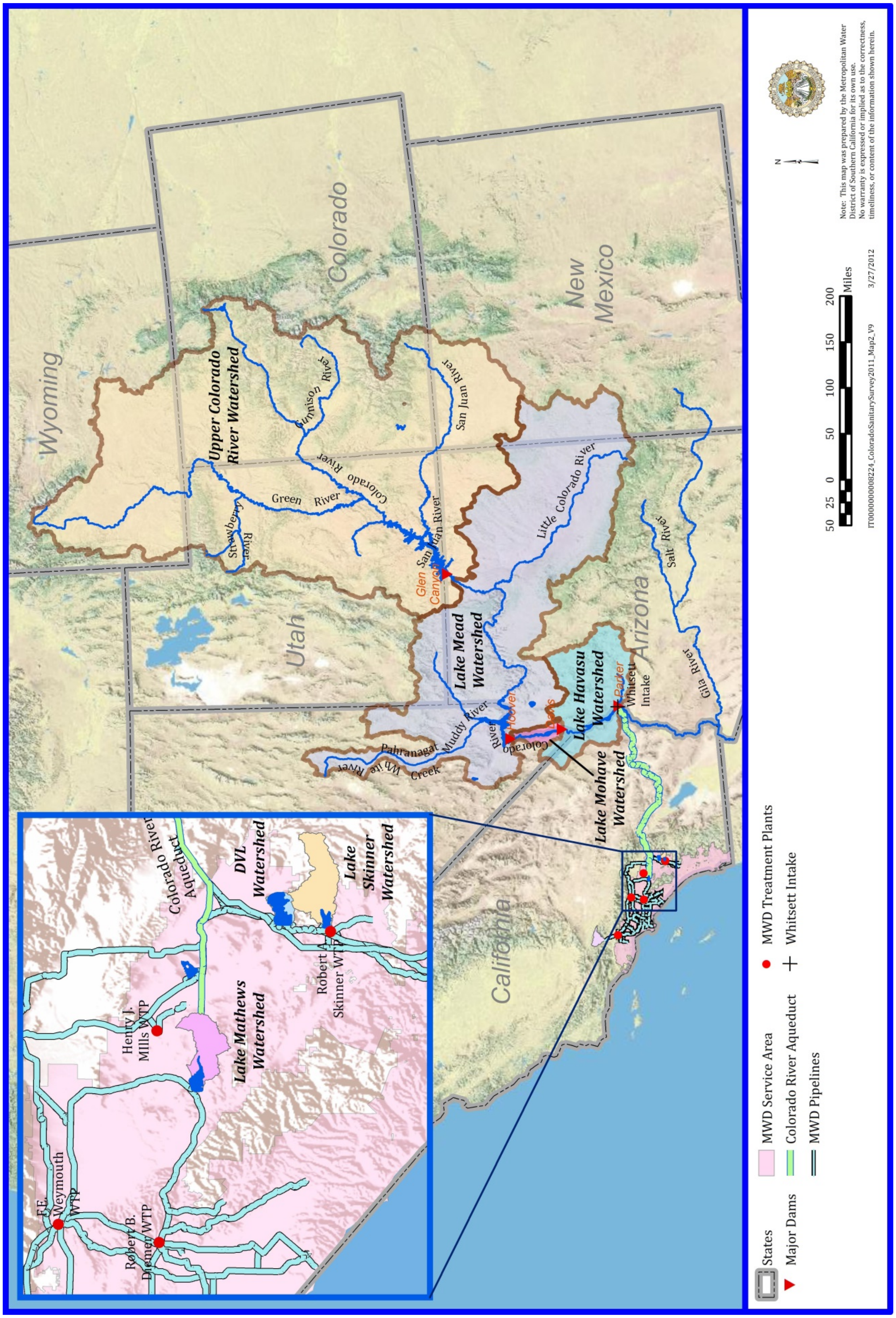


Figure 2-2. Colorado River Watershed Sanitary Survey Study Area

Colorado River System

A number of statutes, compacts, decrees, an international treaty, regulations, contracts, and agreements govern the operation of Colorado River reservoirs, collectively referred to as the "Law of the River". Section 602 of the 1968 Colorado River Basin Project Act (Act) directed the preparation of a set of operating criteria for the Colorado River reservoir system. The 1970 Operating Criteria specified that a formal review take place at least once every five years, sponsored by the Secretary of the Interior. This allows the Secretary, as a result of actual operating experience or unforeseen circumstances, to modify the Operating Criteria after consultation with governor-designated representatives of the seven Colorado River Basin states and other parties and agencies as the Secretary may deem appropriate. The review of the Operating Criteria provides a public process for evaluating how the components of the "Law of the River" interact, and how the Colorado River system should be managed consistent with the existing statutes, compacts, decrees, treaty, regulations, contracts, and agreements.

Each year, the USBR prepares an Annual Operating Plan (AOP), which reports on both the past operations of the Colorado River reservoirs for the completed year as well as projected operations and releases from these reservoirs for the upcoming year. It is prepared in a public process with input from all interested parties for issuance in the fall of each year by the Secretary of the Interior. In recent years, additional operational rules, guidelines, and decisions have been put into place for Colorado River reservoirs including the 1996 Glen Canyon Dam Record of Decision (ROD), the 1997 Operating Criteria for Glen Canyon Dam, the 1999 Off-stream Storage of Colorado River Water Rule, the 2001 Interim Surplus Guidelines addressing operation of Hoover Dam, the 2006 Flaming Gorge Dam ROD, the 2006 Navajo Dam ROD to implement recommended flows for endangered fish, the 2007 Interim Guidelines for the operations of Lake Powell and Lake Mead, and numerous environmental assessments addressing experimental releases from Glen Canyon Dam including the most recent Glen Canyon Dam Long-Term Experimental and Management Plan. Each AOP incorporates these rules, guidelines, and decisions and implements the criteria contained in the applicable decision document or documents. Thus, the AOP makes projections and reports on how USBR will implement these decisions in response to changing water supply conditions as they unfold during the upcoming year, when conditions become known.

Some of the controlling provisions of the "Law of the River" include the Upper Basin delivery of a minimum amount of water every ten years to the Lower Basin, the Mexican Treaty delivery obligation, and the requirements of the Interim Guidelines for the operations of Lake Powell and Lake Mead, under certain circumstances, for equalization or balancing of storage in Lake Powell and Lake Mead.

Each year, the Secretary is required to declare the Colorado River water supply availability conditions for the states of Arizona, California, and Nevada in terms of normal, surplus, or shortage. A shortage would be declared if levels in Lake Mead are projected to drop below 1,075 feet the following year in January. While operating criteria and guidelines have been developed for normal, surplus, and shortage conditions, a shortage has never been declared.

Colorado River Basin Drought

The Colorado River Basin has been experiencing historic drought conditions since 2000, making the last 17-year period the lowest period of inflow to Lake Powell in over 100 years [12]. USBR forecasts that drought conditions will persist through water year 2017 and the total Colorado River Basin reservoir storage system will remain at roughly 50 percent capacity by the end of September 2017. On June 23, 2015, for the first time, the Lake Mead water level fell below the trigger limit of 1,075 feet for shortage conditions to be declared. The Lake Mead water level reached its lowest elevation on record (1,071.61 feet) on July 1, 2016. Shortage declarations were avoided in October 2015 and October 2016 due to fluctuations in Lake Mead water levels. As of October 24, 2016, the Lake Mead water level was 1075.96 feet, which is 37 percent of its storage capacity [13]. Drought conditions have affected overall storage levels in reservoirs as discussed in this chapter.

As noted, drought conditions can have a defined impact on water resources such as decreasing water supplies and reservoir water levels. However, drought impacts to Colorado River water quality have not been as pronounced with some effects of lower reservoir levels noted in **Chapter 3**. Warmer river and reservoir water temperatures have been observed and are related to increasing air temperatures. Also, drought conditions have corresponded to increased wildfire activity, a potential contaminating source to the Colorado River discussed in **Chapter 4**. On the other hand, even though the Colorado River basin has received less runoff under drought conditions, concentration levels of the constituents of concern that are transported via runoff have not been altered. For example, salinity levels have fluctuated reflecting hydrologic conditions since the drought began in 2000, but average salinity levels have remained relatively stable due to salinity control efforts discussed in **Chapter 6.**

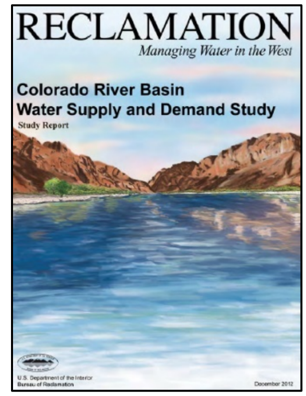
Upper Colorado River Watershed

The upper Colorado River watershed encompasses the drainage area from the Rocky Mountain National Park to Glen Canyon Dam and its reservoir, Lake Powell. In this reach, the river or its tributaries flows through a portion of Colorado, New Mexico, Utah, and Wyoming. While the majority (75 percent) of the flow in the Colorado River comes from snowmelt in the Rocky Mountains, multiple streams and tributaries also contribute to river flows.

The upper Colorado River watershed is mostly rural and has very little urbanization. The predominant land uses in the watershed are forestland and rangeland, which are managed by the U.S. Forest Service (USFS) and Bureau of Land Management (BLM). In the upper Colorado River watershed, river flow is noticeably subject to seasonal climate fluctuations. The fluctuation in flows is observed in Lake Powell, which covers 251 square miles, has a storage capacity of 27 million acre-feet, has a maximum elevation of 3,711 feet, and is the primary regulating reservoir in the watershed. Major land use activities within the watershed include recreation, agriculture, urban, mining, and industrial operations.

Figure 2-3 and **Figure 2-4** show the surface elevations and storage levels for Lake Powell historically and for the period between 2011 and 2015, respectively. The Upper Colorado River Basin continued to experience a multi-year drought for much of the reporting period. Between 2000 and 2015, inflow to Lake Powell was below average in every year except water years 2005, 2008, and 2011. In the summer of 1999, Lake Powell was close to full with storage at 23.5 MAF, or 97 percent of capacity. During the next five years (2000 through 2004), unregulated inflow to Lake Powell was well below average. This resulted in Lake Powell storage decreasing during this period to 8.0 MAF (30 percent of capacity), which occurred on April 8, 2005. During 2005, 2008, and 2009, drought conditions eased somewhat with net gains in storage to Lake Powell. In 2011, a historic snowpack in the Upper Colorado River Basin increased lake inflow due to snowmelt runoff within the basin. Inflow decreased thereafter until spring 2014, when snowpack conditions were above average and inflows to Lake Powell peaked from snowmelt runoff.

USBR completed the Colorado River Basin Water Supply and Demand Study in December 2012, to characterize current and future water supply and demand imbalances in the Upper Colorado River Basin and assess the risks to basin resources [14]. Basin resources include water allocations and deliveries consistent with the apportionments under the Law of the River; hydroelectric power generation;



recreation; fish, wildlife, and their habitats (including candidate, threatened, and endangered species); water quality including salinity; flow and water dependent ecological systems; and flood control. The study confirmed that the Colorado River will have significant shortfalls between projected water supplies and demands in the future and recommends specific actions to be undertaken to resolve this imbalance. The recommended future action areas include water use efficiency and reuse, water banks, water transfers, water supply augmentation, watershed management, tribal water, environmental flows, data and tool development, climate science research, and partnerships.

The U.S. Department of Interior launched the Colorado River Basin Study Moving Forward effort in May 2013 to collaborate with stakeholders in identifying and implementing actions to address the projected water supply and demand imbalances. The Moving Forward Phase 1 Report was released in May 2015 and identified twenty-five opportunities related to water use efficiency (urban and agricultural), and environmental and recreational flows, as related to the action areas listed in the Colorado River Basin Water Supply and Demand Study. USBR is currently working on the Moving Forward Phase 2 Report, which will include a selection of pilot projects to be implemented [14].

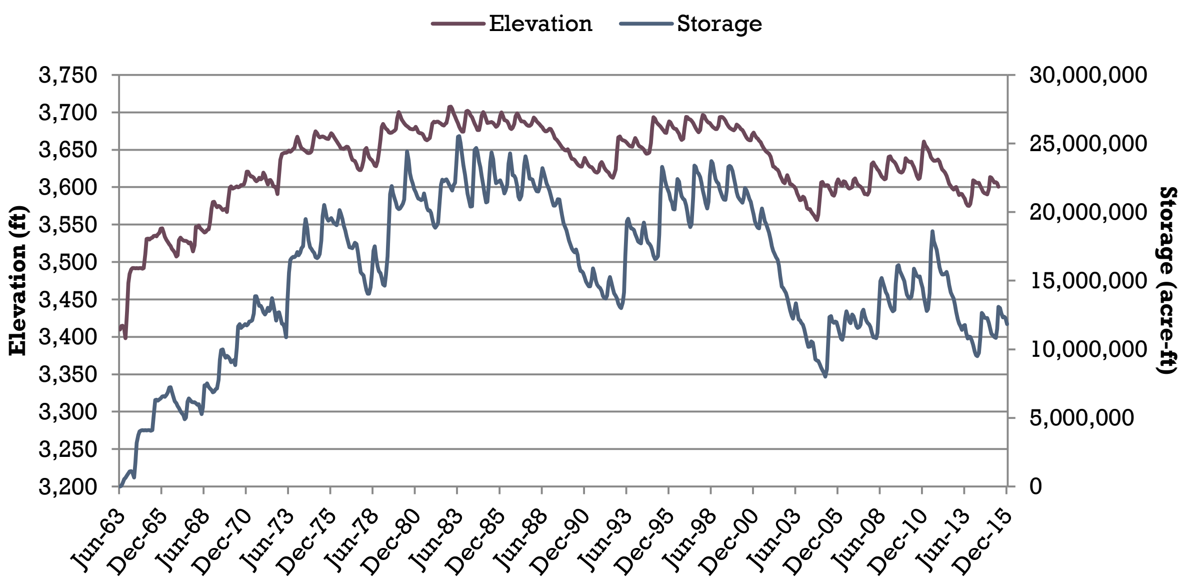


Figure 2-3. Historical Lake Powell Elevation and Storage

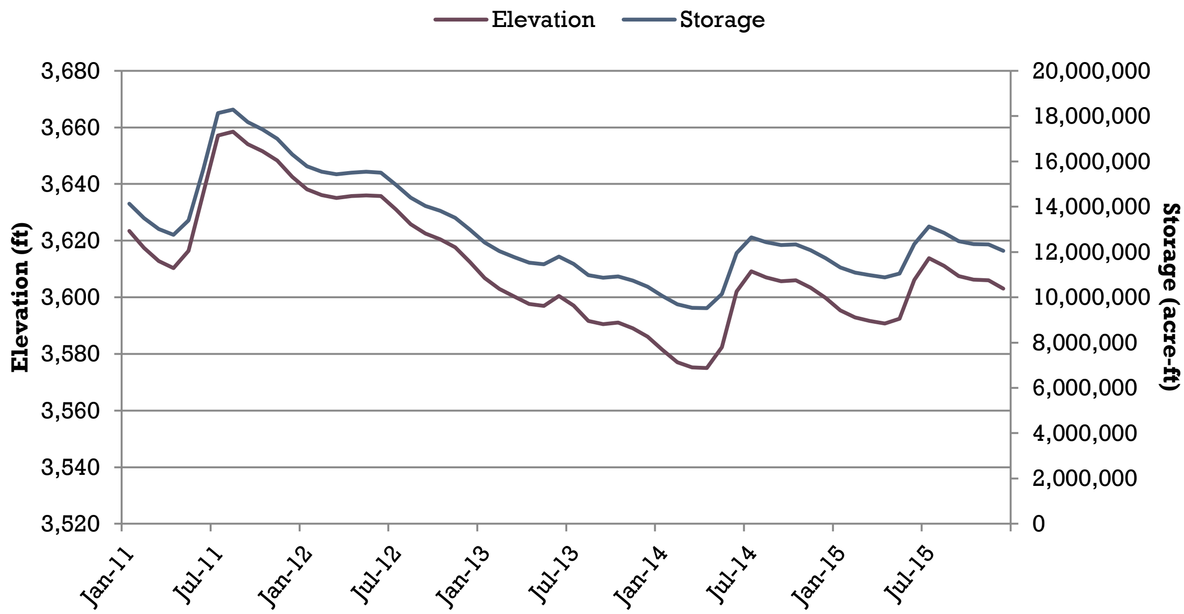


Figure 2-4. Lake Powell Elevation and Storage, 2011–2015

Lake Mead Watershed

The Lake Mead watershed encompasses the Colorado River from Glen Canyon to Lake Mead and Hoover Dam. Major tributaries into Lake Mead include the Virgin River, the Muddy River, and Las Vegas Wash. Major land use activities within the Lake Mead watershed include recreation, agriculture, dairy, urban, mining, and industrial operations. The watershed includes the population centers of Las Vegas, Boulder City, and Henderson, Nevada. Several large wastewater dischargers reside within the watershed, most notably in the Las Vegas region. The rapid population growth in the Las Vegas region has increased the volume of treated wastewater and urban runoff discharged to the river.

Lake Mead is the largest reservoir in the United States by volume (27,620,000 acre-feet of available capacity at the maximum water surface elevation of 1,229 feet), and is second only to Lake Powell in terms of surface area (255 square miles) [15]. The amount of water stored in Lake Mead is controlled by USBR and is predicated on the amount of water released from Glen Canyon Dam, inflow from the Lake Mead watershed, the amount released from Hoover Dam, and evaporation and bank storage at Lake Mead. Similar to Lake Powell, a historic snowpack in the Upper Colorado River Basin in 2011 increased inflows into Lake Mead due to snowmelt runoff within the basin. However, the Lake Mead elevation and storage have generally declined since 2000 due to hydrological and operational conditions. **Figure 2-5** and **Figure 2-6** provide Lake Mead's surface water elevation and storage levels historically and between 2011 and 2015, respectively. Over this update period, the elevation and storage for Lake Mead has declined approximately 9 feet and 510,000 acre-feet, respectively, between January 2011 and December 2015. Retention time in the reservoir is 3.9 years on average, depending on release and inflow patterns [16]. The retention times and lake volumes for both Lake Powell and Lake Mead provide a significant amount of dilution and buffering for potential contaminant sources above Lake Mead.

In May 2012, the Department of Interior implemented a new High-Flow Experiment protocol for conducting releases from Glen Canyon Dam through 2020. High flow experimental releases are conducted when conditions are favorable to maximizing ecological riparian benefits in the Grand

Canyon. The first experimental release under the 2012 High-Flow Experimental Release Protocol was conducted in November 2012 and experimental releases continue to be conducted annually in November. The total annual releases from Glen Canyon are consistent with the estimated release volumes for the water year under the 2007 Interim Guidelines and do not change as a result of the high flow experiments.

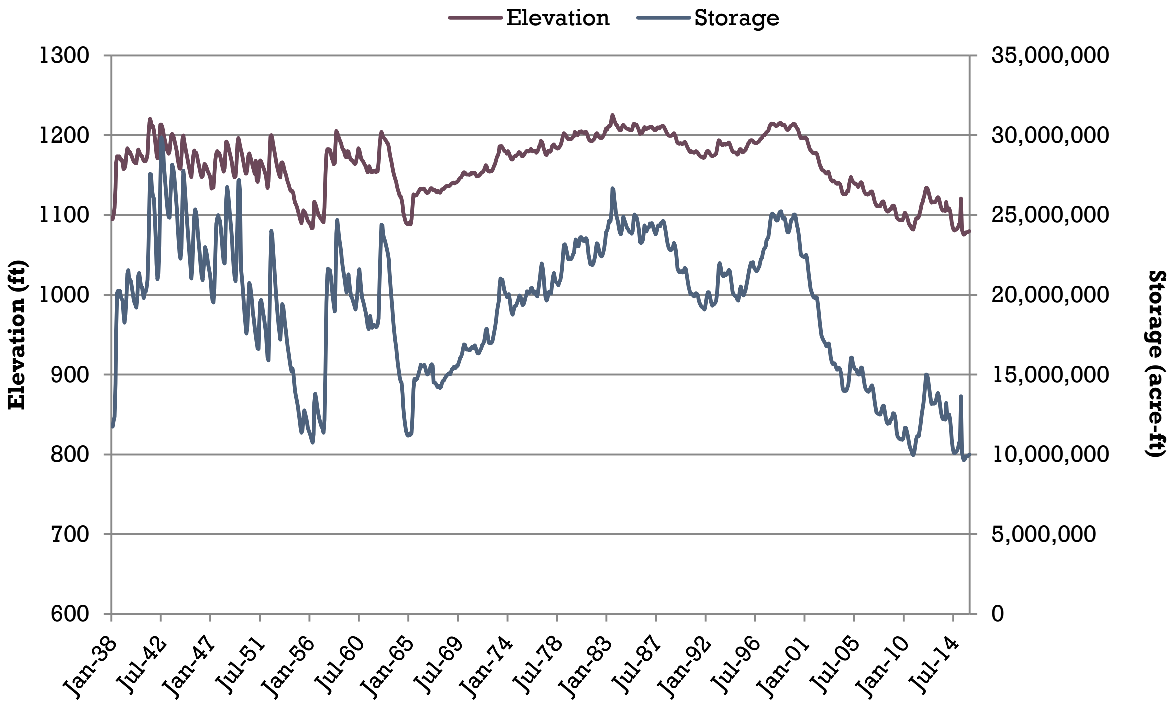


Figure 2-5. Historical Lake Mead Elevation and Storage

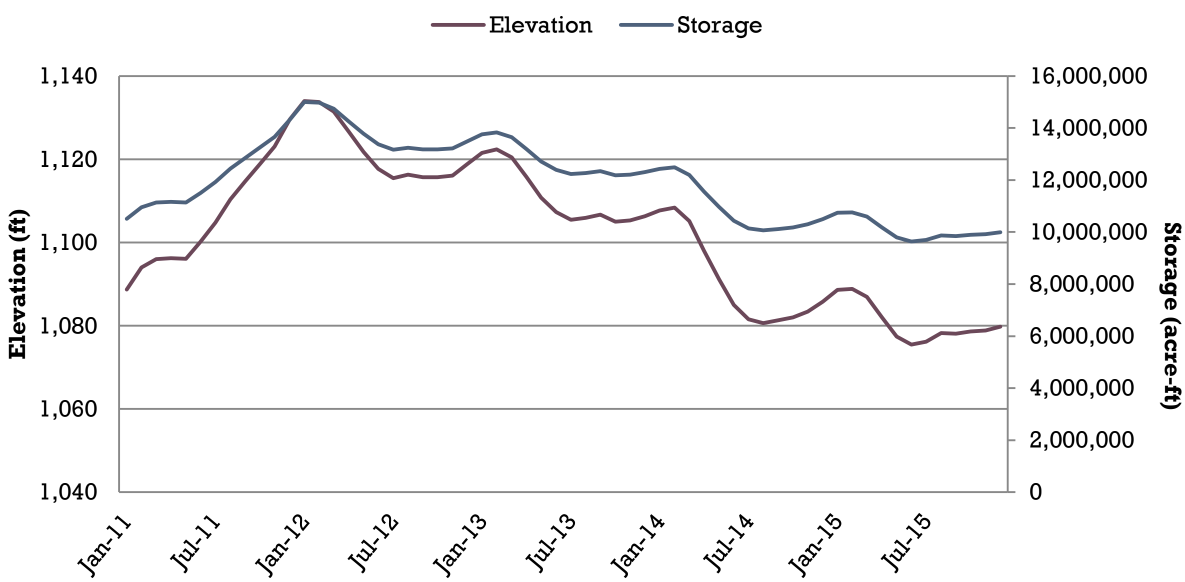


Figure 2-6. Lake Mead Elevation and Storage, 2011–2015

Lake Mohave and Lake Havasu Watersheds

Figure 2-7 provides a map of the Lake Mohave and Lake Havasu watersheds. Lake Mohave has a storage capacity of 1,818,000 acre-feet at a maximum elevation of 647 feet and Lake Havasu has a storage capacity of 646,200 acre-feet at a maximum elevation of 450 feet. The Lake Mohave and Lake Havasu watersheds encompass 503,000 and 6,140,000 acres, respectively, in the tri-state region of Arizona, Nevada, and California. In this reach, the Colorado River flows from Hoover Dam to Parker Dam through canyons and broad alluvial valleys formed by groups of bordering mountains. The majority of the land use in the watershed is rangeland. However, recreation is also a major use on the river and its reservoirs. Popular recreational activities within the watersheds include swimming, kayaking, fishing, boating, and the use of personal watercraft. In comparison to the upper Colorado River and Lake Mead watersheds, a particular challenge in the Lake Mohave and Lake Havasu watersheds are the numerous septic systems in close proximity to the Colorado River. Wastewater treatment for the majority of the drainage area is by septic tank or by evaporation/percolation ponds. Leaching of septic tanks is a major potential contaminant source that threatens groundwater with nitrate and coliform contamination.

Releases from Lake Mohave and Lake Havasu are regulated through the operation of Davis Dam and Parker Dam, respectively. **Figure 2-8** and **Figure 2-9** show historical and reporting period lake elevations and storage levels, respectively, for Lake Mohave [17]. Similarly, **Figure 2-10** and **Figure 2-11** show the historical and reporting period lake elevation and storage data, respectively, for Lake Havasu. Both lakes are typically drawn down in the late summer and fall months to provide storage space for local storm runoff and filled in the winter to meet higher summer water needs [18].

Figure 2-12 shows the inflows and outflows for Lake Havasu [17]. Both Metropolitan and the Central Arizona Project (CAP) divert water from Lake Havasu. Metropolitan and CAP diverted an average of 1,339 and 2,451 cfs (cubic feet per second), respectively, over this update period.

Figure 2-13 shows the basic meteorology data for Lake Havasu; similar data would be applied to the Lake Mohave area. Monthly temperature and rainfall data were collected from the U.S. Climate Data website [19]. The Lake Havasu watershed is predominantly hot and arid with a maximum monthly rainfall of 2.5 inches in July 2012 and maximum air temperature of 121 °F in June 2013. Nightly air temperatures can drop to below 30 °F in the winter months.

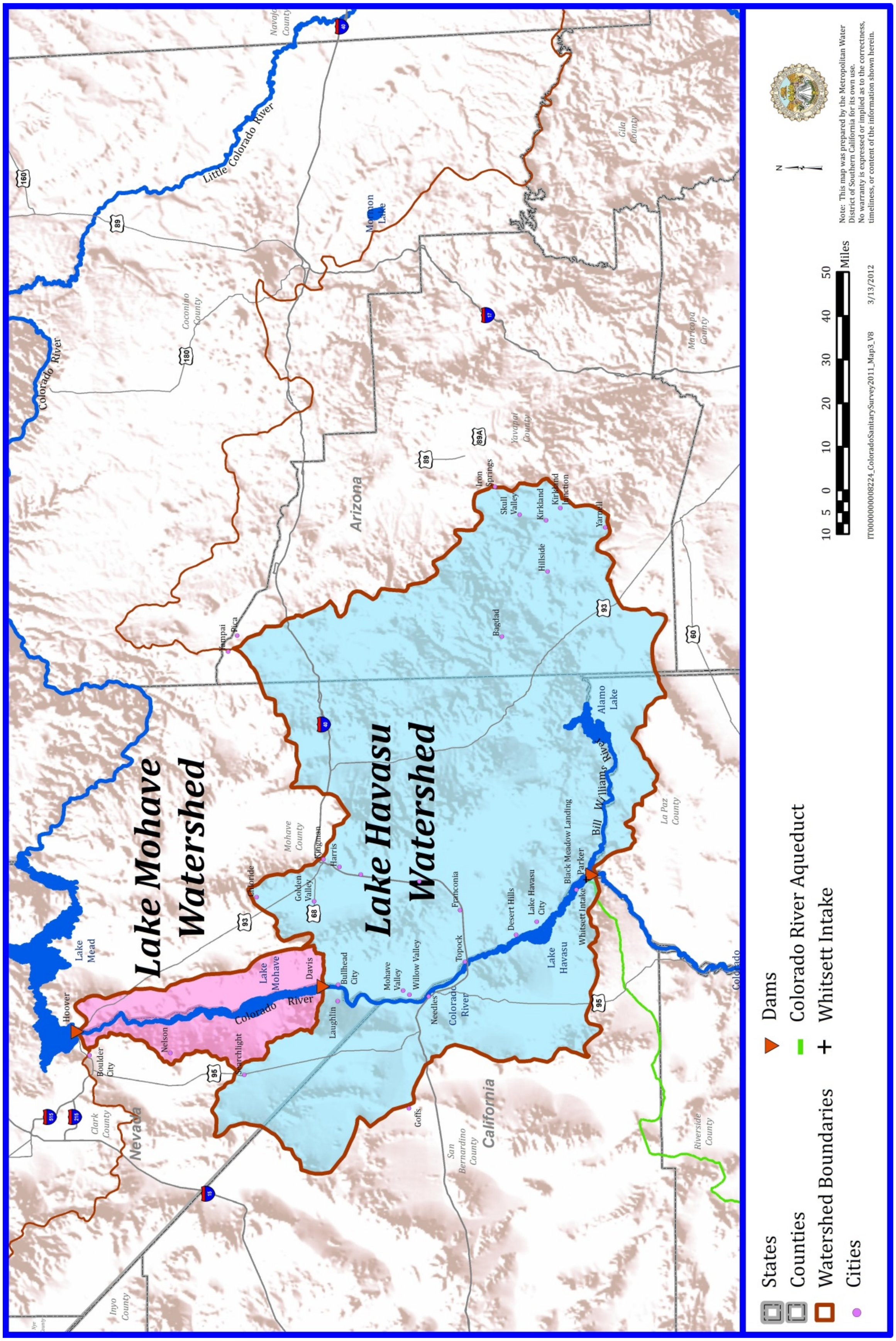


Figure 2-7. Watersheds for Lake Mohave and Lake Havasu

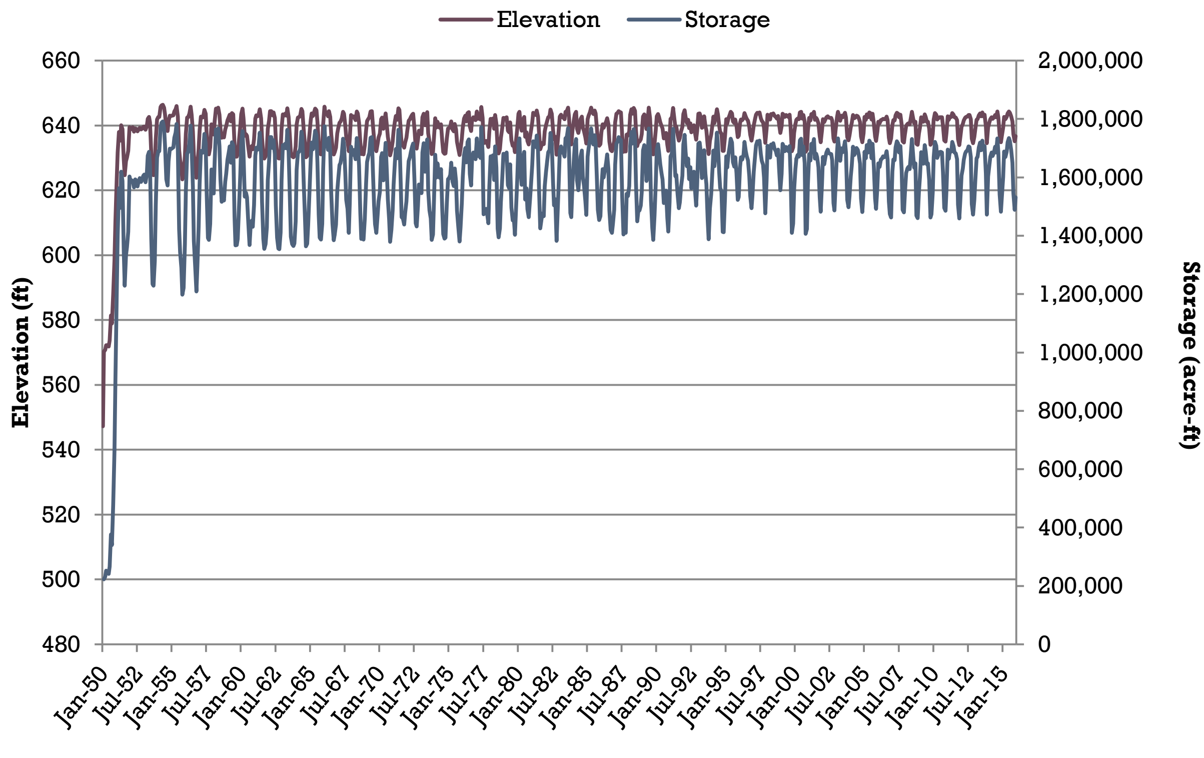


Figure 2-8. Historical Lake Mohave Elevation and Storage

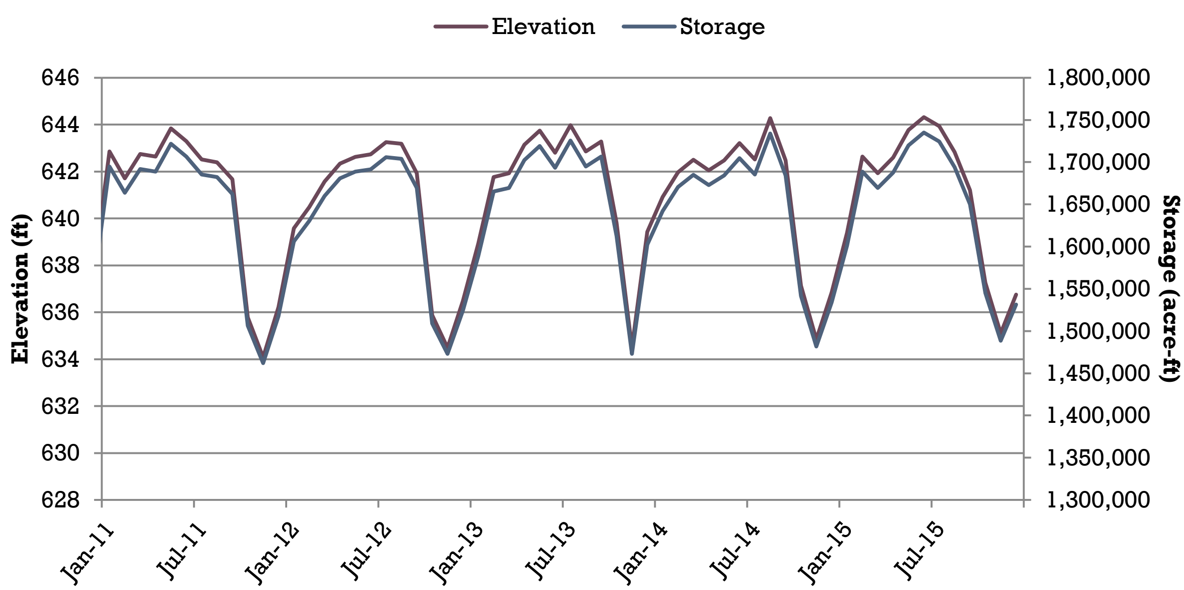


Figure 2-9. Lake Mohave Elevation and Storage, 2011–2015

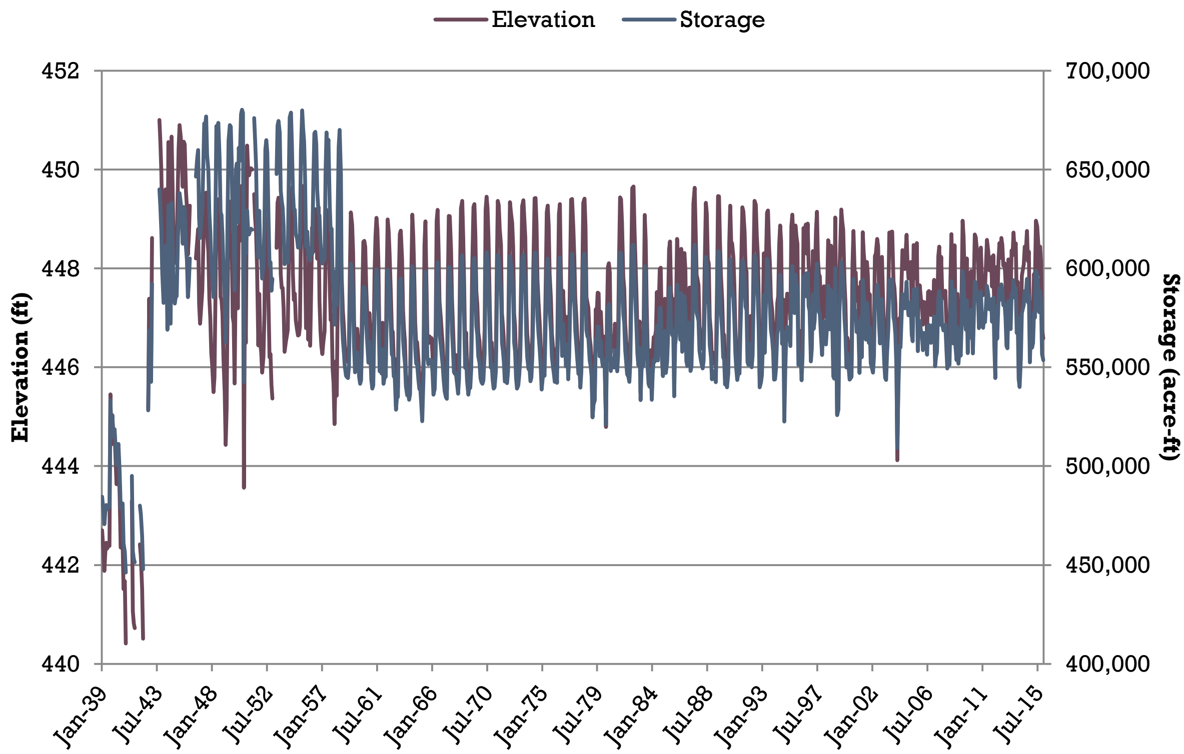


Figure 2-10. Historical Lake Havasu Elevation and Storage

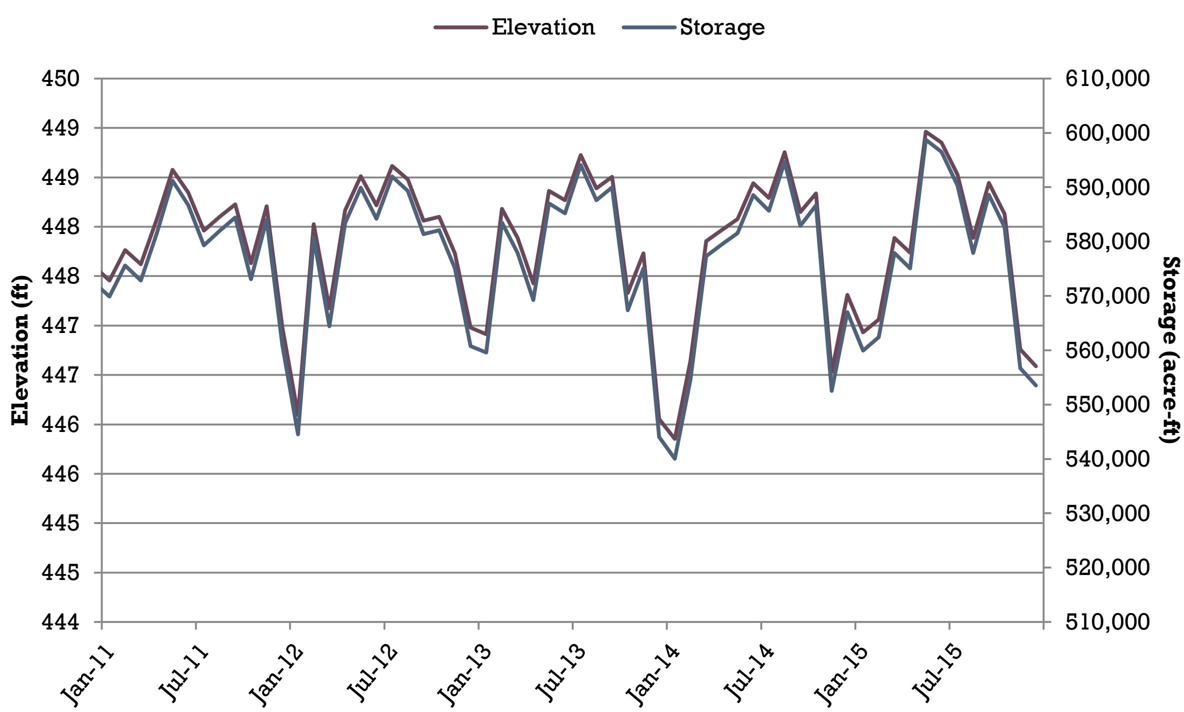


Figure 2-11. Lake Havasu Elevation and Storage, 2011–2015

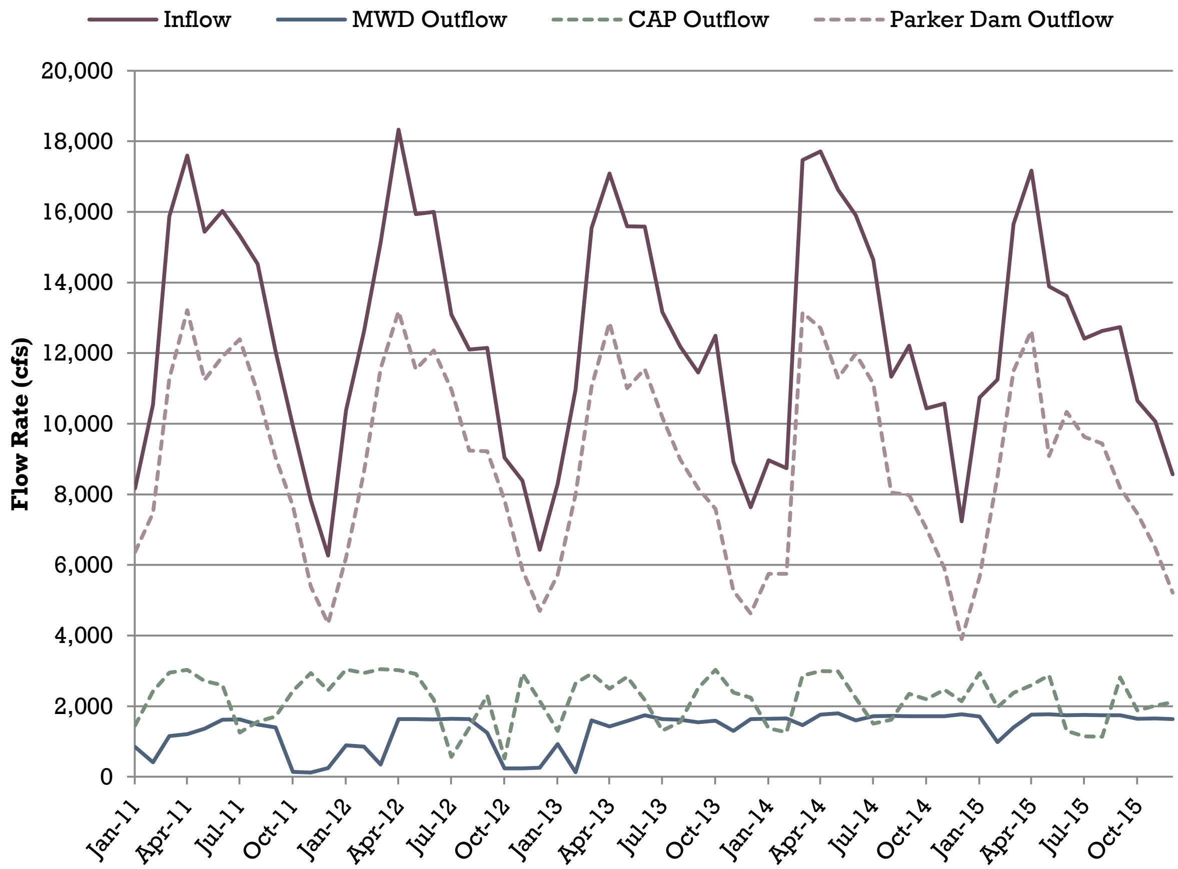


Figure 2-12. Lake Havasu Inflow and Outflow, 2011–2015

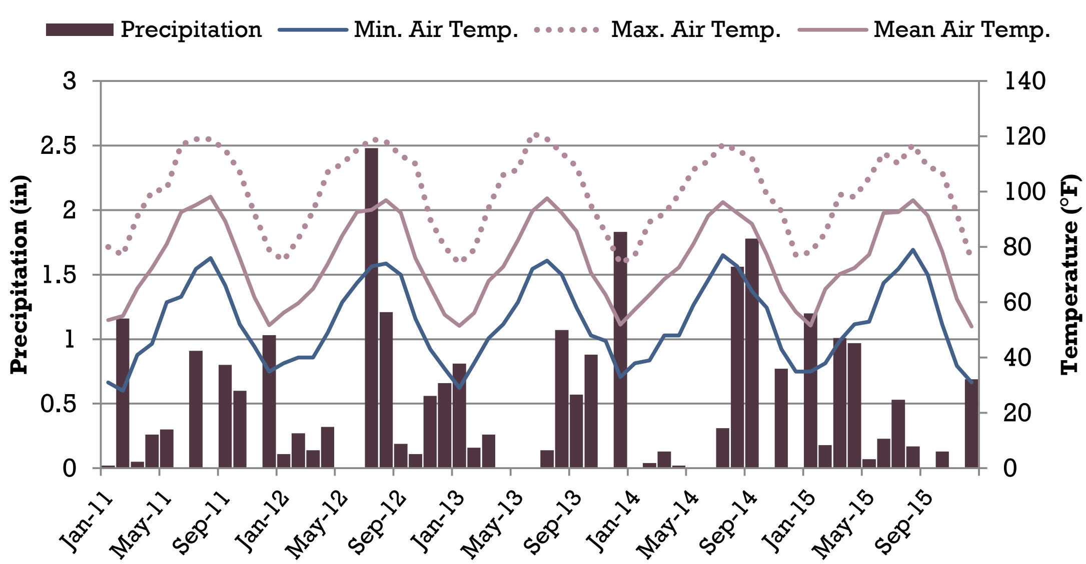


Figure 2-13. Temperature and Rainfall for Lake Havasu, 2011–2015

Watersheds Contributing to Metropolitan's Colorado River Aqueduct and Reservoir System

This watershed sanitary survey also covers Metropolitan's Colorado River Aqueduct (CRA), Lake Mathews (the terminal reservoir for the aqueduct), Diamond Valley Lake, and Lake Skinner (see **Table 1-3** for a comparison of the size of these facilities).

Colorado River Aqueduct

The CRA, completed in 1941, spans 242 miles of desert and mountain ranges between Metropolitan's intake (Whitsett Intake) on Lake Havasu and Lake Mathews in Riverside County. There are five pumping plants along the aqueduct: Whitsett Intake, Gene, Iron Mountain, Eagle Mountain, and Julian Hinds. In addition to the CRA, two additional open canals are used to deliver Colorado River water to Metropolitan's facilities: the Casa Loma Canal and the San Diego Canal. Although the aqueduct and its associated facilities were designed to keep most local runoff out, a few areas of the aqueduct may receive drainage, especially during flood events. Public access to open-channel sections of the CRA system is not allowed. Frequent and routine ground and aerial surveillance help protect the system from unauthorized entry.

Watersheds within Metropolitan's CRA system include the Gene Wash Reservoir, Copper Basin Reservoir, Lake Mathews, Diamond Valley Lake, and Lake Skinner watersheds. As Gene Wash and Copper Basin have relatively small, undeveloped watersheds, no potential contaminant sources for these areas have been identified in the CRWSS 2015 Update.

Gene Wash Watershed

Gene Wash Reservoir is located approximately two miles downstream of the Whitsett Intake (see **Figure 2-14**). The reservoir, which is the smallest in the Colorado River system, has a storage capacity of 6,300 acre-feet at a maximum elevation of 1,037 feet. The watershed for the Gene Wash Reservoir covers 5.5 square miles with a terrain that is barren desert with some steep relief. Meteorological conditions at Gene Wash and Copper Basin mirror those found at Lake Havasu (**Figure 2-13**).

Copper Basin Watershed

Copper Basin Reservoir is about three miles downstream of Gene Wash Reservoir (**Figure 2-14**). The reservoir has a storage capacity of 22,000 acre-feet at a maximum elevation of 1,026 feet. The watershed for this reservoir is approximately 7 square miles of barren, desert terrain characterized by steep mountain slopes. Rainfall and runoff are minimal for this reservoir.

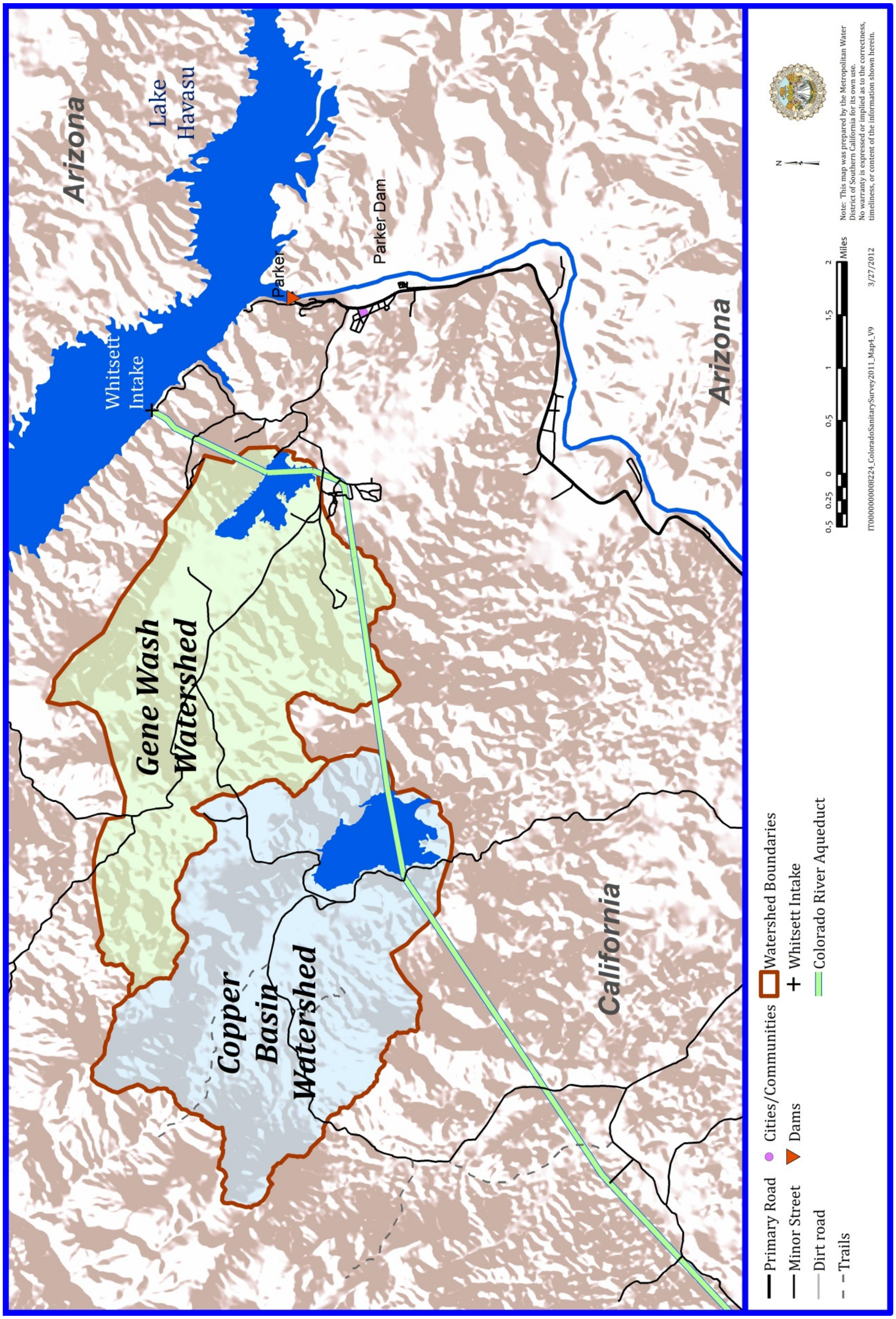
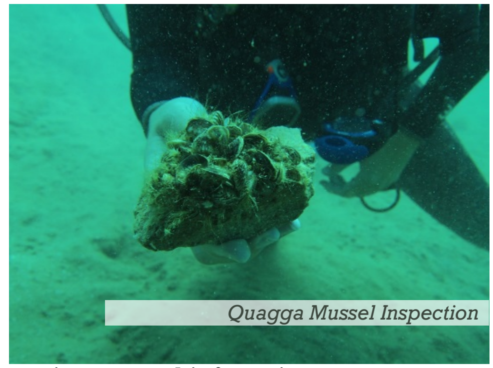


Figure 2-14. Watersheds for Gene Wash and Copper Basin

Quagga Mussels



Quagga Mussel Inspection

Invasive quagga mussels (*Dreissena bugensis*) were discovered in Lake Mead in January 2007 and rapidly spread throughout the lower Colorado River and Metropolitan's CRA system. Quagga mussels are indigenous to Ukraine and are related to the better-known zebra mussels (*Dreissena polymorpha*). Similar to the zebra mussel, which was most likely introduced to the Great Lakes in the late 1980s via ship ballast water, quagga mussels were introduced to Lake Mead most probably through the translocation of boats or maritime equipment. Although the introduction of these two species into drinking water supplies does not typically result in violation of drinking water standards, invasive mussel infestations can adversely impact aquatic environments. Two areas of relevance for aquatic environments used as sources of drinking water are the potential for clogging of intakes and raw water conveyance systems via attachment of high numbers of mussels to surfaces, and a long-term potential for rendering lakes more susceptible to deleterious cyanobacterial and algae blooms.

California Assembly Bill 1683, signed into law on October 10, 2007, authorized California Department of Fish and Game, now California Department of Fish and Wildlife (CDFW), to control zebra and quagga mussels in water supply systems. Public water supply operators are permitted to deliver water in compliance with a CDFW approved mussel control Plan. Metropolitan developed its first five-year Quagga Mussel Control Plan in 2008 and submitted a five-year renewal plan to CDFW in 2013. The plan discusses Metropolitan's surveillance activities, which include annual visual inspections alongside scheduled CRA shutdowns and monthly monitoring for veligers at Lake Havasu, Copper Basin, Lake Mathews, Lake Skinner, Diamond Valley Lake, and uninfested areas in Metropolitan's facilities. The plan also discusses Metropolitan's quagga control activities, which include chlorination in the raw water conveyance system at Copper Basin and the outlets to Lake Mathews and Lake Skinner for quagga larval control. Recent shutdown inspections have demonstrated that the combined use of chlorine and cleaning during regularly scheduled shutdowns effectively control mussel infestation in the CRA since a reduced number of mussels have been found during these inspections.

The use of chlorination within raw water supplies caused Metropolitan to change its treatment technique used to comply with the Stage 1 Disinfectants/Disinfection Byproducts Rule at its water treatment plants that treat Colorado River water (further discussed in **Chapter 5**).

Lake Mathews Watershed

Lake Mathews is located in western Riverside County approximately 10 miles southwest of the city of Riverside. The lake has a storage capacity of 182,000 acre-feet at a maximum elevation of 1,390 feet. The watershed for Lake Mathews encompasses 38.6 square miles (see **Figure 2-15**) and is located in the larger Santa Ana River watershed. Natural open-space grassland, some commercial land use, and agricultural and residential areas characterize the watershed. The western and southern shores of the lake are part of the 5,100-acre Lake Mathews Multiple Species Reserve. Increasing urbanization of the watershed prompted Metropolitan to take a proactive approach to watershed management. Metropolitan worked with Riverside County to develop a specific plan, the Lake Mathews Community Plan, to address growth issues and development within the watershed. Additional planning documents developed for the watershed include the Drainage Water Quality Management Plan (DWQMP), a fire management plan, and the Lake Mathews Multiple Species Habitat Conservation and Natural Community Conservation Plan. Through the DWQMP, Metropolitan has constructed the Cajalco Creek Dam and Detention Basin and several sediment basins within the watershed. In 2012, Metropolitan, Riverside County, and Riverside County Flood Control and Water Conservation District also completed a Lake Mathews Watershed Water Quality Improvement Study and Model to assess effects of land use changes and develop water quality protection strategies.

The Lake Mathews watershed lies in a semi-arid region with hot, dry summers and mild winters characterized with intermittent periods of rainfall. Temperatures range from the low 20s to over 100 °F. The watershed is underlain by granite and widely distributed alluvium, and soil types include clay, sandy loam, and rocky loam. The watershed is drained primarily by Cajalco Creek, which is intermittent, flowing only during storm events or in the presence of agricultural runoff. A flume is located at the downstream end of Cajalco Creek to measure runoff flows entering Lake Mathews. **Figure 2-16** and **Figure 2-17** show the historical and reporting period lake elevations and storage levels, respectively, for Lake Mathews. Under drought conditions and low SWP allocations, Metropolitan relied on storage reserves to meet water demands. During the reporting period, storage in Lake Mathews was gradually depleted and in November 2014 the lake was only 24 percent full with a low elevation of 1321 feet (**Figure 2-17**). **Figure 2-18** shows inflows and outflows for Lake Mathews, respectively. Monthly rainfall totals from 2011 to 2015, shown in **Figure 2-19,** fell well below the average annual precipitation of 10.3 inches in Riverside, California [19].

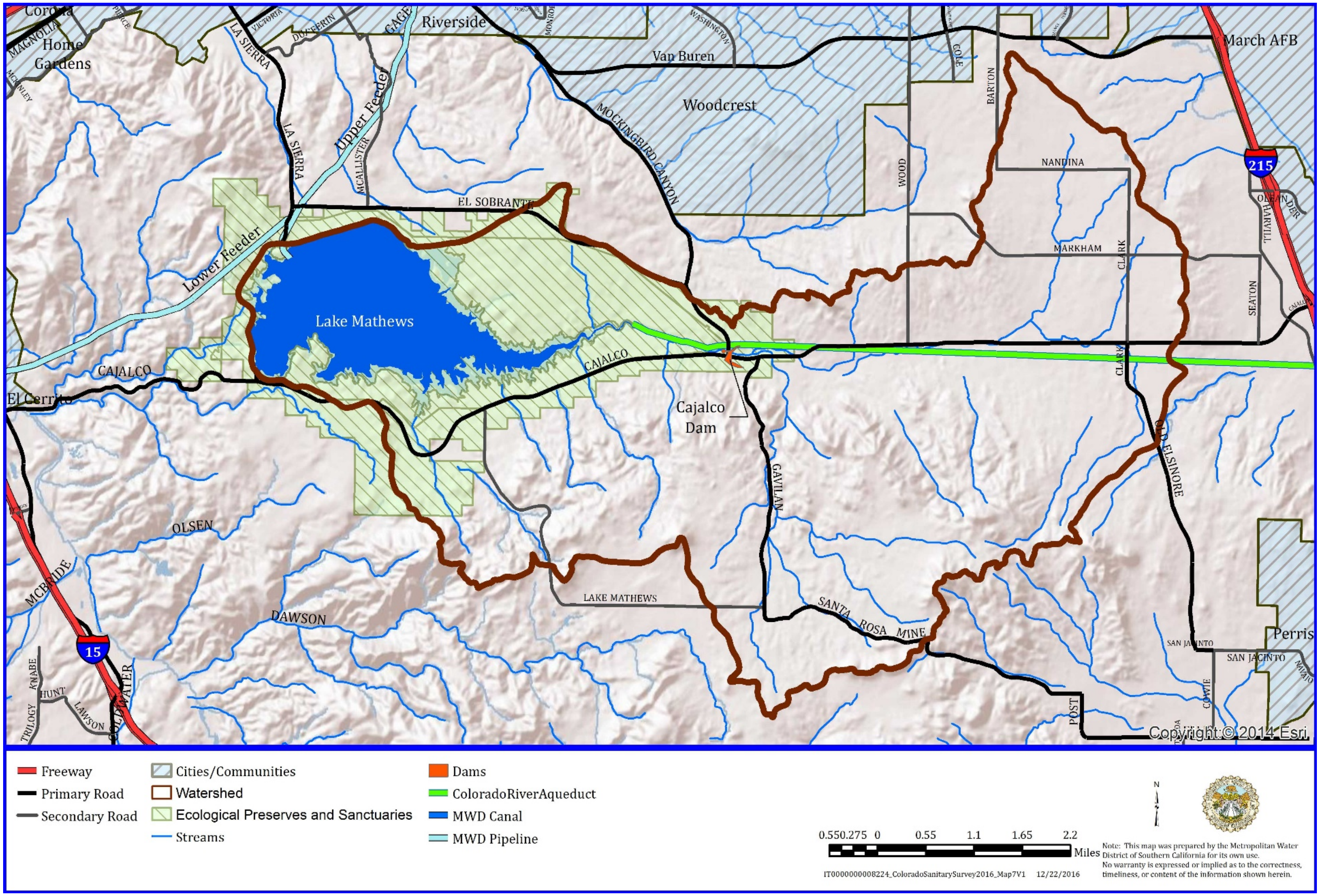


Figure 2-15. Watershed for Lake Mathews

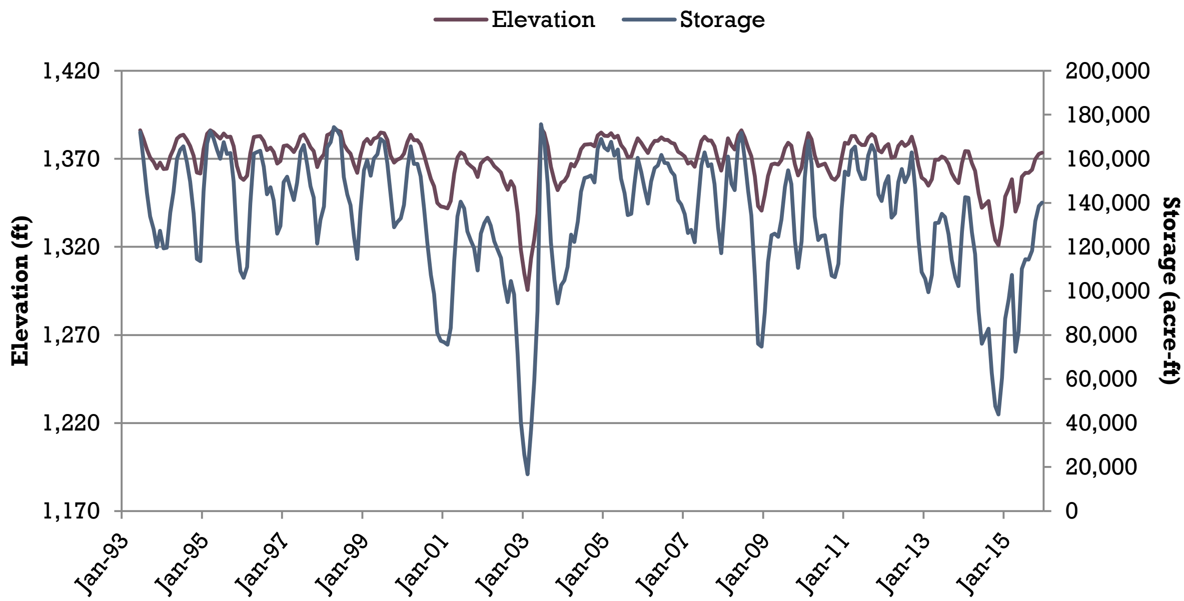


Figure 2-16. Historical Lake Mathews Elevation and Storage

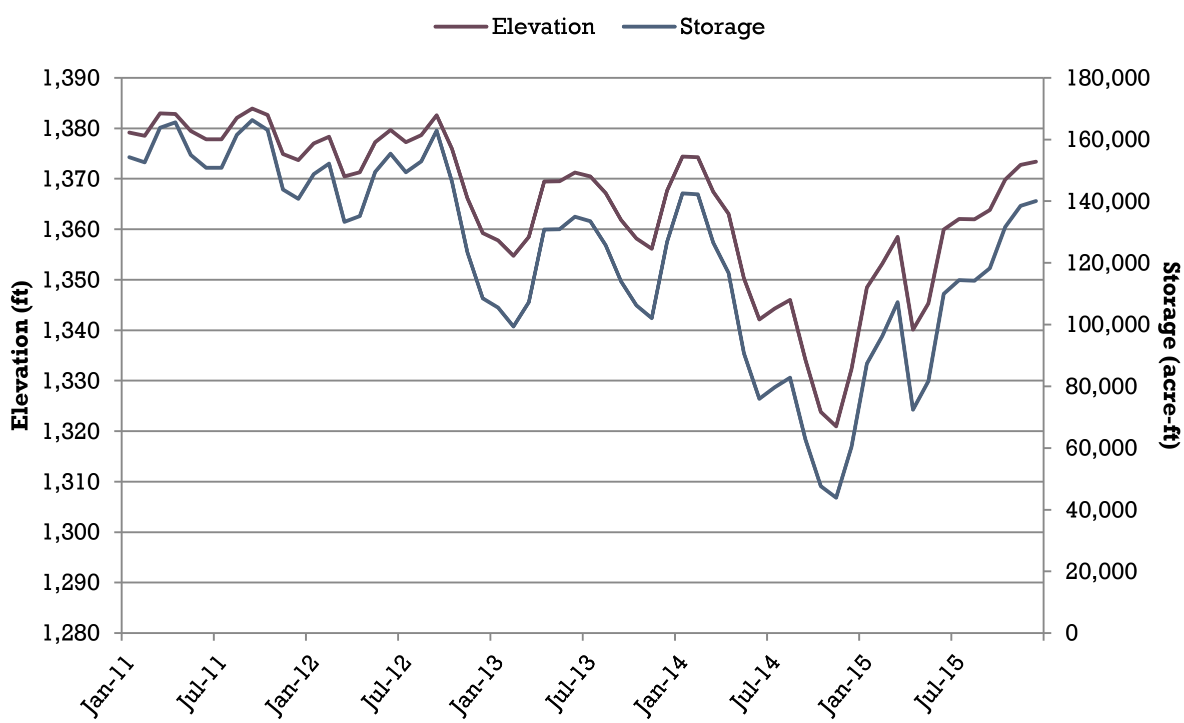


Figure 2-17. Lake Mathews Elevation and Storage, 2011–2015

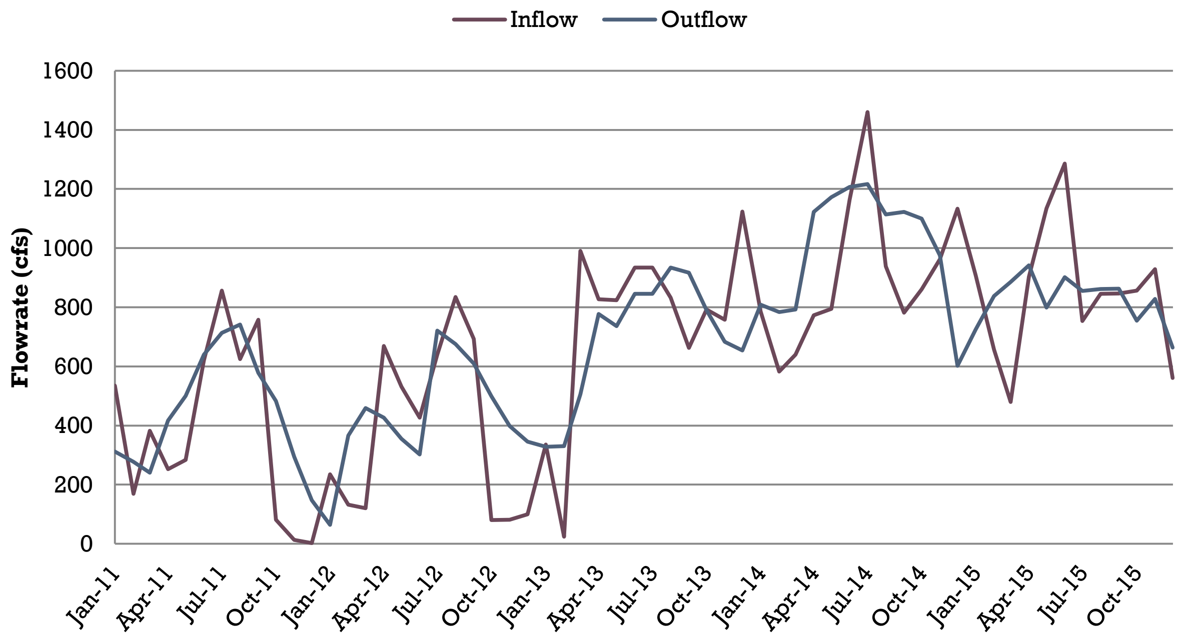


Figure 2-18. Lake Mathews Inflow and Outflow, 2011–2015

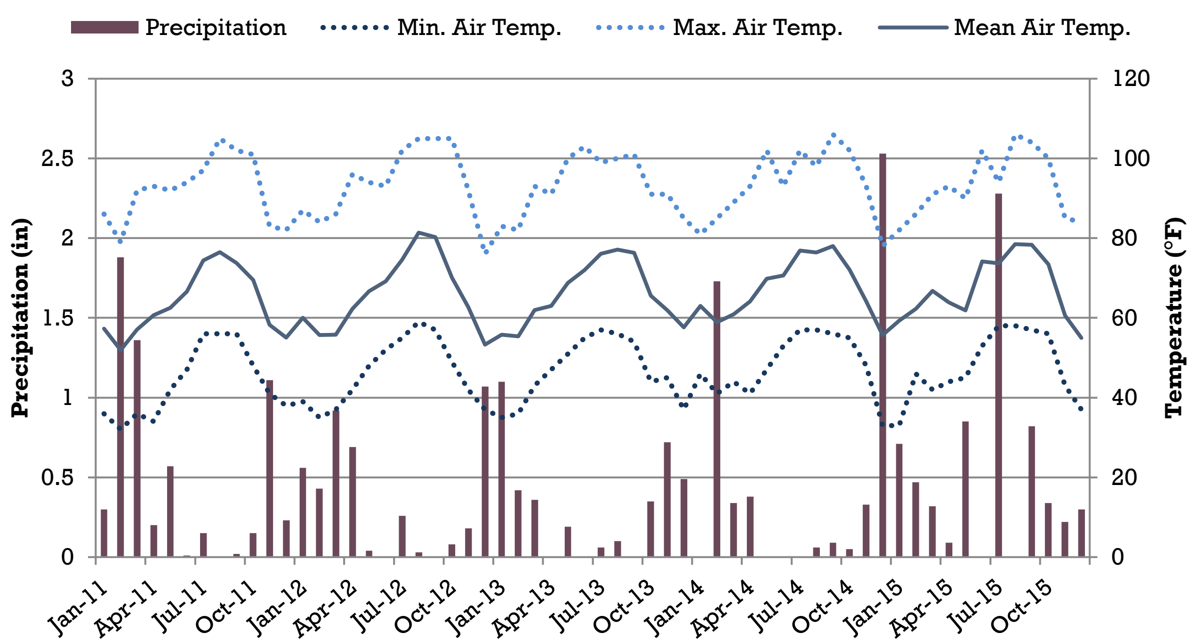


Figure 2-19. Monthly Temperature and Rainfall for Lake Mathews, 2011–2015

Diamond Valley Lake Watershed

Diamond Valley Lake is located approximately four miles southwest of Hemet and three miles southeast of Winchester in western Riverside County. The lake has a storage capacity of 810,000 acre-feet at a maximum elevation of 1,756 feet. The watershed encompasses slightly more than 5 square miles within the Santa Margarita watershed. Diamond Valley Lake provides emergency, drought, and seasonal storage, as well as preserving operating reliability for Metropolitan's service area. Diamond Valley Lake can be filled with Colorado River or SWP water through the inlet/outlet tower and with SWP water through the secondary inlet. The filling of the reservoir began in late 1999 and withdrawals from the reservoir began in January 2001. Since the discovery of quagga mussels in Colorado River water in 2007, only SWP water has been used to fill Diamond Valley Lake.

Since the watershed is small, approximately the same size as the surface area of the lake, and not developed, the main potential contaminant source is recreational activities. The lake features a marina and is open to boating and fishing, along with hiking and other recreational activities around the lake. Body contact is not permitted at Diamond Valley Lake. Recreational activities are managed through a Recreational Activity Plan, which was completed for Diamond Valley Lake in 2003 and approved by DDW. Stricter boating rules, which required low emission engines, were implemented in October 2003.

The watershed area around Diamond Valley Lake is bounded by the hills surrounding the reservoir (see **Figure 2-20**). The only undisturbed and intact natural watercourses are located within these hills. These unnamed watercourses represent highly ephemeral drainages, with most of them being less than 2,000 feet in length. Runoff is not currently measured. The reservoir has three dams: two main embankments at the east end and west end of the valley, as well as a large saddle dam along a low point in the hills that form the northern boundary of the site.

A forebay with approximately 750 acre-feet capacity is located to the west of the west dam. The forebay regulates flow rates between supply inflows from the San Diego Canal and pumping rates to the reservoir. **Figure 2-21** and **Figure 2-22** show historical and reporting period elevation and storage level data, respectively. During the reporting period, the lake storage and elevation decreased significantly due to low SWP allocations. The lake elevation dipped below the existing boat ramp in April 2015, forcing boat launching to be closed. During the closure, Metropolitan extended the middle three launch lanes of the boat launch ramp. **Figure 2-23** and **Figure 2-24** show individual inflows, and combined inflows and outflows at Diamond Valley Lake, respectively. Deliveries from the reservoir are discharged into the forebay prior to entry into the San Diego Canal. Due to California's drought conditions and the need to preserve SWP water for SWP exclusive areas, minimal inflows were made to Diamond Valley Lake from February 2013 through the end of this reporting period (December 2015).

The climate in the Diamond Valley Lake watershed is generally semi-arid with hot and dry summers, but having moderate temperatures and humidity in the winters (**Figure 2-25**). The extreme temperature ranges from 16 °F to 114 °F, with an annual mean of 63 °F. Wind direction is predominantly from the northwest, with a mean wind speed of three knots.

Soils consist of alluvial deposits (primarily sand, silt, clay, and gravel) in the reservoir floor and colluvium soils (mostly fine sandy loams) on the steep valley slopes. There are also areas of gneiss. Native flora includes California chaparral with some live oak, sycamore, and cottonwood trees. Southern willow scrub, California sagebrush, black sage, and white sage are abundant. Non-indigenous species have also been planted in various locations throughout the watershed.

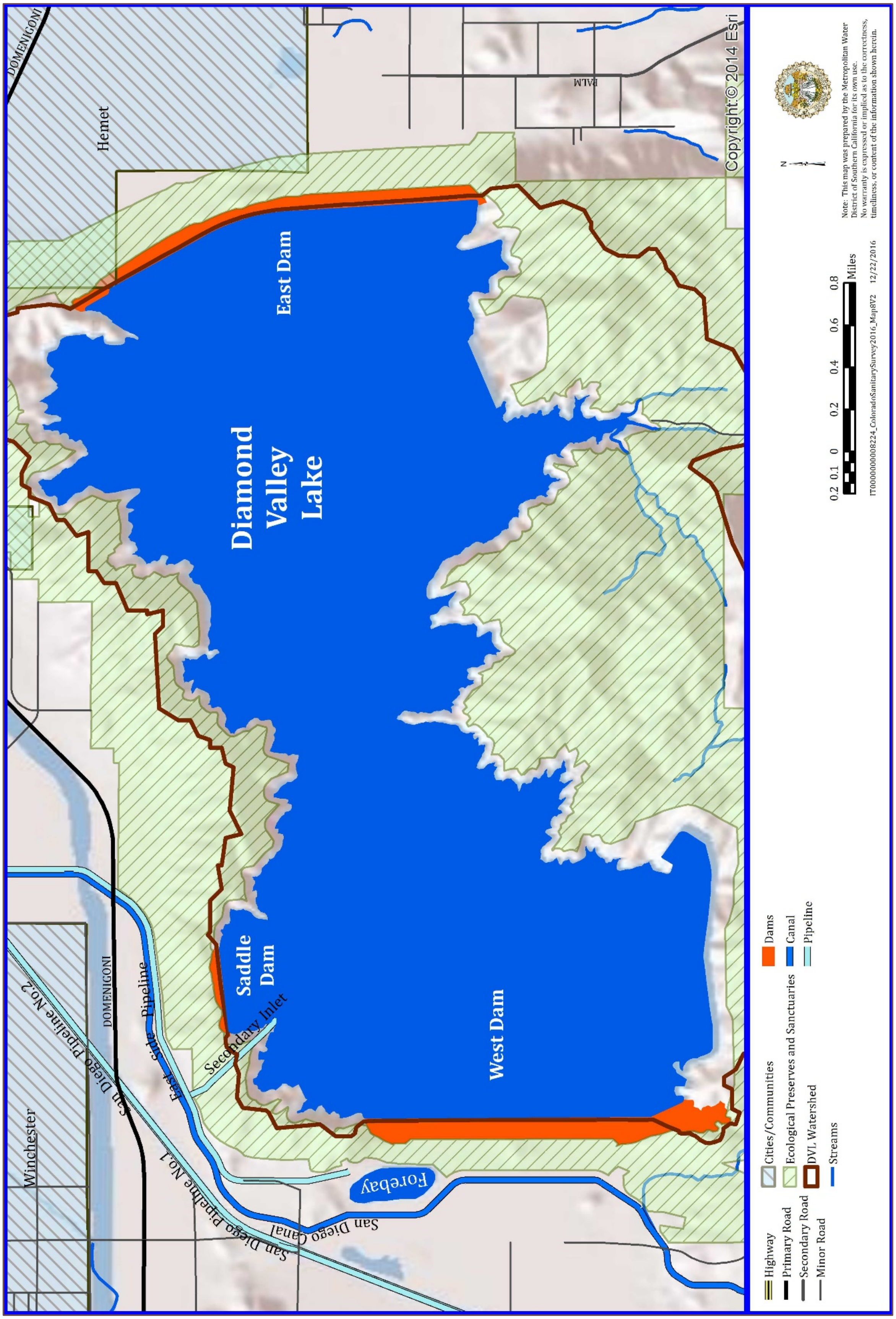


Figure 2-20. Watershed for Diamond Valley Lake

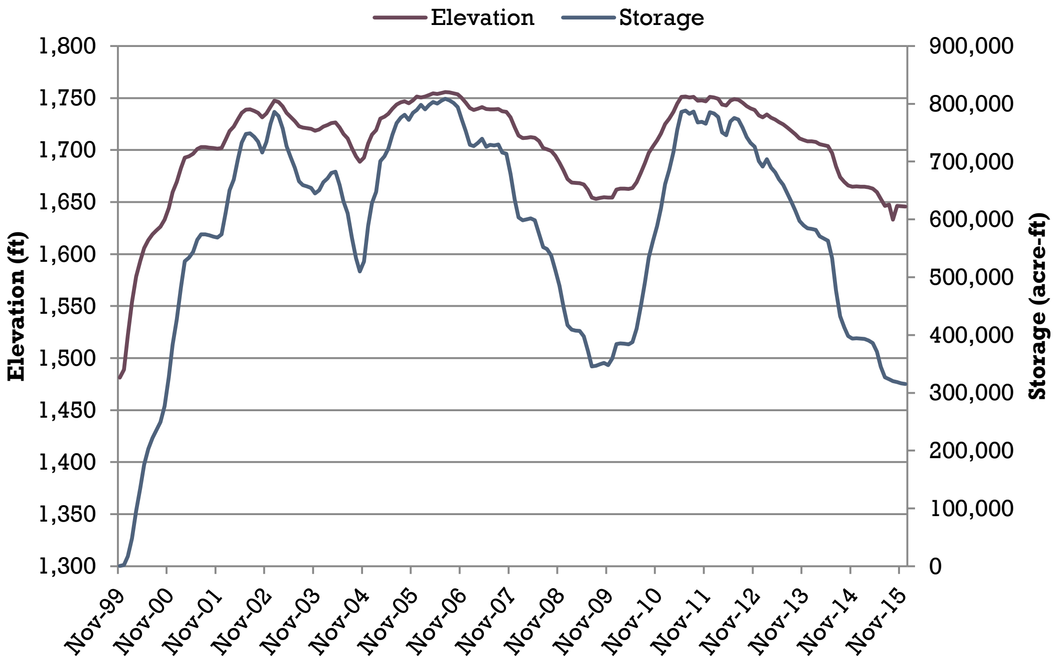


Figure 2-21. Historical Diamond Valley Lake Elevation and Storage

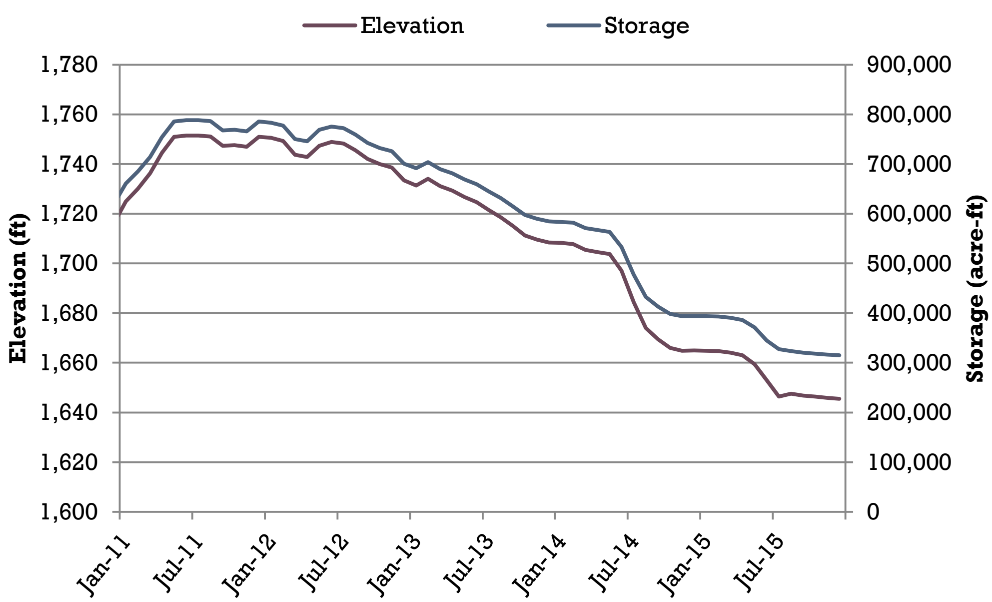


Figure 2-22. Diamond Valley Lake Elevation and Storage, 2011–2015

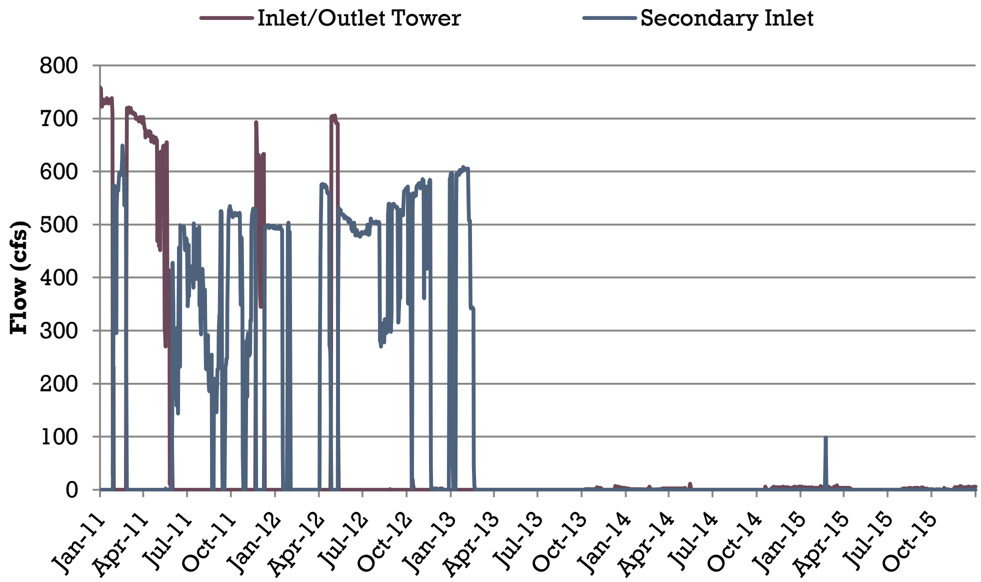


Figure 2-23. Diamond Valley Lake Inflow Data, 2011–2015

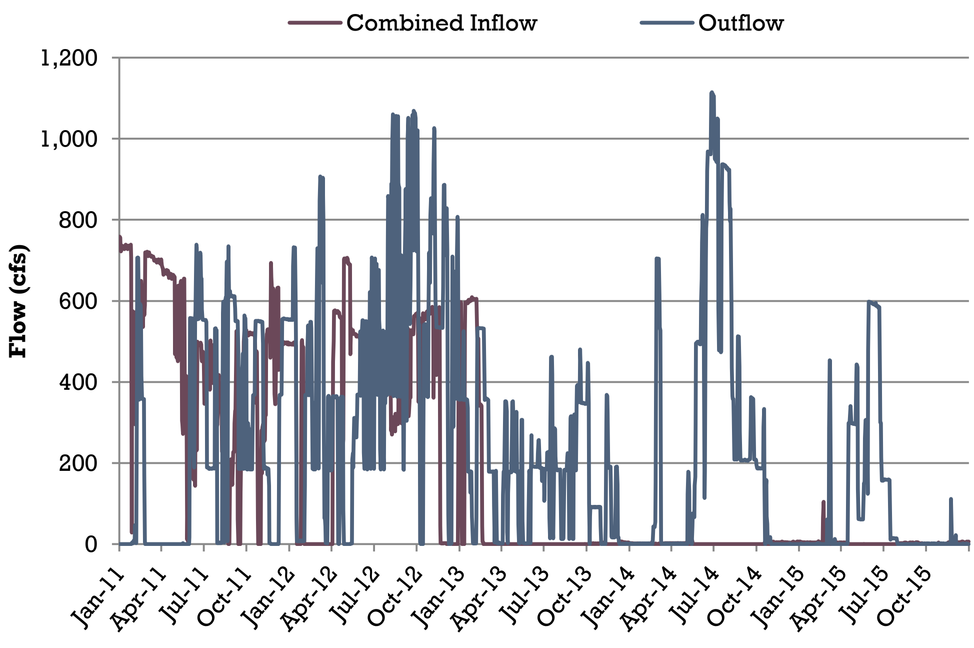


Figure 2-24. Diamond Valley Lake Combined Inflow and Outflow Data, 2011–2015

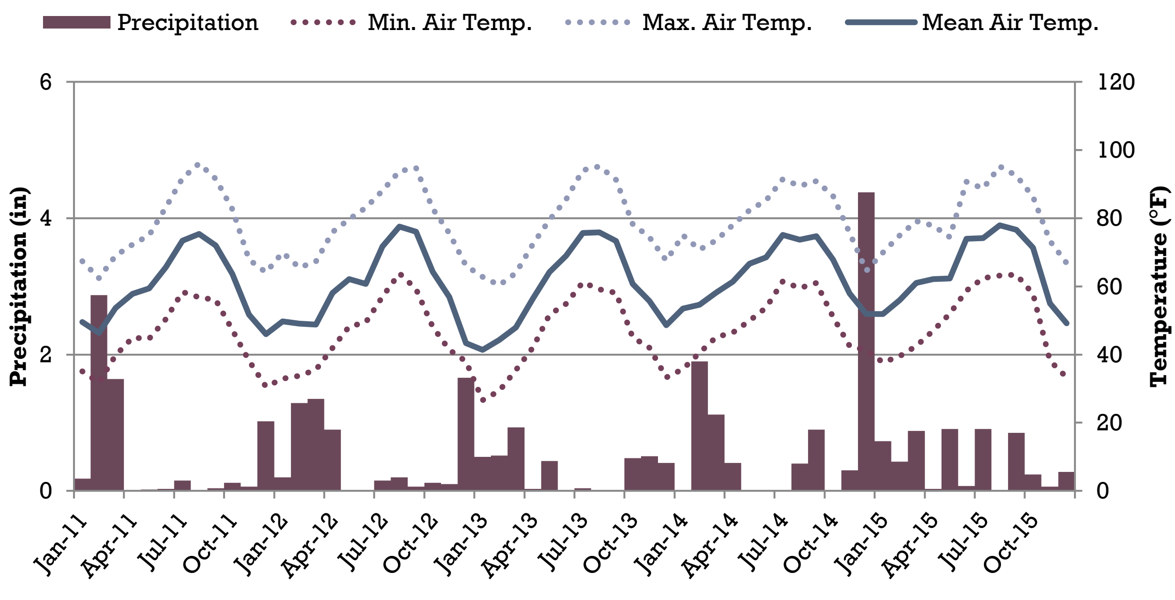


Figure 2-25. Monthly Temperature and Rainfall for Diamond Valley Lake, 2011–2015

Lake Skinner Watershed

Lake Skinner is located near the city of Temecula in Riverside County and has a storage capacity of 44,000 acre-feet at a maximum elevation of 1,479 feet. The Lake Skinner watershed consists of approximately 51 square miles (see **Figure 2-26**), which is drained primarily by Tucalota Creek, Rawson Canyon Creek, and Middle Creek. The streams are generally ephemeral, flowing only after prolonged or heavy rains. Flows from Tucalota Creek into Lake Skinner are recorded on a monthly basis. Lake Skinner's elevation and storage are typically lower in the winter months and the lake is filled for the summer season (**Figure 2-27** and **Figure 2-28**). The major water sources for the reservoir are the Colorado River and the SWP. **Figure 2-29** shows individual inflows and outflows at Lake Skinner. In late 2014, the reservoir storage dropped significantly (**Figure 2-28**), as inflow into the lake decreased due to low availability of water supplies for storage; inflow into the lake decreased from an average of 688 cfs during the reporting period to 371 cfs and 348 cfs in December 2014 and February 2015 (**Figure 2-29)**, respectively.

The watershed is in a semi-arid region with hot, dry summers and mild winters characterized by intermittent periods of rainfall. Monthly rainfall totals from 2011 to 2015, shown in **Figure 2-30**, fell well below the average annual precipitation of 11.1 inches in Winchester, California [20]. Temperatures range from the low 20s to over 100 °F, similar to Diamond Valley Lake watershed temperatures. Shale, sandstone, granitic rock, and thick deposits of alluvium dominate the geology of the watershed. Soils include sandy soils and loams.

Riverside County manages recreation on Lake Skinner pursuant to Metropolitan's guidelines and restrictions. Recreational use is limited to non-body contact activities such as boating and fishing. Similar to Diamond Valley Lake, stricter boating rules, which required low emission engines, were implemented in October 2003. An equestrian trail is located along the perimeter of the Riverside County park area. In addition to recreation, the watershed uses include several horse properties (i.e., small ranches and hobby farms) along Tucalota Creek.

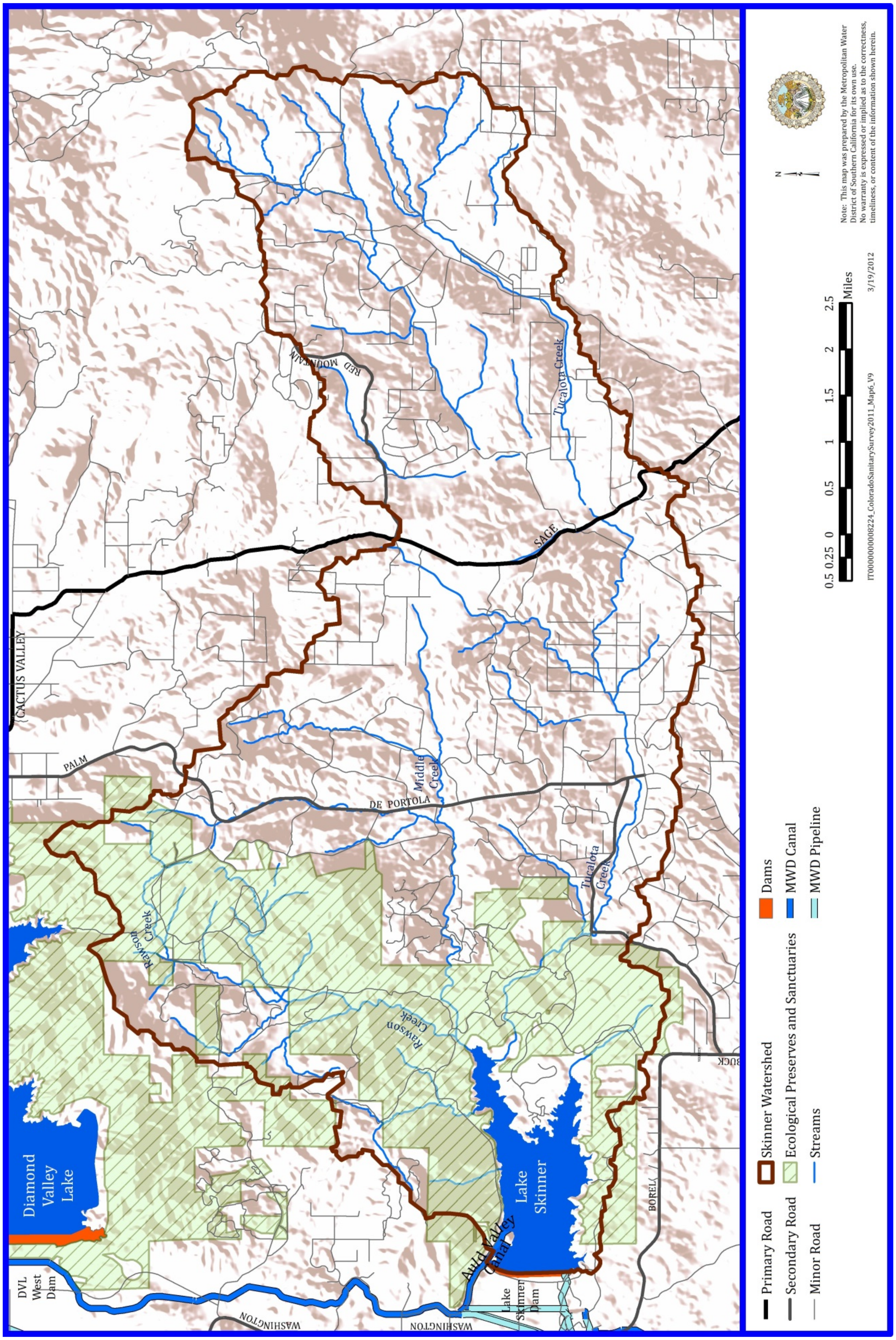


Figure 2-26. Watershed for Lake Skinner

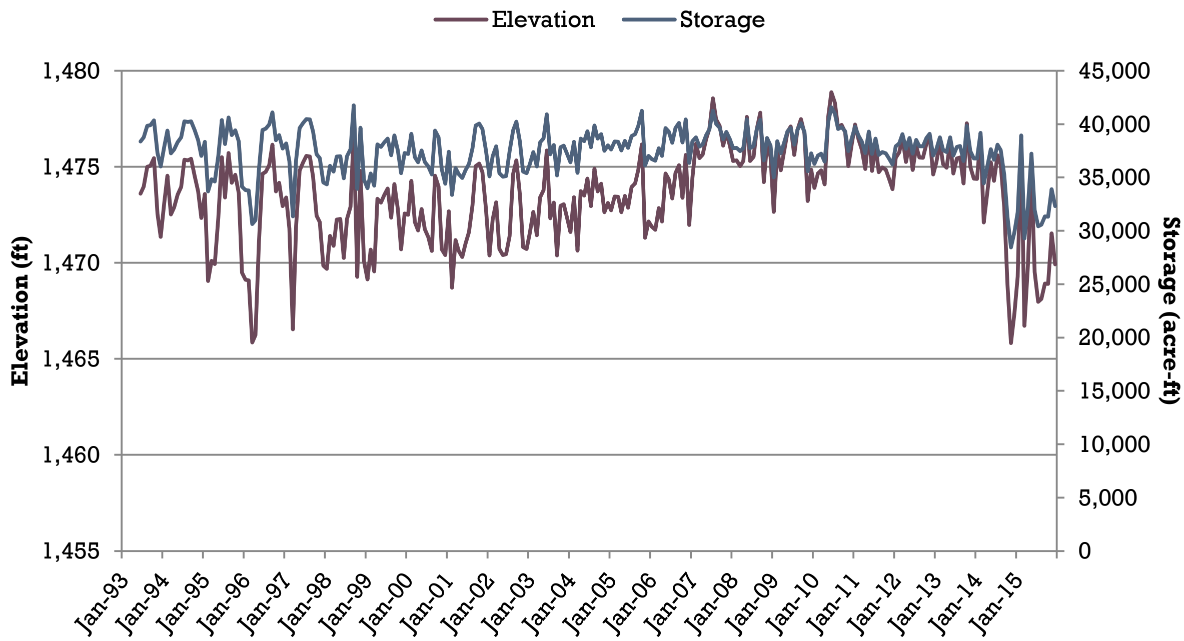


Figure 2-27. Historical Lake Skinner Elevation and Storage

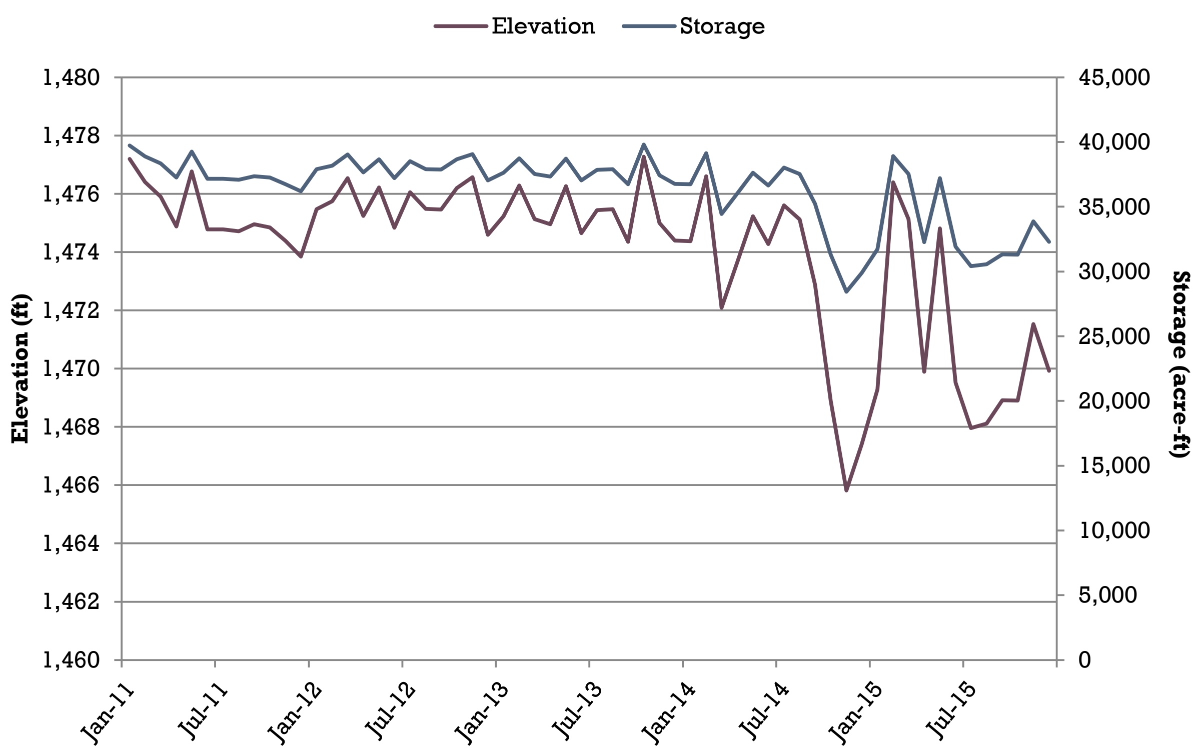


Figure 2-28. Lake Skinner Elevation and Storage, 2011–2015

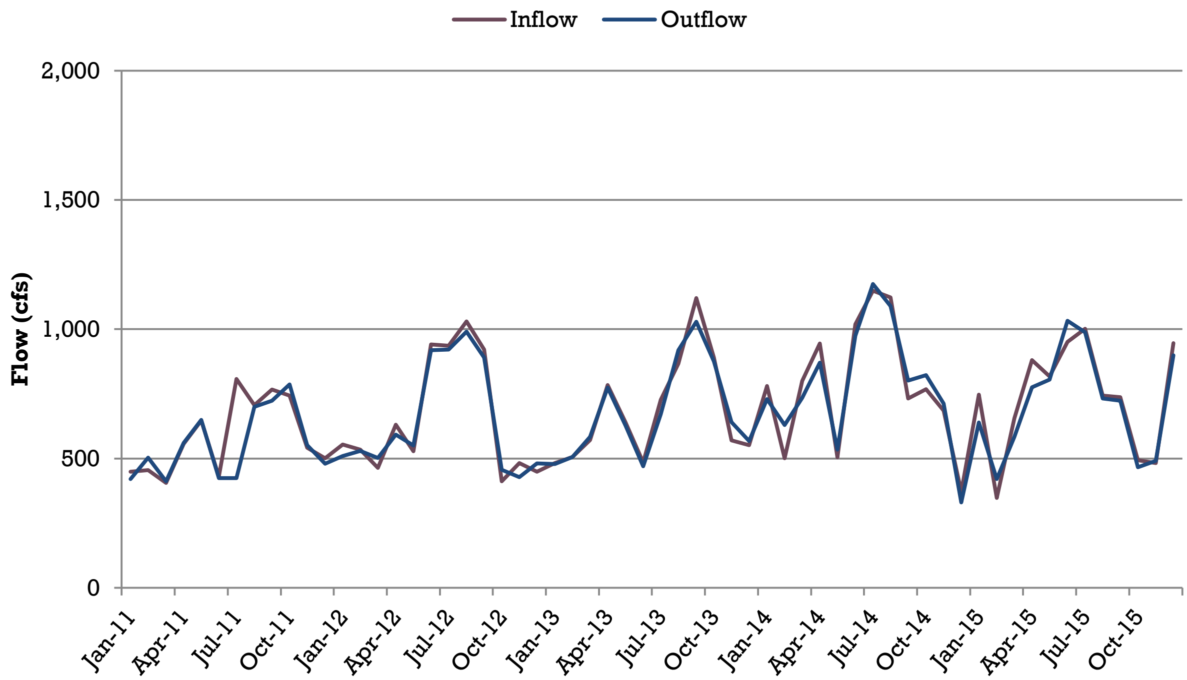


Figure 2-29. Lake Skinner Inflow and Outflow, 2011–2015

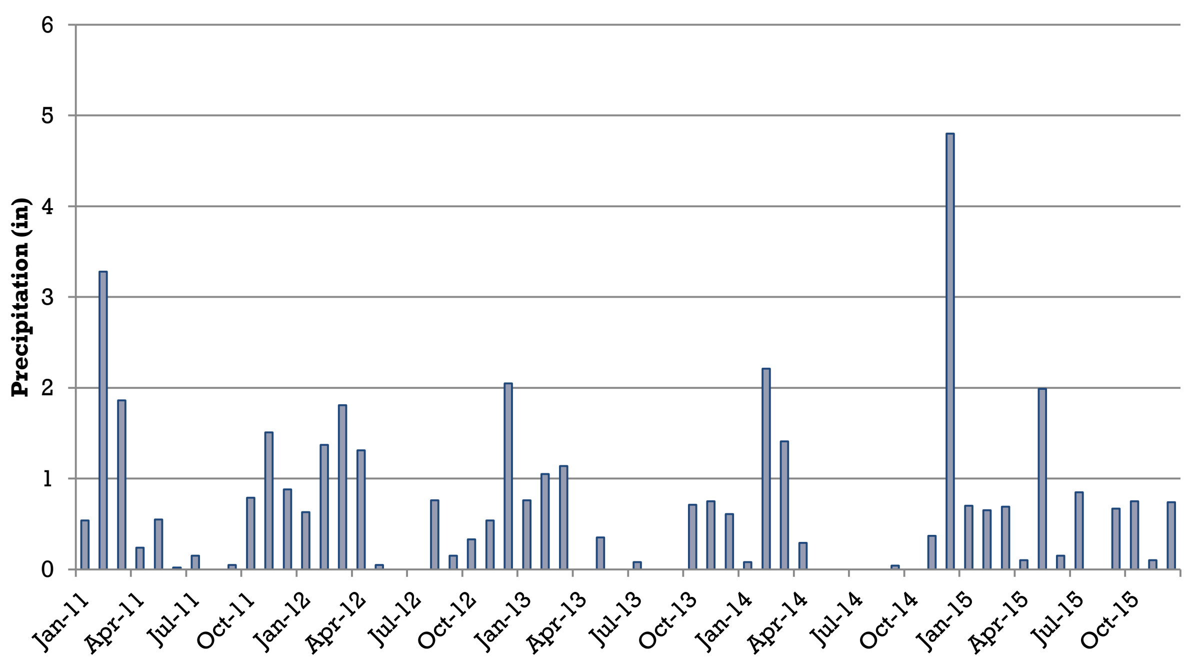


Figure 2-30. Monthly Rainfall for Lake Skinner, 2011–2015

This page intentionally left blank

3 Source Water Quality Data Review

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Chapter 3 Source Water Quality Data Review

This chapter provides 1) a description of Metropolitan's water quality monitoring programs, and 2) an evaluation of selected constituents of interest. Water quality monitoring programs were developed in compliance with California Surface Water Treatment Rule (SWTR)—Title 22, Article 7, Section 64665 of California Code of Regulations (California Title 22). Source water is monitored at Whitsett Intake on Lake Havasu, San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, and Diamond Valley Lake. The following constituents of concern were selected for evaluation in the CRWSS 2015 Update: various inorganic compounds (i.e., aluminum, boron, chromium-6, perchlorate, total dissolved solids [TDS], nutrients [total phosphorus and nitrate]), radionuclides (i.e., uranium, radium, gross alpha and gross beta emitters, strontium-90, and tritium), turbidity, organic compounds (i.e., total organic carbon [TOC], *N*-nitrosodimethylamine [NDMA], pharmaceuticals and personal care products [PPCPs]), and microbiological constituents (i.e., coliforms and pathogens). Detailed evaluations for these constituents of interest are presented later in this chapter. A summary of Title 22 inorganic and organic constituents as reported in Metropolitan's *Annual Water Quality Report to MWD Member Agencies* for calendar years 2011 to 2015 for Metropolitan's source and treated waters can be found in **Appendix C**. For annual summaries of microbiological constituents, also see **Appendix C**.

Water Quality Monitoring Programs

Chemical Compliance Monitoring Program

The U.S. Environmental Protection Agency (USEPA) and DDW regulations require monitoring of Metropolitan's source and finished water for general mineral constituents, general physical parameters, trace metals, pesticides, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), synthetic organic compounds (SOCs), disinfection byproducts (DBPs), DBP precursors, asbestos, and radiological constituents. California Title 22 requires samples to be collected (except for DBP-related constituents) from each water source or from the point of entry into the distribution system that is representative of each water source after treatment. **Table 3-1** lists the compliance monitoring sampling sites, source water/point of entry, and DDW primary station code. Several sites along the Colorado River Aqueduct (CRA) system (Lake Havasu, San Jacinto Tunnel West Portal, and Lake Mathews) were chosen to characterize the water quality along the aqueduct. Lake Skinner and Diamond Valley Lake were also sampled, although these reservoirs can receive a blend of both Colorado River water and water from the SWP. Lake Skinner was sampled at the outlet conduit and Diamond Valley Lake was sampled from the inlet/outlet tower when water was flowing out of the lake and near the outlet tower in the west basin at 12 m depth when water was not flowing out. The influents of the Diemer, Skinner, and Weymouth plants were sampled as they represent the source water quality at the point of entry into Metropolitan's water treatment system. Some of the plant influents were sampled for radiologicals, trace metals, and asbestos in order to assess any changes through the treatment process. Water treatment plant effluent data are discussed in **Chapter 5**.

DDW's required monitoring schedule is based on a compliance cycle spanning nine calendar years (see **Table 3-2**). Each compliance cycle is divided into three, three-year compliance periods. The initial compliance cycle started on January 1, 1993. **Table 3-3** shows Metropolitan's compliance monitoring schedule by analytical group.

Table 3-1. Metropolitan Water District of Southern California Monitoring Sample Sites

Station Code	Sample Location	Source Water/Treated Water
Compliance Locations		
1910087-024	Diamond Valley Lake–WB Center (12 m)	Near outlet tower of Diamond Valley Lake
1910087-024	Diamond Valley Lake–Inlet/Outlet (I/O)	Effluent from the inlet/outlet line
1910087-007	Lake Havasu–Near Whitsett Intake (12 m)	Effluent from Lake Havasu
1910087-008	Lake Mathews Headworks	Effluent from Lake Mathews
1910087-012	Lake Skinner Outlet Conduit	Effluent from Lake Skinner
1910087-015	San Jacinto Tunnel West Portal (WP)	Colorado River Aqueduct
1910087-003	Diemer Plant Effluent	Point of entry
1910087-026	Skinner Reservoir Effluent	Point of entry
1910087-020	Weymouth Plant Effluent	Point of entry
Non-Compliance Locations		
1910087-025	Lake Mathews Inlet	Influent to lake
1910087-004	Diemer Plant Influent	Influent to plant
1910087-019	Skinner Plant 1 Influent	Influent to plant
	Skinner Plant 2 Influent	Influent to plant
1910087-021	Weymouth Plant Influent	Influent to plant

Table 3-2. Compliance Scheme

	Effective	End
1. Compliance Cycle	January 1, 1993	December 31, 2001
I. Compliance Period	January 1, 1993	December 31, 1995
II. Compliance Period	January 1, 1996	December 31, 1998
III. Compliance Period	January 1, 1999	December 31, 2001
2. Compliance Cycle	January 1, 2002	December 31, 2010
I. Compliance Period	January 1, 2002	December 31, 2004
II. Compliance Period	January 1, 2005	December 31, 2007
III. Compliance Period	January 1, 2008	December 31, 2010
3. Compliance Cycle	January 1, 2011	December 31, 2019
I. Compliance Period	January 1, 2011	December 31, 2013
II. Compliance Period	January 1, 2014	December 31, 2016
III. Compliance Period	January 1, 2017	December 31, 2019

The California Title 22 initial monitoring requirements for regulated constituents were set at frequencies greater than the follow-up monitoring requirements. **Table 3-4** shows the required initial and follow-up monitoring for each analytical constituent group. Previous CRWSS updates discussed the initial and follow-up sampling. Initial sampling for gross beta emitters, tritium, and strontium-90 were completed in 2005 and 2006; follow up sampling for VOCs and radionuclides (uranium, gross alpha and beta emitters, radium-226 and radium-228, tritium and strontium-90) continued during this reporting period. **Table 3-5** shows the baseline compliance monitoring requirements for each analytical group by sample location. Some constituents (e.g., general minerals) are monitored more frequently than required (see Metropolitan's Proactive Monitoring Program below). Metropolitan monitors select distribution system locations on a quarterly basis for compliance with the Stage 1 Disinfectants/Disinfection Byproducts Rule.

Proactive Chemical Monitoring Programs

Metropolitan maintains a proactive chemical monitoring program, which extends beyond that required by the regulations for source water and finished water quality. Follow-up monitoring is conducted more frequently than required as part of Metropolitan's source water protection program. **Table 3-3** shows the monitoring schedule for the second compliance cycle, covering January 2011 through December 2015. Compliance monitoring periods and Metropolitan's proactive monitoring periods are indicated in **Table 3-3**. General mineral and physical parameters are also analyzed monthly. Radiological constituents gross alpha and uranium are monitored monthly at select locations on the Colorado River water system because of natural uranium deposits in the watershed and because of the uranium mill tailings pile located adjacent to the Colorado River near Moab, Utah. Since 1997, perchlorate has been monitored quarterly at select locations at Metropolitan's source and finished waters because of concern about contamination from the Henderson, Nevada area. Perchlorate has become a routine constituent, which is monitored quarterly (see **Table 3-4**) and more frequently (typical monthly) at Metropolitan's Whitsett Intake. SVOCs and pesticides are monitored the required two times in one-year of a three-year period.

Several constituents of interest were monitored at various times from the source and treated waters. NDMA, used in the production of rocket fuel, has also become a constituent of concern and monitoring has been conducted routinely since 2000. The solvent 1,4-dioxane was detected in some groundwater by DDW in 1998 and monitoring of Metropolitan's source water was subsequently conducted. The fuel oxygenates MTBE, *tert*-amyl methyl ether, and ethyl *tert*-butyl ether have been incorporated into Metropolitan's routine VOC monitoring program. The fuel oxygenate byproduct *tert*-butyl alcohol was also monitored in the source water.

Metropolitan also maintains a proactive monitoring program for taste and odor control. Samples are analyzed by a group of trained panelists by the flavor profile analysis (FPA) technique. At least once each week, the FPA panel monitors treatment plant samples. In addition, the treatment plant laboratory personnel conduct daily FPA screenings. Threshold odor numbers are determined annually for compliance with the secondary standard for odor.

Table 3-3. Metropolitan's Compliance and Voluntary Monitoring Schedule, 2011-2015

	Compliance Cycle (2011-2019)																			
	1ST Compliance Period												2nd Compliance Period							
	1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR	1st QTR	2nd QTR	3rd QTR	4th QTR
	2011				2012				2013				2014				2015			
Volatile Organic Compounds	C					C					C					C	C			
Synthetic Organic Compounds						C		C										C		C
Inorganic Chemicals																				
Asbestos			C																	
Cyanide		C				C				C				C				C		
Fluoride†		C		V		C		V		C		V		C		V		C		V
General Mineral/ General Physical		C		V		C		V		C		V		C		V		C		V
Chromium-6		V				V				V				V	C			C		
Lead and Copper*			C												C					
MBAS		C				C				C				C				C		
Nitrite		C				V				V				C				V		
Nitrate		C				C				C				C				C		
Odor Threshold		C				C				C				C				C		
Perchlorate		C				C				C				C				C		
Trace Metals#		C				C				C				C				C		
Radiological																				
Gross Alpha	C	C	C	C									C	C	C	C				
Gross Beta	C	C	C	C									C	C	C	C				
Radium 226/228	C	C	C	C									C	C	C	C				
Strontium-90	C	C	C	C									C	C	C	C				
Tritium	C	C	C	C									C	C	C	C				
Uranium	C	C	C	C									C	C	C	C				

* Lead and copper is only performed in Metropolitan's domestic water systems – see Small Systems Monitoring Plan for details
# Aluminum will be analyzed and reported monthly for the treatment plant effluent when alum is used as the coagulant
† Additional fluoride monitoring at the treatment plant effluents is reported under Metropolitan's Fluoride Plan
C Compliance monitoring
V Voluntary monitoring

Table 3-4. Metropolitan's Compliance Monitoring Requirements

Compound Group	Initial Monitoring		Follow-up Monitoring	
	Frequency	Effective	Frequency	Effective
Volatile Organic Compounds				
	Quarterly	Jan. 1988/Jan. 1996	Annually	Jan. 2005
Synthetic Organic Compounds				
Pesticides	Quarterly	Jan. 1993–94	2x/period[1]	Jan. 1996
Semi-volatile organics	Quarterly	Jan. 1994	2x/period[1]	Jan. 1996
Inorganic Constituents				
Asbestos	1x/cycle	Jan. 1993	1x/cycle	Jan. 2002
Cyanide	Annually	Jan. 1993	Annually	Jan. 1994
Fluoride	Annually	Jan. 1993	Annually	Jan. 1994
General Minerals	Annually	Jan. 1993	Annually	Jan. 1994
Nitrate	Quarterly	Jan. 1993	Annually[2]	Jan. 1994
Nitrite	1x/period	Jan. 1993	1x/period	Jan. 1996
Perchlorate	Quarterly	2001–2002	Annually	Oct. 2007
Trace Elements	Annually	Jan. 1993	Annually[2]	Jan. 1994
Radiological				
Gross alpha, Ra 226/228	Quarterly	2002–2003	4x/Period[1]	2005–2006
Gross beta	Quarterly	2005–2006	4x/Period[1]	2006
Tritium/Strontium-90	Annually	2005–2006	1x/Period[1]	2006
Uranium	Quarterly	2002–2003	4x/Period[1]	2005–2006
Secondary Standards				
Foaming Agents	Annually	Jan. 1993	Annually	Jan. 1994
General Physical	Annually	Jan. 1993	Annually	Jan. 1994
Odor Threshold	Annually	Jan. 1993	Annually	Jan. 1994
Chloride/Sulfate	Annually	Jan. 1993	Annually	Jan. 1994
State UCMR				
Boron	Quarterly	2002	Not Required	
Chromium-6	Quarterly	2001–2002	Annually	Jul. 2014
Vanadium	Quarterly	2002	Not Required	
Dichlorodifluoromethane	Quarterly	2002–2003	Not Required	
Gasoline additives	Quarterly	2002–2003	Not Required	
1,2,3-trichloropropane	Quarterly	2002–2003	Not Required	
Federal UCMR 1 – List 1	Quarterly[3]	2001–2003	Not Required	
Federal UCMR 2 – List 1/2	Quarterly[3]	2008–2010	Not Required	
Federal UCMR 3 – List 1/2/3	Quarterly[3]	2013–2015	Not Required	

UCMR – unregulated contaminant monitoring regulation

* Includes compounds on DDW's unregulated chemicals required monitoring list.

1 Monitoring must occur one time, two times, or four times in one year of a three-year period.

2 Nitrate monitoring reduced to annually since all quarterly results < 50% of the MCL in 2011.

3 Monitoring must occur in 4 consecutive quarters (List 1 and List 2) or twice (List 3), during one consecutive 12-month period; the next stage of the Federal UCMR process will be implemented when promulgated.

Table 3-5. Metropolitan's Compliance Reporting Schedule by Location

	Primary Station Code	VOC†	Synthetic Organic Chemicals	Asbestos	General Mineral & Physical*	Fluoride	Nitrate	Nitrite, Cyanide, Foaming Agents & Odor	Trace Elements & Chromium-6	Radiological	Perchlorate
Diamond Valley Lake	024	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual	Annual	Annual	Annual	Annual	4x/1yr in a 3-yr period	Annual
Lake Havasu Near Intake	007	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual	Annual	Annual	Annual	Annual	4x/1yr in a 3-yr period	Annual
Lake Mathews Headworks	008	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual	Annual	Annual	Annual	Annual	4x/1yr in a 3-yr period	Annual
Lake Skinner Outlet Conduit	012	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual	Annual	Annual	Annual	Annual	4x/1yr in a 3-yr period	Annual
San Jacinto West Portal	015	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual	Annual	Annual	Annual	Annual	4x/1yr in a 3-yr period	Annual
Diemer Plant Effluent	003	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual**	Annual***	Annual	Annual	Annual#	4x/1yr in a 3-yr period	Annual
Skinner Reservoir Effluent	026	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual**	Annual***	Annual	Annual	Annual#	4x/1yr in a 3-yr period	Annual
Weymouth Plant Effluent	020	Annual	2x/1 yr in a 3-yr period	1x/yr in a 9-yr period	Semi-annual**	Annual***	Annual	Annual	Annual#	4x/1yr in a 3-yr period	Annual

† Includes 1,2,3-TCP
* Color reported annually
** Monthly composite samples/results except for color
*** Fluoride also reported monthly under Metropolitan's Fluoride Plan
\# Aluminum reported monthly when alum used as coagulant

Table 3-6 shows the analytical methods used for each constituent. Most of the analyses are conducted at Metropolitan's Water Quality Laboratory in La Verne. Methods (e.g., pesticides, dioxin, asbestos, radiological, and cyanide) that are more cost effective to contract out are conducted by accredited commercial laboratories.

Table 3-6. Analytical Methods for Compounds to be Monitored (Regulated, Required Unregulated, and Non-Required Unregulated)

Compound	USEPA Method	SM Method	Methodology
VOLATILE ORGANICS			
Benzene	524.2		PT/GCMS
Bromobenzene	524.2		PT/GCMS
Bromochloromethane	524.2		PT/GCMS
Bromodichloromethane	524.2		PT/GCMS
Bromoform	524.2		PT/GCMS
Bromomethane	524.2		PT/GCMS
n-Butylbenzene	524.2		PT/GCMS
sec-Butylbenzene	524.2		PT/GCMS
tert-Butylbenzene	524.2		PT/GCMS
Carbon Disulfide	524.2		PT/GCMS
Carbon Tetrachloride	524.2		PT/GCMS
Chlorodibromomethane	524.2		PT/GCMS
Chloroethane	524.2		PT/GCMS
Chloroform	524.2		PT/GCMS
Chloromethane	524.2		PT/GCMS
o-Chlorotoluene	524.2		PT/GCMS
p-Chlorotoluene	524.2		PT/GCMS
Dibromomethane	524.2		PT/GCMS
1,2-Dichlorobenzene	524.2		PT/GCMS
1,3-Dichlorobenzene	524.2		PT/GCMS
1,4-Dichlorobenzene	524.2		PT/GCMS
1,1-Dichloroethane	524.2		PT/GCMS
1,2-Dichloroethane	524.2		PT/GCMS
1,1-Dichloroethene	524.2		PT/GCMS
cis-1,2-Dichloroethene	524.2		PT/GCMS
trans-1,2-Dichloroethene	524.2		PT/GCMS
1,1-Dichloropropene	524.2		PT/GCMS
1,2-Dichloropropane	524.2		PT/GCMS
1,3-Dichloropropane	524.2		PT/GCMS
2,2-Dichloropropane	524.2		PT/GCMS
1,3-Dichloropropene	524.2		PT/GCMS
Ethylbenzene	524.2		PT/GCMS
Hexachlorobutadiene	524.2		PT/GCMS
Hexachloroethane	524.2		PT/GCMS
Isopropylbenzene	524.2		PT/GCMS
p-Isopropyltoluene	524.2		PT/GCMS
Methylene chloride (dichloromethane)	524.2		PT/GCMS
Methyl *tert*-butyl ether (MTBE)	524.2		PT/GCMS
Methyl ethyl ketone (MEK)	524.2		PT/GCMS

Compound	USEPA Method	SM Method	Methodology
Methyl isobutyl ketone (MIBK)	524.2		PT/GCMS
Monochlorobenzene	524.2		PT/GCMS
Naphthalene	524.2		PT/GCMS
n-Propylbenzene	524.2		PT/GCMS
Styrene	524.2		PT/GCMS
1,1,1,2-Tetrachloroethane	524.2		PT/GCMS
1,1,2,2-Tetrachloroethane	524.2		PT/GCMS
Tetrachloroethene	524.2		PT/GCMS
Toluene	524.2		PT/GCMS
1,2,3-Trichlorobenzene	524.2		PT/GCMS
1,2,4-Trichlorobenzene	524.2		PT/GCMS
1,1,1-Trichloroethane	524.2		PT/GCMS
1,1,2-Trichloroethane	524.2		PT/GCMS
Trichloroethene	524.2		PT/GCMS
Trichlorofluoromethane (Freon 11)	524.2		PT/GCMS
1,1,2-Trichloro-1,2,2-tri-fluoroethane (Freon 113)	524.2		PT/GCMS
1,2,4-Trimethylbenzene	524.2		PT/GCMS
1,3,5-Trimethylbenzene	524.2		PT/GCMS
Vinyl chloride	524.2		PT/GCMS
Xylenes	524.2		PT/GCMS
SYNTHETIC ORGANICS			
Alachlor	507		LLE/GC
Aldicarb	531.1		HPLC
Aldicarb sulfone	531.1		HPLC
Aldicarb sulfoxide	531.1		HPLC
Aldrin	508 or 525.2		LLE/GC or SPE/GCMS
Atrazine	507, 508.1, or 525.2		LLE/GC or SPE/GCMS
Baygon	531.1		HPLC
Bentazon	515.1		LLE/GC
Benzo(a)pyrene	525.2		SPE/GCMS
α-BHC	508		LLE/GC
β-BHC	508		LLE/GC
δ-BHC	508		LLE/GC
Bromacil	507		LLE/GC
Butachlor	507		LLE/GC
Carbaryl	531.1		HPLC
Carbofuran	531.1		HPLC
Chlordane	508 or 525.2		LLE/GC or SPE/GCMS
Chlorothalonil	508		LLE/GC
2,4-D	515.1 or 515.2		LLE/GC
4,4'-DDD	508		LLE/GC
4,4'-DDE	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
4,4'-DDT	508, 508.1, or 525.2		LLE/GC or SPE/GCMS

Compound	USEPA Method	SM Method	Methodology
Dalapon	515.1		LLE/GC
Diazinon	526		SPE/GCMS
Dibromochloropropane (DBCP)	504.1		LLE/GC
Dicamba	515.1 or 515.2		LLE/GC
Dieldrin	508 or 525.2		LLE/GC or SPE/GCMS
Di(2-ethylhexyl)adipate	525.2		SPE/GCMS
Di(2-ethylhexyl)phthalate	525.2		SPE/GCMS
Dimethoate	507		LLE/GC
Dinoseb	515.1 or 515.2		LLE/GC
Diquat	549.1		HPLC
Endosulfan I	508		LLE/GC
Endosulfan II	508		LLE/GC
Endosulfan sulfate	508 or 525.2		LLE/GC or SPE/GCMS
Endothall	548.1		SPE/GCMS
Endrin	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Endrin Aldehyde	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Ethylene dibromide (EDB)	504.1		LLE/GC
Glyphosate	547		HPLC
Heptachlor	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Heptachlor epoxide	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Hexachlorobenzene	508 or 525.2		LLE/GC or SPE/GCMS
Hexachlorocylopentadiene	508		LLE/GC
3-Hydroxycarbofuran	531.1		HPLC
Lindane	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Methiocarb	531.1		HPLC
Methomyl	531.1		HPLC
Methoxychlor	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Metolachlor	507		LLE/GCMS
Metribuzin	507 or 525.2		LLE/GC or SPE/GCMS
Molinate	507 or 525.2		LLE/GC or SPE/GCMS
Naled	507		LLE/GC
Oxamyl	531.1		HPLC
Pentachlorophenol	515.1 or 515.2		LLE/GC
Picloram	515.1 or 515.2		LLE/GC
Polychlorinated Biphenyls (PCBs)	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
Prometryn	507		LLE/GC
Propachlor	508 or 525.2		LLE/GC or SPE/GCMS
Simazine	507		LLE/GC
2,3,7,8-TCDD (Dioxin)	1613		High resolution GCMS
2,4,5-TP (Silvex)	515.1 or 515.2		LLE/GC

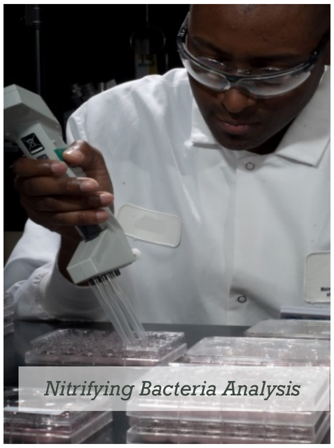
Compound	USEPA Method	SM Method	Methodology
Thiobencarb	507		LLE/GC
Toxaphene	508, 508.1, or 525.2		LLE/GC or SPE/GCMS
RADIOLOGICALS			
Gross alpha	900.0	7110 C	Evaporation/Co-precipitation
Gross beta	900.0	7110 B	Evaporation
Radium-226†	903.1/903.0	7500-Ra C 7500-Ra B	Radon emanation/co-precipitation
Radium-228†	904.0, Ra05	7500-Ra D	Radiochemical
Radon-222		7500- Rn	Liquid scintillation
Strontium-90	905.0	7500-Sr	Radiochemical
Tritium	906.0	7500-^{3}H B	Liquid scintillation
Uranium	908.0, 200.8	7500-U B	Radiochemical, ICP-MS
INORGANIC COMPOUNDS			
Asbestos	100.2		Transmission electron microscopy
Cyanide	335.4		Spectrophotometric
Fluoride	300.0		IC
Alkalinity		2320B	Titrimetric
Bicarbonate			Calculated
Bromide	300.0		IC
Carbonate			Calculated
Calcium		3500Ca-B, 3111B	Flame AA
Chromium-6	218.6/218.7		IC
Magnesium		3111B	Flame AA
Perchlorate	314.0/332.0		IC
Potassium		3111B	Flame AA, Titrimetric
Silica		4500-Si D	Spectrophotometric
Sodium		3111B	Flame AA
Total hardness		2340 B/C	Calculation/titration
pH		4500-H^{+} B	Electrometric
Nitrate (as nitrogen)	300.0		IC, IC-MS
Nitrite (as nitrogen)		4500-NO2-B	Spectrophotometric
Nitrate + Nitrite (sum as nitrogen)			Calculation
Trace Elements			
Aluminum	200.8		ICP-MS
Antimony	200.8		ICP-MS
Arsenic	200.8		ICP-MS
Barium	200.8		ICP-MS
Beryllium	200.8		ICP-MS
Cadmium	200.8		ICP-MS
Chromium	200.8		ICP-MS
Copper	200.8		ICP-MS
Lead	200.8		ICP-MS
Mercury	200.8		ICP-MS
Molybdenum	200.8		ICP-MS

Compound	USEPA Method	SM Method	Methodology
Nickel	200.8		ICP-MS
Selenium	200.8		ICP-MS
Thallium	200.8		ICP-MS
SECONDARY STANDARDS			
Foaming Agents (MBAS)		5540 C	Spectrophotometric
Chloride	300.0		IC
Color		2120 B	Visual comparison
Corrosivity		2330 B	Corrosion index calculation
Iron		3111 B	Atomic absorption, flame
Manganese	200.8		ICP-MS
Silver	200.8		ICP-MS
Specific conductance (micromhos/cm)		2510 B	Platinum electrode
Sulfate	300.0		IC
Total filterable residue – total dissolved solids (TDS)		2540 C	Gravimetric
Turbidity		2130 B	Nephelometric method
Zinc	200.8		ICP-MS
Odor threshold		2150 B	Sensory
STATE UNREGULATATED			
Boron	200.8		ICP-MS
Dichlorodifluoromethane	524.2		PT/GCMS
Ethyl *tert*-butyl ether (ETBE)	524.2		PT/GCMS
tert-amyl methyl ether (TAME)	524.2		PT/GCMS
tert-butyl alcohol (TBA)	524.2		PT/GCMS
1,2,3-Trichloropropane	524.2M		PT/GCMS - modified
Vanadium	200.8		ICP-MS

Flame AA – Atomic absorption, flame
IC – ion chromatography
ICP-MS – inductively coupled plasma/mass spectrometry
LLE/GC - liquid/liquid extraction with gas chromatography
PT – purge and trap
PT/GC/MS – purge and trap gas chromatograph/mass spectrometry
SPE/GC/MS – solid phase extraction with gas chromatography/mass spectrometry
SM - Standard Methods for the Examination of Water and Wastewater, 19th & 20th Edition

Microbiological Monitoring Program

Coliforms


Nitrifying Bacteria Analysis

Total coliform and *E. coli* samples are collected monthly at the Whitsett Intake Pumping Plant influent, Lake Mathews (headworks), Diamond Valley Lake, and Lake Skinner; weekly at the water treatment plant influents; and daily at the treatment plant effluents. Metropolitan has monitored total coliform, fecal coliform, and *E. coli* at the influents to its water treatment plants and reported these results to DDW since 2002. In the distribution system, Metropolitan has sampled an average of 780 samples per month—significantly more than the minimum number of samples (480) required by USEPA for compliance with the Total Coliform Rule.

Metropolitan analyzes source water samples by the membrane filtration (MF) method recovered on MI medium (USEPA 1604) for total coliform and *E. coli* detection. The MF-MI method typically has higher recovery efficiency for total coliform than the multiple-tube-fermentation (MTF) method, the industry standard. As per agreement with DDW in 2006, the primary indicator for the microbial quality of water for Metropolitan's source water monitoring was changed to *E. coli* instead of total coliform, with a trigger level for *E. coli* of 100 CFU per 100 mL. If the trigger level for *E. coli* is exceeded, operational changes, such as operating from a different outlet tier, going on reservoir or lake bypass, or changing the source water blend, will be made.

Pathogens

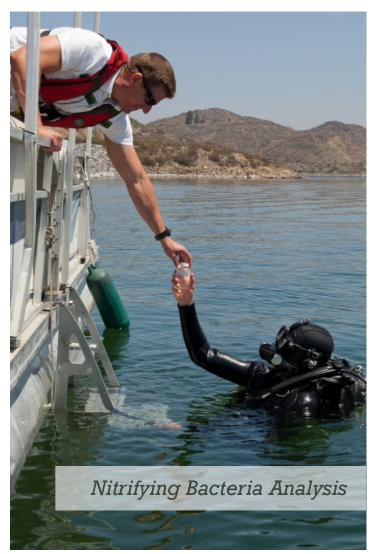
Metropolitan is monitoring for *Cryptosporidium, E. coli*, and turbidity for compliance monitoring under Round 2 of the LT2ESWTR, which began in April 2015 and will be completed in March 2017.

During the period from October 2006 to September 2008, monthly monitoring of treatment plant influents was mandated and reported under the Round 1 LT2ESWTR. As required by the rule, 24 monthly samples were analyzed using USEPA Method 1623 for each of Metropolitan's treatment plants. Turbidity and *E. coli* concentrations (USEPA Method 1604) were also monitored. *Cryptosporidium* oocysts were not detected in the influents of plants treating Colorado River water. Therefore, the plants were classified as Bin 1 under Round 1 LT2ESWTR, and required no additional treatment for compliance with regulations.

Monthly source water monitoring for *Giardia* and *Cryptosporidium* was initiated in July 2004 for San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, and Diamond Valley Lake, but was terminated in 2010. Metropolitan's pathogen monitoring program includes monthly monitoring of water treatment plant influents for *Giardia* and *Cryptosporidium*. The pathogen monitoring program uses an immunofluorescence microscopy assay for *Cryptosporidium* and *Giardia* as required by USEPA Method 1623 or 1623.1 (USEPA 815-R-05-002) with results expressed as oocysts or cysts per 10 L.

Reservoir Monitoring Program

In addition to compliance monitoring, Metropolitan has developed a reservoir monitoring program to evaluate long-term limnologic changes in the water quality of the source water reservoirs and to provide a continuous status report on current conditions. The monitoring program serves as an early warning system for water quality degradation events, e.g., off-flavors, contamination, turbidity excursions, and oxygen depletion. When the early warning system detects excursions from the norm, resources can be rapidly allocated to analyze the event and develop an appropriate response.



Nitrifying Bacteria Analysis

The reservoir monitoring program includes manual and automated electronic vertical profiles. A variety of physical, chemical, and biological constituents are measured at one-meter intervals. These constituents include (but are not limited to) temperature, dissolved oxygen, pH, and conductivity. Manual lake profiles are generated monthly at Lake Havasu, Lake Mathews, Lake Skinner, and Diamond Valley Lake unless water quality events require more frequent monitoring. Automated remote water quality monitoring platforms conduct daily profiles at Lake Mathews, Lake Skinner, and Diamond Valley Lake. The electronic profile data are immediately downloaded, plotted, and posted internally for evaluation.

Chemical profiles are collected from the reservoirs listed above on a monthly basis. Samples are collected at various depths using a Kemmerer sampler, and dispensed into the appropriate sample containers. The samples are placed on ice and returned to the Water Quality Laboratory for analysis. Analytes include (but are not limited to) nitrate, nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, soluble reactive phosphorus, ammonia, pH, conductivity, turbidity, alkalinity, chlorophyll-*a*, total organic carbon, dissolved organic carbon, UV absorbance, volatile organic compounds and trace metals. Trace metals are collected with disposable samplers to avoid contamination.

Light profiles are conducted monthly at each reservoir to measure the photosynthetically active radiation (PAR) available to algae and cyanobacteria throughout the water column. PAR values are read at one-meter intervals using LI-COR Underwater Quantum Sensors. Data are stored electronically and transferred to a database immediately upon return to the laboratory.

Zooplankton samples are collected at monthly intervals to track community structure and changes in biomass as a general indicator of overall biological activity. Three vertically integrated samples are collected by pulling a 63-micron mesh plankton net through each of three 6-meter thick strata (0–6 m, 6–12 m, 12–18 m). Analysis of zooplankton populations is performed by gravimetric analysis and identification of the zooplankton into broad categories (e.g., large and small *Daphnia*) is done by stereoscope.

Monitoring of phytoplankton populations is performed with the goal of identifying potentially problematic species. These organisms may cause turbidity, pH shifts, off-flavors, filter clogging, toxicity and, upon death and decomposition, severe oxygen depletion. Cyanobacteria (blue-green algae) that produce off-flavors and/or cyanotoxins are of the greatest concern. Phytoplankton samples are collected at various depths using Kemmerer samplers and net tows are made from a depth of 20 meters. Phytoplankton profiles and net tows are collected monthly and as needed during a bloom. Metropolitan has also developed an extensive benthic algae and cyanotoxin monitoring program. Divers locate benthic cyanotoxin growth and collect samples for microscopic examination in the laboratory. Samples are collected by lifting small pieces of cyanotoxins from the sediment or rock and placing them in plastic sample bottles. Divers also collect samples just above the benthic algae mats for taste and odor (T&O) analysis.

Metropolitan has a long history of T&O issues in its source waters, especially with geosmin and 2-methylisoborneol (MIB). These compounds are produced by both planktonic and benthic cyanobacteria. Samples are collected monthly for these T&O compounds from various sites and depths to characterize the water column. Treatment plant influent and effluent samples are collected at a greater frequency (weekly) to enhance the early warning aspects of the program and to track the aesthetic quality of the water received by customers. All of these routine samples are part of an early warning system to detect T&O production well before it results in consumer complaints. These samples are evaluated using solid phase micro extraction (SPME) and Flavor Profile Analysis (FPA) at Metropolitan's Water Quality Laboratory. USEPA regulates taste and odors as a secondary aesthetic standard with a TON (threshold odor number) of 3. These odors do not constitute a health threat, but they potentially can reduce consumer confidence in the quality of drinking water.

While there are no federal water quality criteria or regulations for cyanotoxins in drinking water or raw surface waters, USEPA's Office of Water has listed cyanobacteria and cyanotoxins on drinking water Candidate Contaminant Lists (CCLs) and the fourth Unregulated Contaminant Monitoring Regulation (UCMR 4). USEPA included ten cyanotoxin chemical contaminants on UCMR 4, published on December 20, 2016, which require monitoring between 2018 and 2020. Metropolitan continues to address the issue of cyanotoxins in sources of drinking water through participation in regional and national workgroups, technical advisory committees, regular interaction with DDW, and communication with member agencies, including delivering specialist workshops on cyanotoxins in 2015. Metropolitan's Water Quality Laboratory monitors for microcystins in source waters during significant bloom events and continues to refine and evaluate cyanotoxin detection methods, as described in an upcoming publication, Analysis of Microcystins in Drinking Water by ELISA and LC/MS/MS [21].

Evaluation of Selected Constituents

Based on previous CRWSS updates, as well as ongoing water quality and source water protection work at Metropolitan, various constituents of concern were selected for evaluation in the CRWSS 2015 Update. These constituents included inorganic compounds (i.e., aluminum, boron, chromium-6, perchlorate, TDS, and the nutrients total phosphorus and nitrate), radionuclides (i.e., uranium, radium, and gross alpha and gross beta emitters), turbidity, organic compounds (i.e., TOC, NDMA, and PPCPs), and microbiological constituents (i.e., total coliform, *E. coli*, *Giardia*, and *Cryptosporidium*). A discussion of each of these constituents of interest is presented below.

Inorganic Compounds

Aluminum

Aluminum has been selected for evaluation since the CRWSS 2005 Update based on its inclusion on USEPA's Drinking Water CCL [22] and the fact that Metropolitan's water treatment plants use aluminum sulfate (alum) for coagulation that may contribute to aluminum in the finished water effluent. Aluminum is the third most abundant element in the Earth's crust and occurs naturally in soil and water. High levels in the environment can be caused by the mining and processing of aluminum ores or the production of aluminum metal, alloys, and compounds.

Aluminum is generally considered nontoxic in water, except at very high doses. Some toxicity can be traced to deposition in bone and the central nervous system, a process that is increased in patients with reduced renal function. Because aluminum competes with calcium for adsorption, increased amounts of dietary aluminum may contribute to the reduced skeletal mineralization (osteopenia) observed in preterm infants and infants with growth retardation. Recent studies have suggested that aluminum is a potential neurotoxin, though definitive studies are currently unavailable. A small percentage of people are allergic to aluminum and experience contact dermatitis, digestive disorders, vomiting, or other symptoms upon contact or ingestion of aluminum.

DDW has set an aluminum primary standard of 1 mg/L and a secondary aesthetics-based standard of 0.2 mg/L. Aluminum is monitored monthly at Metropolitan's source waters and the treatment plant influents and effluents.

Monitoring Results for Aluminum

Maximum, median, and minimum data for aluminum at all of the monitoring sites are presented in **Table 3-7.** Concentrations in the Colorado River source waters are typically low with levels well below the secondary standard. However, during the rainy season, heavy precipitation causes runoff that may introduce sediments containing aluminum into the source waters. **Figure 3-1** shows increases in aluminum levels at Lake Mathews in November 2014, likely due to local runoff from heavy rains. The highest level of aluminum (0.270 mg/L) in source waters was detected at Lake Mathews from the late 2014 rain events.

Table 3-7. Aluminum Summary for Source Waters, 2011–2015, mg/L

	Minimum	Maximum	Median*
Whitsett Intake	0.011	0.051	0.018
San Jacinto Tunnel West Portal	ND (< 0.010)	0.080	0.016
Lake Mathews	ND (< 0.010)	0.270	0.027
Diamond Valley Lake	ND (< 0.010)	0.035	0.012
Lake Skinner	ND (< 0.010)	0.061	0.020
Diemer Influent	0.013	0.130	0.036
Weymouth Influent	0.010	0.150	0.032

* Median values calculated assuming non-detects (NDs) equaled one-half the MRL
MRL = 0.010 mg/L using USEPA Method 200.8

Because aluminum is primarily associated with particles, it is partially settled out in transit before reaching the water treatment plants. The plant influent aluminum levels during this reporting period ranged from less than 0.010 to 0.150 mg/L (**Figure 3-2**). The maximum aluminum readings at the Diemer and Weymouth plant influents (0.130 mg/L and 0.150 mg/L respectively), corresponded with heavy rain events in early 2011. While particles (and thus particulate aluminum) are removed through the treatment processes at Metropolitan's large treatment plants, the finished water aluminum concentrations are dependent upon the coagulant type (both ferric chloride and alum have been used) and dose, and other operational conditions such as pH adjustment.

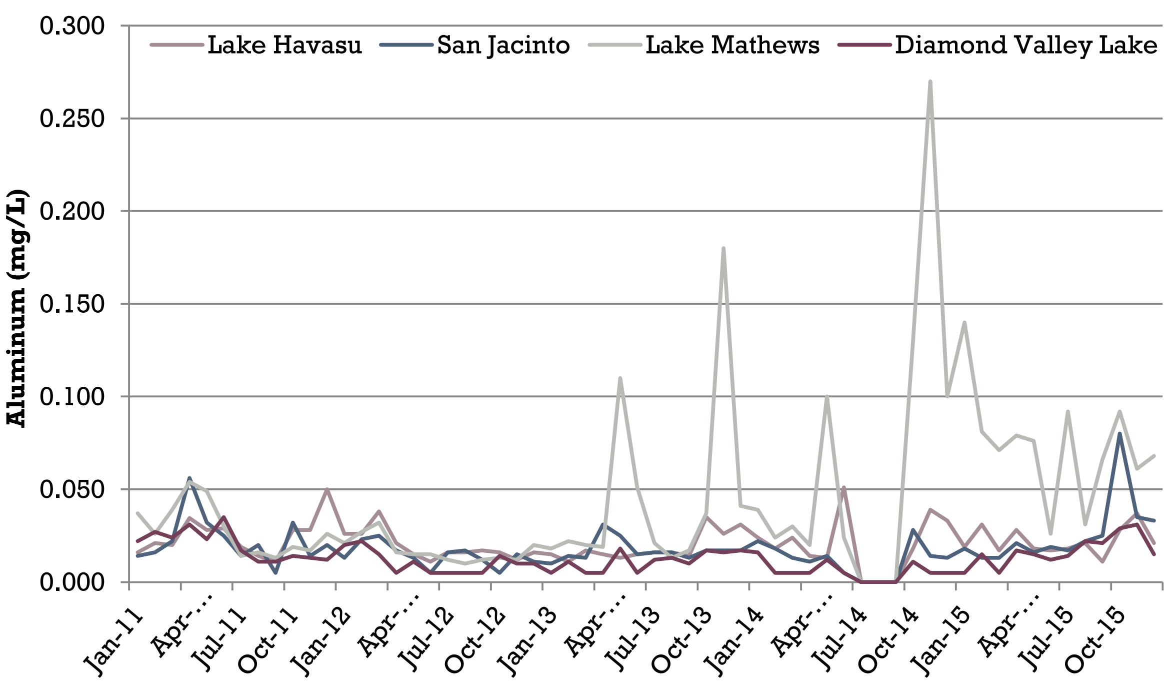


Figure 3-1. Aluminum Levels in Source Waters, 2011–2015

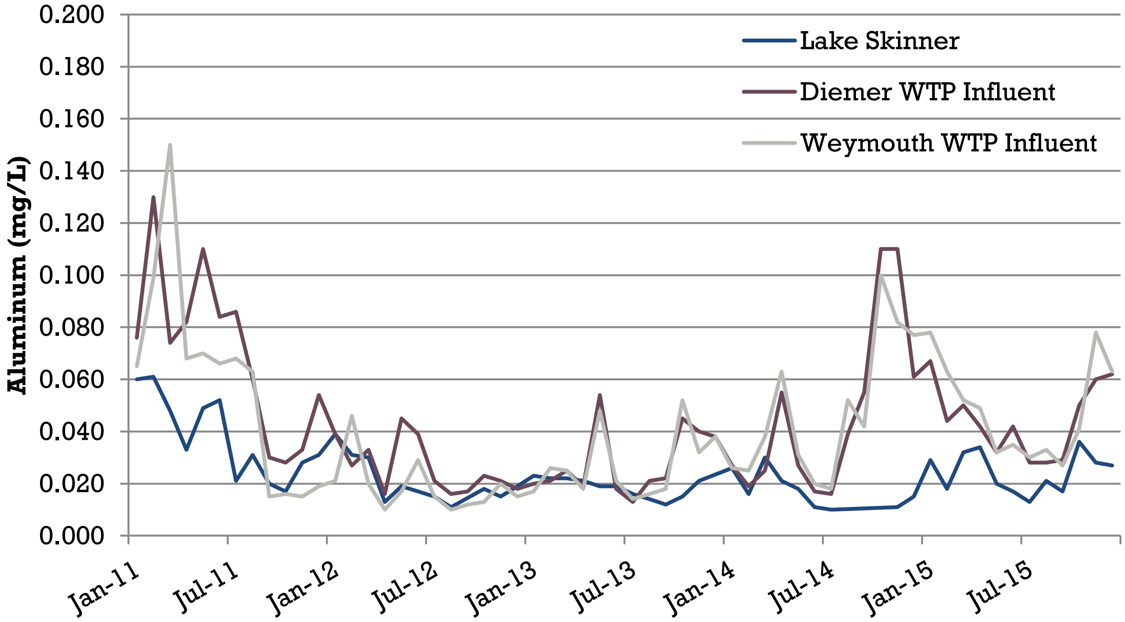


Figure 3-2. Aluminum Levels at Water Treatment Plant Influents, 2011–2015

Summary of Findings for Aluminum

Concentrations in Colorado River source waters are typically low with levels well below the secondary standard. However, in the rainy season, heavy precipitation causes runoff and may introduce sediments containing aluminum into the source waters.

Boron

Boron has been selected for evaluation since the CRWSS 2005 Update based on its inclusion on USEPA's CCL list [22] and based on Metropolitan's member agencies' concerns. Boron is a naturally occurring element that is widespread in nature. Boron in the environment is always found chemically bound to oxygen, usually as alkali or alkaline earth borates or as boric acid. Boric acid and sodium borates are widely used for a variety of industrial purposes. The most important source of exposure for human populations is ingestion of boron from food, primarily fruits and vegetables.

Studies in laboratory animals conducted by oral exposure have identified the developing fetus and the testes as the two most sensitive targets of boron toxicity in multiple species. The developmental effects that have been reported following boron exposure include high prenatal mortality, reduced body weight, and malformations and variations of the eyes, central nervous system, cardiovascular system, and axial skeleton [23].

Currently there is no MCL for boron. The DDW notification level for boron is 1 mg/L. Treatments for boron include ion exchange and reverse osmosis. Conventional treatment, as practiced by Metropolitan, has no effect on boron concentrations.

Monitoring Results for Boron

Boron, as an unregulated chemical, was monitored semi-annually between 2011 and 2015 in all of Metropolitan's source waters (**Table 3-8)**. **Figure 3-3** shows that boron during the reporting period (2011 to 2015) was relatively stable, ranging between 0.09 and 0.17 mg/L.

Table 3-8. Boron Summary for Source Waters, 2011–2015, mg/L

	Minimum	Maximum	Median
Whitsett Intake	0.10	0.13	0.12
San Jacinto Tunnel West Portal	0.09	0.13	0.11
Lake Mathews	0.10	0.14	0.12
Diamond Valley Lake	0.13	0.17	0.14
Lake Skinner	0.10	0.13	0.13

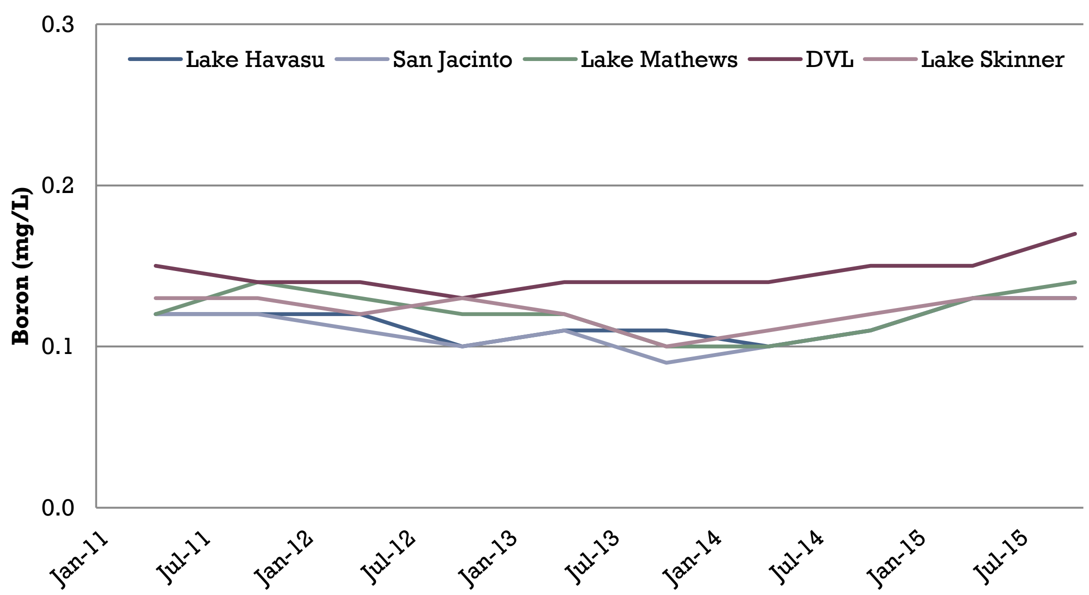


Figure 3-3. Boron Levels in Source Waters, 2011–2015

Summary of Findings for Boron

- Though boron levels appear to be stable, Metropolitan will continue its source water monitoring efforts.
- Levels of boron in Colorado River water are well below the DDW notification level of 1 mg/L.

Chromium-6

Chromium has been selected for evaluation since the 2005 CRWSS, after Metropolitan became aware of a chromium-6 groundwater plume near Pacific Gas and Electric's (PG&E's) Topock Compressor Station near Needles, California in 2003. Chromium is a naturally occurring element, typically found in chrome-iron ore. Average surface water concentrations of total chromium are around 0.000001 mg/L in the United States [24]. Chromium is also used in industrial processes such as mining, electroplating, fossil fuel combustion, wood treatment, pigments, and cooling tower treatment for corrosion control.

Chromium is found in two primary valence states: chromium-3 and chromium-6. Speciation is directly affected by redox potential, with oxidizing conditions resulting in more chromium-6.

Chromium-6 is toxic to cellular tissue and can cause liver and kidney damage. It has been determined to be carcinogenic via the inhalation route, but limited data do not demonstrate that it is carcinogenic via the ingestion route (i.e., from drinking water). Ingesting large amounts of chromium-6 can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death.

In 1977, DDW set a primary MCL for total chromium in drinking water at 0.05 mg/L. USEPA adopted the same standard, but in 1991 raised the federal MCL to 0.1 mg/L. In July 2011, the California Office of Environmental Health Hazard Assessment (OEHHA) announced a final public health goal (PHG) for chromium-6 of 0.00002 mg/L. California adopted a drinking water standard for chromium-6 of 0.010 mg/L effective on July 1, 2014. USEPA is currently conducting human health assessments for chromium-6 and will determine whether to regulate chromium-6 in drinking water beyond the current regulations for total chromium.

The federal- and state-approved technologies for removing total chromium from drinking water include coagulation/filtration, ion exchange, reverse osmosis, and lime softening. Potential treatment technologies for chromium-6 in drinking water may include reduction/chemical precipitation/filtration, ion exchange, or reverse osmosis.

Monitoring Results for Chromium-6

Metropolitan has conducted regular monitoring of its source and treated waters for chromium-6. The peak concentrations at Diamond Valley Lake, Lake Havasu, San Jacinto Tunnel West Portal, and Lake Mathews were all at or below 0.00009 mg/L. Diamond Valley Lake had a detectable median (maximum) concentration of 0.00004 mg/L (0.00009 mg/L) (**Table 3-9**). The water treatment plant influent monitoring at the Diemer and Weymouth plants showed a range of chromium-6 from non-detect (ND; < 0.00003 mg/L) to 0.00016 mg/L. The source of the elevated chromium-6 at Diamond Valley Lake and influents to the Diemer and Weymouth plants was most likely caused by blending of other source waters, most notably from groundwater pump-in programs along the SWP system.

A plume of chromium-6 was discovered in the groundwater near PG&E's Topock Compressor Station near Needles, California in 2003. The plume was a result of past disposal practices of cooling waters from PG&E's gas compressor station. Since 2003, Metropolitan has regularly monitored for chromium-6 around the PG&E site. Metropolitan's sample locations are shown in **Figure 3-4**, with three sampling stations upstream of the site, and three downstream of the gas compressor station. Data contained within brackets ([]) in **Table 3-10** are from piezometers measuring the sediment concentrations of chromium-6 at various locations. As shown in **Table 3-10** and **Figure 3-5**, chromium-6 has been sporadically detected at low levels in Colorado River water, upstream and downstream of the site. All piezometer readings during the reporting period had median levels of non-detect (i.e., less than 0.00003 mg/L). Metropolitan staff closely monitors the progress of this remediation effort, and further information is discussed in **Chapter 6**.

Table 3-9. Chromium-6 Summary for Source Waters, 2011–2015, mg/L

	Minimum	Maximum	Median*
Whitsett Intake	ND (< 0.0003)	0.00005	ND (< 0.0003)
San Jacinto Tunnel West Portal	ND (< 0.0003)	0.00006	ND (< 0.0003)
Lake Mathews	ND (< 0.0003)	0.00004	ND (< 0.0003)
Diamond Valley Lake	ND (< 0.0003)	0.00009	0.00004
Lake Skinner	ND (< 0.0003)	0.00007	ND (< 0.0003)
Diemer Influent	ND (< 0.0003)	0.00014	0.00004
Weymouth Influent	ND (< 0.0003)	0.00016	0.00004

* Median values calculated assuming non-detects (NDs) equaled one-half the RDL
RDL = 0.00003 mg/L using USEPA Method 218.6

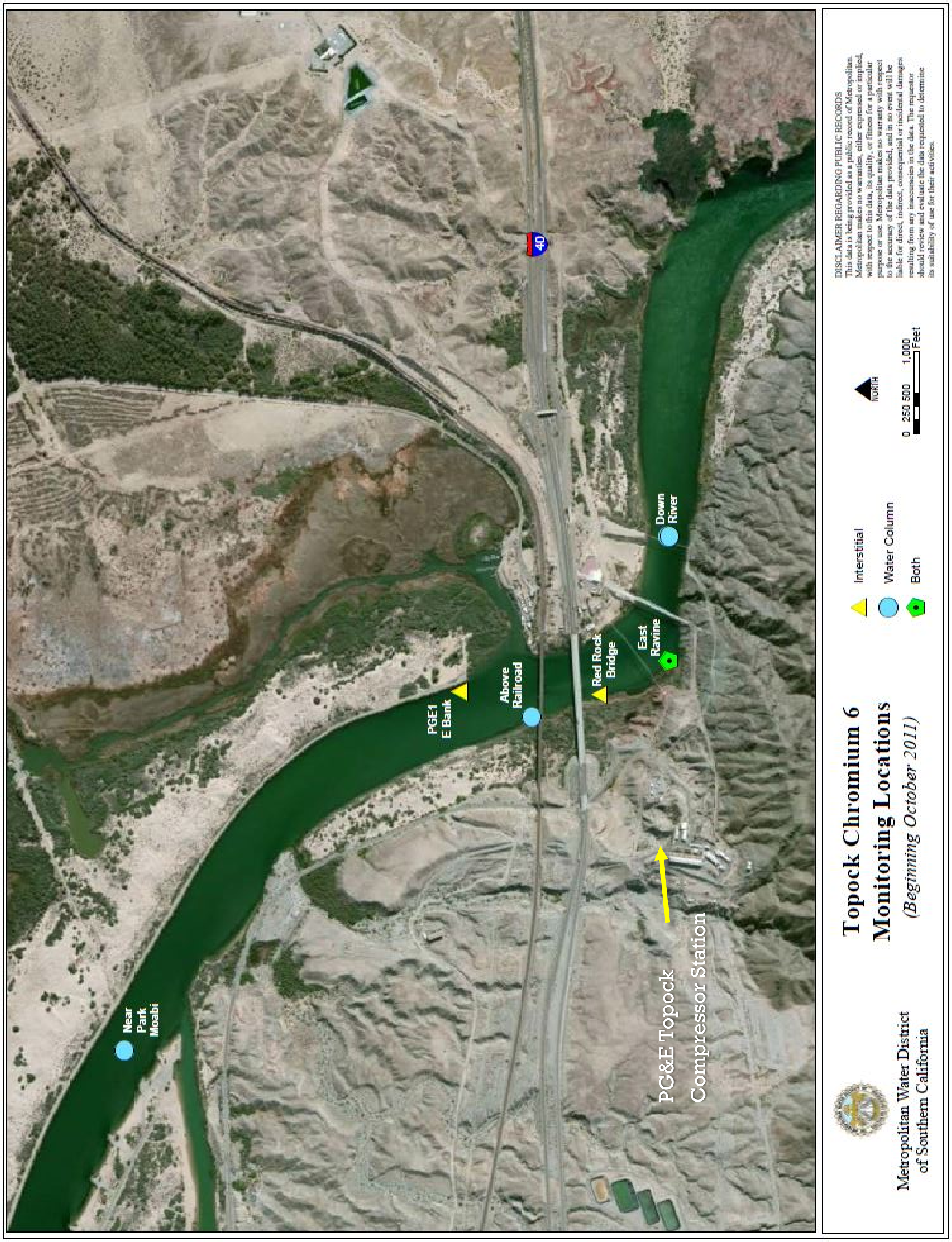


Figure 3-4. Metropolitan's Sampling Points for Chromium-6 near PG&E's Topock Gas Compressor Station

Table 3-10. Chromium-6 Summary in Colorado River near PG&E's Topock Gas Compressor Station, 2011–2015, mg/L

	Minimum	Maximum	Median*
Near Park Moabi	ND (< 0.00003)	0.00005	0.00004
East Ravine	ND (< 0.00003)	0.00005	0.00004
East Ravine (interstitial)	[ND] (< 0.00003)	[ND] (< 0.00003)	[ND] (< 0.00003)
PGE 1 E Bank (interstitial)	[ND] (< 0.00003)	[0.00006]	[ND] (< 0.00003)
Above Railroad	ND (< 0.00003)	0.00006	0.00004
Red Rock Bridge (interstitial)	[ND] (< 0.00003)	[0.05]	[ND] (< 0.00003)
Down River	ND (< 0.00003)	0.00005	0.00004
Whitsett Intake	ND (< 0.00003)	0.00005	0.00003

* Median values calculated assuming non-detects (NDs) equaled one-half the MRL.
Data in brackets ([]) indicate piezometer samples of sediment pore water.

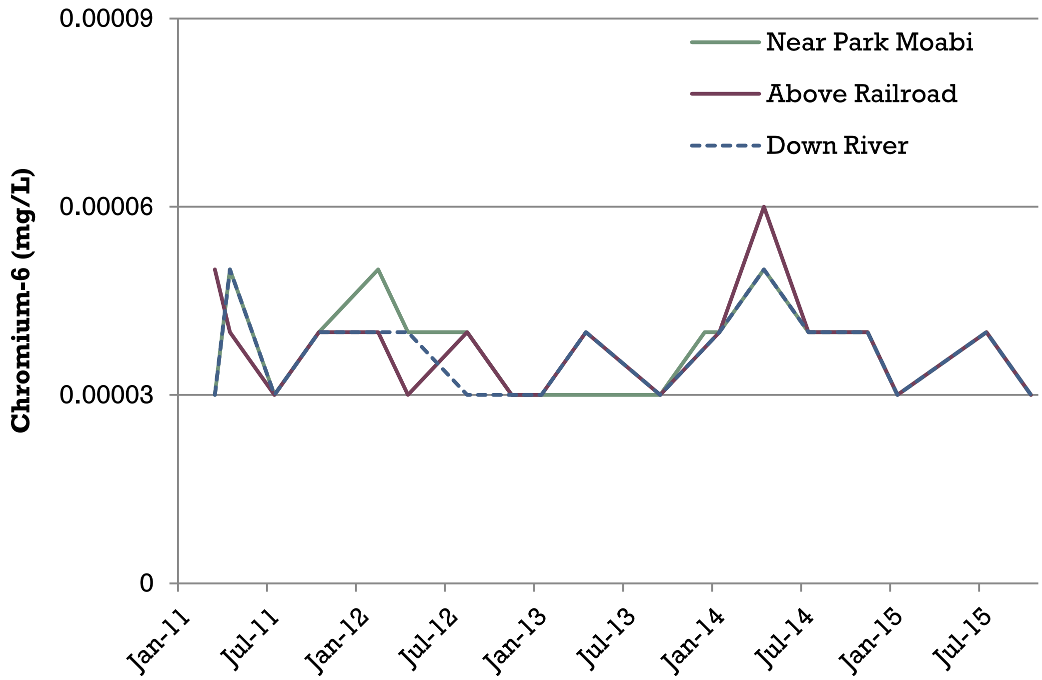


Figure 3-5. Chromium-6 Levels at PG&E's Topock Compressor Station

Summary of Findings for Chromium-6

- Median source water concentrations of chromium-6 are very low—less than 0.0001 mg/L, if even detectable—along the CRA and the terminal reservoirs.
- Concentrations of chromium-6 at water treatment plant influents, Diamond Valley Lake, and Lake Skinner are influenced by blending with other source waters from outside the Colorado River watershed.
- A groundwater plume of chromium-6 exists at PG&E's Topock Compressor Station near Needles, California, adjacent to the Colorado River. Metropolitan has initiated chromium-6 sampling near the site. There have been only minimal low level detections of chromium-6 in Colorado River just

downstream of the site. See **Chapter 6** for further discussion of PG&E's remediation efforts and Metropolitan's involvement in various phases of the project.

Perchlorate

Perchlorate has been selected for evaluation since the CRWSS 2000 Update after it was detected in Colorado River water in June 1997. Perchlorate compounds are used as a main component in solid rocket propellant, and are also found in some types of munitions and fireworks. Perchlorate compounds quickly dissolve and become highly mobile in groundwater. Unlike many other groundwater contaminants, perchlorate neither readily interacts with the soil matrix nor degrades in the environment. Conventional drinking water treatment (as utilized at Metropolitan's water treatment plants) is not effective in removing perchlorate.

The primary human health concern related to perchlorate is its effects on the thyroid. Perchlorate interferes with the thyroid's ability to produce hormones required for normal growth and development. Pregnant women who are iodine deficient and their fetuses, infants and small children with low intake of dietary iodide, and individuals with hypothyroidism may be more sensitive to the effects of perchlorate.

The source of perchlorate contamination in Colorado River water was found to be from a groundwater plume that flowed into Lake Mead via the Las Vegas Wash. The perchlorate plume emanated from a chemical manufacturing facility in Henderson, Nevada, which was owned by Kerr-McGee Corporation and later transferred to Tronox, Inc. Remediation efforts of the perchlorate plume started in 1998 under the oversight of the Nevada Division of Environmental Protection (NDEP). Another large perchlorate groundwater plume is also present in the Henderson area from a second industrial site. Remediation activities at the second site are ongoing by Endeavour, LLC (former American Pacific Corporation).

In January 2009, Tronox filed for Chapter 11 bankruptcy protection citing significant environmental liabilities taken from the previous site owner. Remediation responsibilities have now been assumed by an environmental trust established for the site. In April 2014, Tronox reached a $5.15 billion settlement with its predecessors, which awarded $1.1 billion to the trust to clean up the perchlorate and other contaminants at the former Tronox site. Metropolitan continues to coordinate closely with NDEP and track perchlorate remediation efforts in Henderson, Nevada. Further details about the current remediation efforts and Metropolitan's involvement are presented in **Chapter 6**.

In October 2007, DDW set the MCL for perchlorate at 0.006 mg/L—the same as the PHG previously set by OEHHA in 2004. In February 2015, OEHHA lowered the PHG to 0.001 mg/L. In response to the new PHG, DDW will review the perchlorate MCL and determine if it warrants revision. Perchlorate is currently unregulated by USEPA. However, in February 2011, USEPA announced its decision to regulate perchlorate under the Safe Drinking Water Act (SDWA); USEPA proposes to issue a final rule for perchlorate by December 19, 2019.

Monitoring Results for Perchlorate

In response to the continued release of perchlorate into the Las Vegas Wash, Metropolitan initiated a comprehensive monitoring program for perchlorate at nine sites. Metropolitan initially conducted monthly monitoring (through December 2006), and later switched to quarterly, for perchlorate at the Hoover Dam on Lake Mead, Davis Dam on Lake Mohave, Whitsett Intake at Lake Havasu (Whitsett Intake returned to a monthly frequency), San Jacinto West Portal, Metropolitan's terminal Colorado River reservoirs (Lake Mathews, Diamond Valley Lake, and Lake Skinner), and the influents to the Diemer and

Weymouth plants. Depending on the sample location, either the high-level detection perchlorate method (USEPA Method 314.0; MRL 0.004 mg/L until September 2003 and MRL 0.002 mg/L until January 2007) or the low-level perchlorate method (USEPA Method 332; MRL 0.0001 mg/L since January 2007) were used.

Figure 3-6 shows perchlorate loading in the Las Vegas Wash at the Northshore Road Bridge. Continued remediation efforts at the contamination site have led to perchlorate loadings entering Lake Mead to decline from approximately 1,000 lbs per day in January 1998 to between 47 and 102 lbs per day since 2007. Sampling at Metropolitan's Whitsett Intake on Lake Havasu shows the perchlorate is diluted prior to entering Metropolitan's system and that perchlorate concentrations have trended downward (**Figure 3-7**). It should be noted that the MRL for perchlorate for Whitsett Intake samples was reduced from 0.004 to 0.002 mg/L in September 2003 and further reduced to 0.0001 mg/L in January 2007.

Metropolitan evaluated perchlorate levels at various depths in Lake Mead near the Hoover Dam (**Figure 3-8**). Quarterly monitoring for perchlorate showed the highest concentrations occurring in the near-surface waters. The highest perchlorate measurement was 0.0043 mg/L in August 2015 and occurred at a depth of 0-5 meters. The late summer months of August and September typically have the highest concentrations due to stratification in Lake Mead that confines the inflowing perchlorate in the epilimnion in the spring, summer, and fall. Metropolitan is less impacted by the peak concentrations found in the epilimnion, as water leaving Lake Mead is typically drawn out from the hypolimnion. At the depth where water is drawn out of Lake Mead, the median and maximum concentrations of perchlorate were both non-detectable (ND; < 0.0001 mg/L).

Table 3-11 provides a summary of the quarterly data in Colorado River water during the reporting period. Perchlorate data at Davis Dam, Lake Havasu, the San Jacinto Tunnel West Portal, Lake Mathews, Diamond Valley Lake, Lake Skinner, and the plant influents for the Diemer and Weymouth plants showed levels well below the California MCL of 0.006 mg/L, throughout the reporting period. Perchlorate is not found in the SWP and the practice of blending Colorado River water with SWP water further reduces perchlorate levels at the water treatment plant influents.

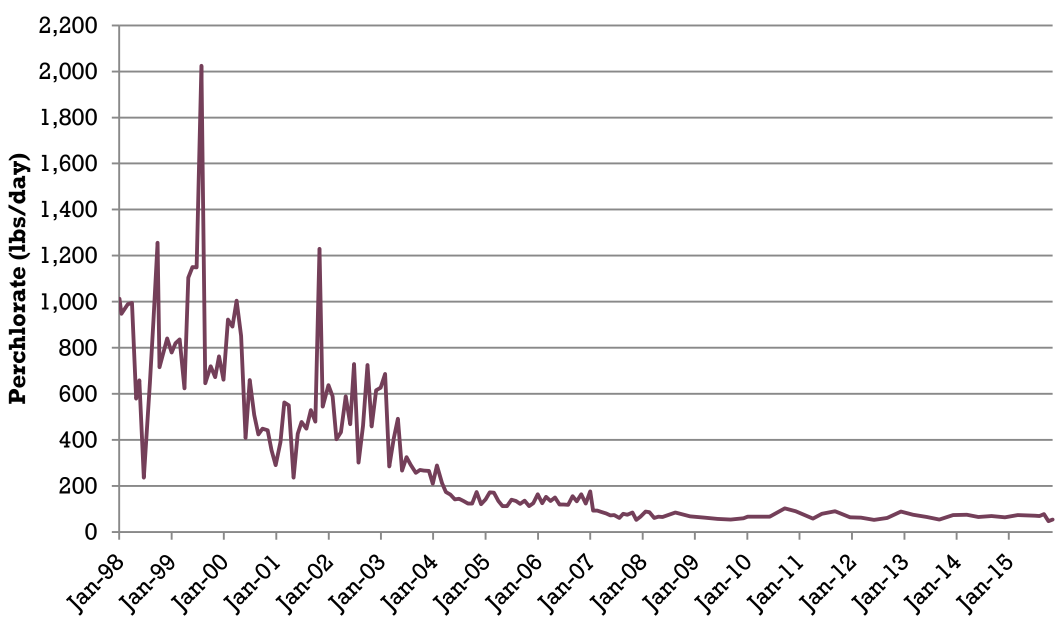


Figure 3-6. Historical Perchlorate Loading into Las Vegas Wash

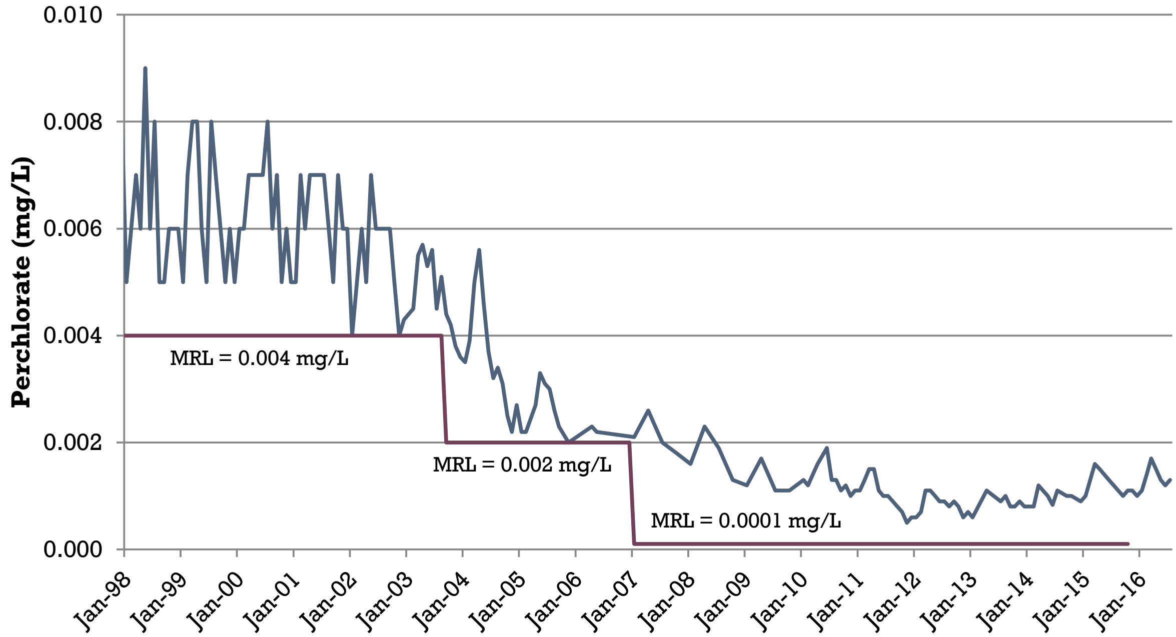
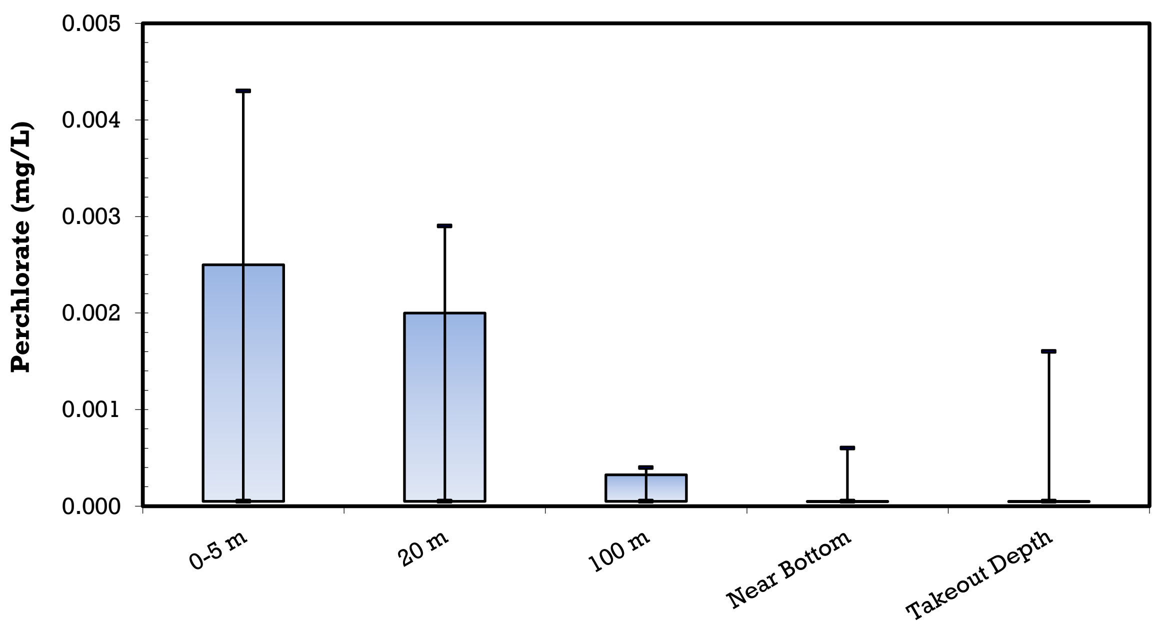


Figure 3-7. Historical Perchlorate Levels at Whitsett Intake in Lake Havasu



Box-and-whisker plots show minimum and maximum (whiskers) and 25th and 75th percentiles (boxes). Median values are the same as the minimum values.
All data calculated assuming non-detects (NDs) = ½ MRL. MRL = 0.0001 mg/L using USEPA Method 332.

Figure 3-8. Perchlorate Levels at Depth in Lake Mead, 2011–2015

Table 3-11. Perchlorate Summary for Source Waters, 2011–2015, mg/L

	Minimum	Maximum	Median*
Davis Dam	0.0007	0.0016	0.0011
Whitsett Intake	0.0005	0.0016	0.0010
San Jacinto Tunnel West Portal	0.0008	0.0016	0.0010
Lake Mathews	0.0008	0.0013	0.0010
Diamond Valley Lake	ND (< 0.0001)	0.0010	0.0010
Lake Skinner	0.0008	0.0014	0.0010
Diemer Influent	0.0009	0.0013	0.0010
Weymouth Influent	0.0007	0.0013	0.0010

* Median values calculated assuming non-detects (NDs) equaled one-half the MRL.
MRL = 0.0001 mg/L using USEPA Method 332.

Summary of Findings for Perchlorate

- DDW has set an MCL for perchlorate at 0.006 mg/L and issued a revised PHG of 0.001 mg/L. While currently unregulated at the federal level, USEPA has announced its intent to set an MCL for perchlorate by December 19, 2019.
- Since perchlorate was first discovered in Colorado River water, source water sampling at Las Vegas Wash, which feeds into Lake Mead, showed a decrease in perchlorate loading over time. During the reporting period, perchlorate loading into Las Vegas Wash was typically below 100 lbs/day; indicating that the remediation efforts in Henderson, Nevada have been effective and have resulted in over 90 percent reduction of perchlorate loading into Las Vegas Wash.
- Perchlorate concentrations at Lake Mead continue to show the highest levels at or near the surface. The annual peak concentrations at Lake Mead occur in the late summer.
- Levels of perchlorate continue to decline as a result of remediation efforts in Henderson, Nevada. Perchlorate is not found in SWP water, so blending at the water treatment plant influents further reduces perchlorate levels.
- Perchlorate levels in source waters and influent levels at the Diemer, Skinner, and Weymouth plants were all well below the current California MCL of 0.006 mg/L.

Total Dissolved Solids

Total dissolved solids (TDS) has been selected for evaluation since the original CRWSS because TDS is an important constituent to Metropolitan and its member agencies. Of Metropolitan's two source waters, Colorado River water has much higher TDS content compared to SWP water. High salinity water increases scaling potential, reduce agricultural crop yields, limit groundwater recharge efforts, and can reduce the marketability and usability of reclaimed water. Wastewater treatment plants are also concerned about TDS in the water that they receive, as they need to comply with TDS discharge limits specified in their National Pollution Discharge Elimination System (NPDES) permits.

TDS in Colorado River water comes from both natural and human sources in the watershed. The natural sources include saline springs, erosion of saline geologic formations, and runoff from stream channels and banks. Human sources include irrigation, discharge of municipal and industrial wastewater into the river, and reservoir evaporation. The Colorado River Basin Salinity Control Forum (Forum) was formed in 1973 to develop numeric standards and a basin-wide implementation plan for salinity control. The Forum recommended average flow-weighted TDS water quality standards, which include the following:

- Below Hoover Dam 723 mg/L
- Below Parker Dam 747 mg/L
- At Imperial Dam 879 mg/L

Metropolitan is an active member of the Forum, which fosters interstate cooperation on the issue of elevated salinity in the Colorado River. The Forum aids in the control of salinity in the Colorado River Basin through projects designed to intercept and control non-point sources, such as surface runoff, as well as wastewater and saline hot springs. These projects include on-farm and off-farm delivery and irrigation improvements to reduce deep percolation and replacement of unlined canals with lined canals or pipelines. Other projects include deep well injection of brine, brine evaporation ponds, and erosion control. More information on the Forum and its efforts are included in **Chapter 6**.

TDS has a secondary MCL; therefore, it is regulated based on aesthetics rather than a health hazard. The TDS secondary MCL is not a fixed value, but rather a range of concentrations. Water with TDS lower than the recommended level (500 mg/L) is considered desirable for a high degree of customer acceptance; concentrations ranging to the upper contaminant level (1,000 mg/L) are acceptable if it is neither reasonable nor feasible to provide more suitable waters. TDS ranging to the short-term contaminant level (1,500 mg/L) is acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources.

On April 13, 1999, Metropolitan's Board of Directors approved a Salinity Management Policy. The policy set a goal of achieving salinity concentrations in delivered water of less than 500 mg/L TDS (based on a running annual average) when practical and feasible, based on hydrologic conditions. It also identified the need for both local and imported water sources to be managed comprehensively to enhance the use of recycled water and groundwater recharge. To achieve these targets, SWP supplies are blended with Colorado River supplies when hydrologic and water supply conditions allow. Metropolitan is currently working with USBR and Southern California Salinity Coalition to update the 1999 Salinity Management Study.

Metropolitan has alerted its member agencies that due to imported water supply conditions, high salinity could be a concern at times. Metropolitan has also urged its member agencies to structure the operation and management of their local projects and groundwater so they are prepared to mitigate the effect of higher salinity levels in imported waters.

Monitoring Results for TDS

Total Dissolved Solids

Figure 3-9 and **Figure 3-10** show the historical and reporting period TDS values, respectively, in the CRA system. TDS is monitored monthly at all of Metropolitan's source waters. TDS in the Colorado River is generally stable, with cycles up and down over multiple years, corresponding to hydrologic cycles. TDS at Lake Havasu gradually increased from 585 mg/L in January 2011 to a peak of 650 mg/L in October 2015. Between 2011 and 2015, TDS at Lake Havasu ranged from 551 to 650 mg/L, with a median of 585 mg/L (**Table 3-12**). Lake Mathews and San Jacinto Tunnel West Portal follow the same trend, with the exception of a low TDS value (471 mg/L) for San Jacinto Tunnel in November 2011. The median TDS was 585 mg/L and 583 mg/L for San Jacinto Tunnel West Portal and Lake Mathews, respectively, with respective ranges of 471–651 mg/L, and 554–647 mg/L.

Lake Skinner and Diamond Valley Lake receive water from both the Colorado River and SWP. However, Diamond Valley Lake stopped receiving water from the Colorado River after quagga mussels were discovered in Lake Mead in early 2007. The TDS values are dependent upon the percent blend of the two source waters. The ranges and medians for these two reservoirs are summarized in **Table 3-12**.

Due to low SWP allocation and drought conditions during this reporting period, DVL received minimal SWP water inflows and Lake Skinner primarily received Colorado River water. Metropolitan's current strategy of blending Colorado River water with lower-TDS SWP water to maintain a 500-mg/L TDS level has proven effective when sufficient SWP supplies are available. However, during the reporting period, with the exception of Diamond Valley, the maximum TDS levels in source waters exceeded the target goal of 500 mg/L. A summary of TDS data in Metropolitan's water treatment plant effluents can be found in **Chapter 5**.

Table 3-12. Summary of TDS Monitoring Levels in Source Waters, 2011–2015, mg/L

	Maximum	Median	Minimum
Whitsett Intake	650	585	551
San Jacinto Tunnel West Portal	651	585	471
Lake Mathews	647	583	554
Diamond Valley Lake	345	298	281
Lake Skinner	650	485	235

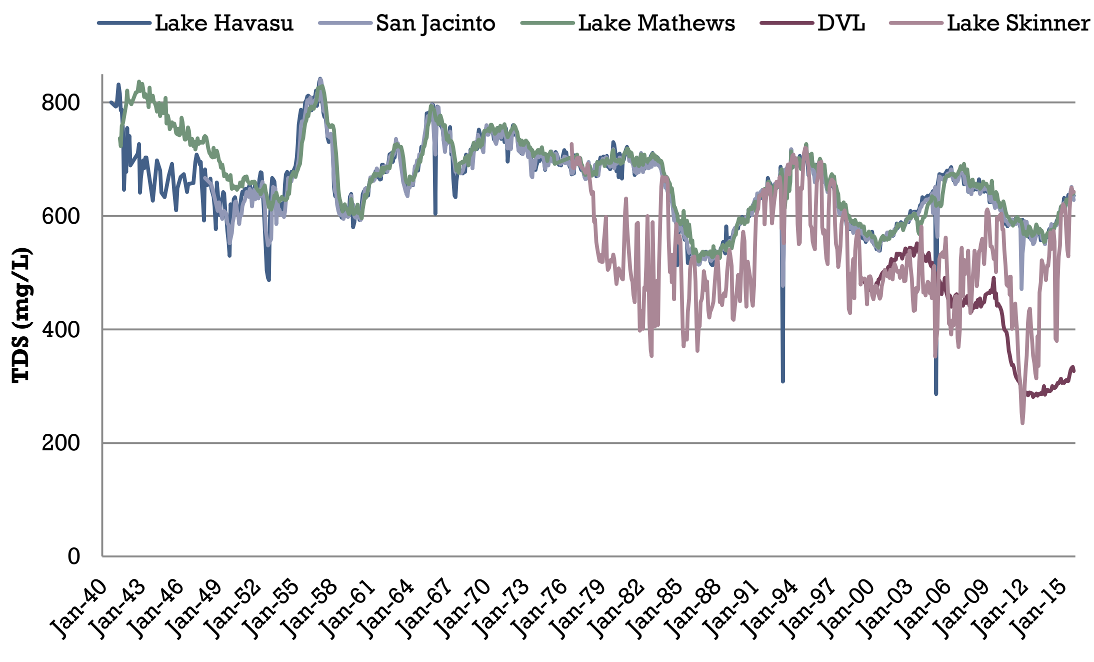


Figure 3-9. Historical TDS Levels in Source Waters, 1940–2015

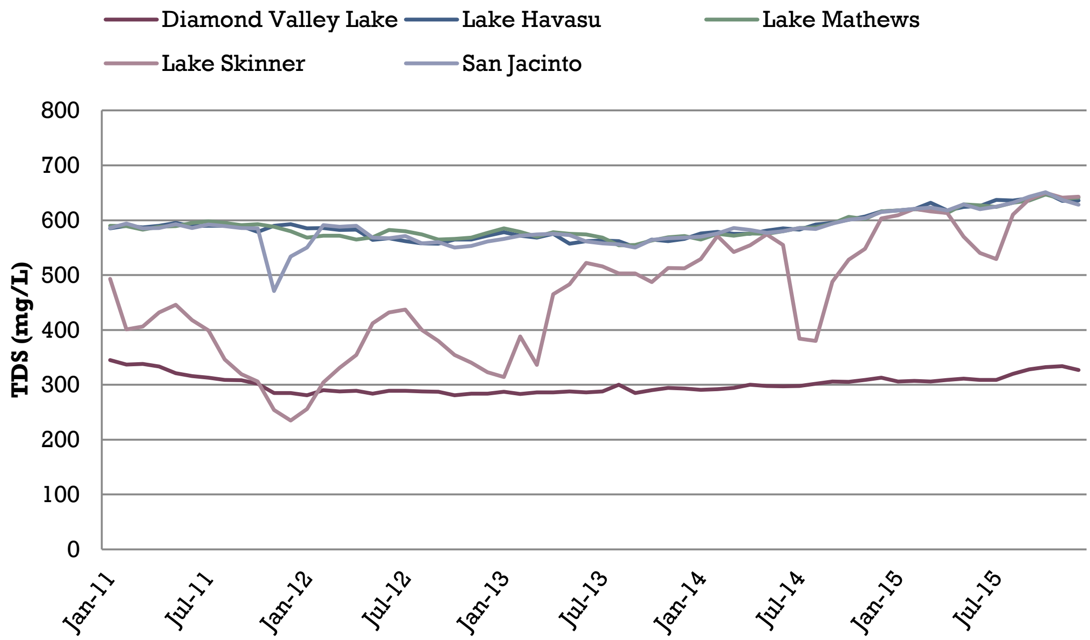


Figure 3-10. TDS Levels in Source Waters, 2011–2015

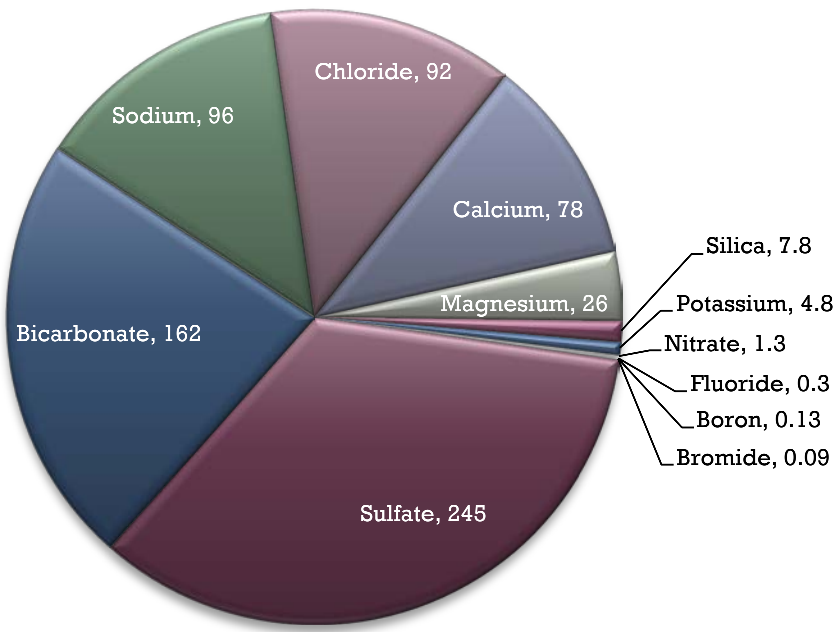


Figure 3-11. Average TDS Composition of Lake Havasu Water for Year 2015, mg/L

Sulfate

Figure 3-11 shows the relative breakdown on the ionic constituents that comprise Colorado River water taken from Lake Havasu. Sulfate constitutes approximately 34 percent of the minerals in Colorado River water. As such, sulfate has been selected for evaluation since the CRWSS 2005 Update. Sulfate has a secondary MCL; therefore, it is regulated based on aesthetics rather than a health hazard. Similar to TDS, sulfate is regulated with acceptance ranges. The recommended level is 250 mg/L; the upper contaminant level and the short-term contaminant level are 500 mg/L and 600 mg/L, respectively.

Figure 3-12 shows sulfate levels at Whitsett Intake, San Jacinto Tunnel West Portal, Lake Mathews, Diamond Valley Lake, and Lake Skinner for 2011–2015. The maximum, median, and minimum values are summarized in **Table 3-13**. Other than one low level (166 mg/L) of sulfate in Lake Havasu in November 2011, sulfate levels trended slightly upward for Lake Havasu, San Jacinto Tunnel West Portal, and Lake Mathews over the reporting period. In general, sulfate levels trended similar between Lake Havasu, San Jacinto Tunnel West Portal, and Lake Mathews. The highest level (250 mg/L) was detected at Lake Mathews and San Jacinto Tunnel West Portal in October 2015. Median sulfate concentrations along the CRA system were below the recommended level of 250 mg/L. Because sulfate is a major component of TDS, sulfate trends correlate to TDS trends as shown in **Figure 3-10**.

Concentrations of sulfate in Lake Skinner varied depending on the percent blend of SWP water. Due to low SWP allocations and drought conditions, Lake Skinner primarily received Colorado River water. As such, sulfate levels for Lake Skinner reached levels similar to Lake Havasu. Sulfate levels in DVL remained relatively stable, reflecting the minimal SWP inflows that went into DVL due to low SWP allocations.

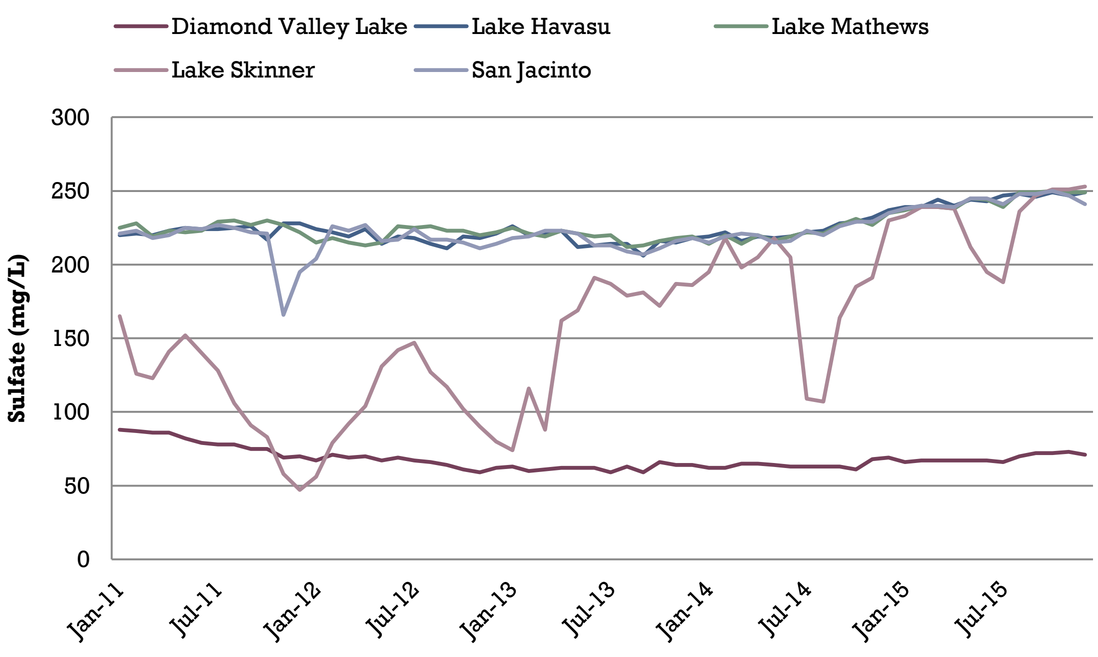


Figure 3-12. Sulfate Levels in Source Waters, 2011–2015

Table 3-13. Sulfate Summary for Source Waters, 2011–2015, mg/L

	Minimum	Maximum	Median
Whitsett Intake	206	249	222
San Jacinto Tunnel West Portal	166	250	221
Lake Mathews	212	250	223
Diamond Valley Lake	59	88	67
Lake Skinner	47	253	165

Summary of Findings for Total Dissolved Solids and Sulfate

- Metropolitan has an existing Salinity Management Policy with a goal of achieving a running annual average of 500 mg/L TDS for treated waters when practical and feasible. This goal is primarily achieved by blending higher TDS Colorado River water with SWP water, and was anticipated to be met in 7 out of 10 years when due to hydrologic variability.
- TDS in the Colorado River cycled up and down over multiple years and showed a slight increasing trend between 2011 and 2015.
- The median sulfate levels in Lake Skinner were below 250 mg/L, but trended upwards due to blending with a higher percentage of Colorado River water under low SWP allocations. Diamond Valley Lake sulfate levels were lower since only SWP water is stored in Diamond Valley Lake.
- Metropolitan's current operation of blending will continue into the future to manage TDS levels. When adequate SWP supplies are available, Metropolitan has met its salinity objective. Metropolitan is currently working with its partners on an update to its 1999 Salinity Management Study.
- Various TDS control projects are planned or implemented by the Colorado River Basin Salinity Control Program to meet the agreed-upon TDS concentration numeric criteria at specific locations in the lower Colorado River. Further discussion of the Colorado River Basin Salinity Control Program can be found in **Chapter 6**.

Nutrients (Total Phosphorus and Nitrate)

Total phosphorus has been selected for evaluation since the CRWSS 2005 Update as it is considered the primary limiting nutrient for algal growth in Colorado River water. Nitrate was added for evaluation for the CRWSS 2010 Update due to potential impacts of septic systems along the lower Colorado River. Nutrients are naturally occurring in aquatic ecosystems, but when present in excess may result in taste and odor production, nuisance algal blooms, and/or excessive macrophyte (aquatic plant) growth, toxin production, increased TOC levels, and/or shortened filter runs at treatment plants; all of which have been observed in Metropolitan's system. Past algal assays conducted by Metropolitan (unpublished) in these waters clearly demonstrated phosphorus limitation with a linear algal growth response to phosphorus additions. Any additions of phosphorus to Colorado River water will result in increased algal growth and potential water quality problems associated with that growth. Colorado River water is currently classified towards the lower end of the productivity scale due to total phosphorus concentrations near 0.010 mg/L—a classical limnologic threshold for an oligotrophic system.

Cyanobacterial blooms occur when populations of one or more cyanobacterial species begin to grow at exponential rates. Human sources of phosphorus and nitrogen compounds include, but are not limited to, wastewater discharges, agricultural runoff, and septic systems. Nutrient levels in Colorado River water are much lower than those found in SWP water. As a result, Colorado River water plays a significant role in blending down the high nutrient SWP water in Lake Skinner, Diamond Valley Lake, and at Metropolitan's three blended water treatment plants.

The consequences of increased nutrient loading complicate lake water quality management as well as treatment plant operations. A small percentage of cyanobacteria can produce the taste and odor compounds geosmin and/or MIB, both of which are resistant to standard treatment practices. Potent producers are often minor components of the phytoplankton community. Increased TOC levels associated with phytoplankton can also result in higher disinfection byproducts during the treatment process. Excessive macrophyte growth can impede the flow of water along conveyance systems and clog screen facilities at treatment plants. Filter clogging algae will reduce run-times, restrict production, and increase treatment costs. An additional concern is the potential effect that increased nutrient loading may have on the proliferation of quagga mussels in downstream waters.

Total phosphorus has no primary or secondary MCL. However, it is the driver for algae growth anywhere in the Colorado River conveyance and storage system exposed to light. Wastewater treatment plants in the Las Vegas area represent a source of phosphorus loading into the Colorado River system. Through the implementation of NPDES permits, Las Vegas area dischargers must comply with State of Nevada water quality standards. The Nevada Administrative Code contains standards for total phosphorus for the Colorado River below Hoover Dam. These standards establish a 0.050 mg/L beneficial use standard and a 0.020 mg/L requirement to maintain higher quality (anti-degradation) standard, both measured as annual averages. It should be noted that Metropolitan believes that these standards do not sufficiently protect downstream drinking water uses. In 2009, NDEP developed a Nutrient Criteria Strategy for Nevada, in cooperation with USEPA Region IX, with the end goal of developing statewide nutrient criteria. NDEP is evaluating nutrient pollution issues and recently established nutrient criteria for the Lahontan and South Fork Reservoirs. NDEP is also in the process of finalizing nutrient criteria recommendations for wadeable streams. Nitrate is a regulated constituent and has a primary MCL of 10 mg/L (as nitrogen).

Treatment for phosphorus includes filtration for particulate phosphorus and chemical precipitation and biological treatment for total phosphorus. Nitrate may be removed from water sources using ion exchange, reverse osmosis, and biological treatment. Currently, Metropolitan's water treatment plants only have a limited capability in removing total phosphorus from the source water (although the primary concern is the potential for algal productivity in source waters) and no capability in removing nitrate. Given these conditions, Metropolitan is sensitive to any activity within remote and local watersheds that will increase nutrient loads to the source water.

Monitoring Results for Nutrients

In May 2008, the nutrient monitoring program was expanded to include total phosphorus, nitrate, ammonia, nitrite, Total Kjehldahl nitrogen (TKN), and soluble reactive phosphorus (SRP). All of these nutrients were monitored in Metropolitan's Colorado River water system between 2011 and 2015. However, the following discussion focuses on total phosphorus and nitrate.

Nutrient samples are collected at six sites along the Colorado River and CRA system (see **Figure 3-13**). The upstream site is Davis Dam, where samples are collected from the river just downstream of Davis Dam. There are three sites in Lake Havasu including inlet (where the river enters the lake), Mid-lake (midpoint of the lake), and Whitsett Intake (the outlet structure from Lake Havasu). Samples are also collected from the inlet and outlet structure in Lake Mathews.

Figure 3-13. Nutrient Monitoring Locations along the Colorado River Aqueduct System

Total Phosphorus

The descriptive statistics for total phosphorus values between Davis Dam and Lake Mathews outlet are displayed in **Table 3-14**. Median total phosphorus increased from 0.005 mg/L at Davis Dam to 0.008 mg/L at the inlet location for Lake Havasu. This increase may be linked to presence of septic systems in this reach of the Colorado River, urban runoff and/or inputs from the Havasu National Wildlife Refuge, which protects 30 Colorado River miles between Needles California and Lake Havasu City, Arizona. The median total phosphorus values decreased slightly as the water moved through Lake Havasu (0.008 mg/L at Lake Havasu Inlet vs. 0.006 mg/L at Whitsett Intake). The decline across the lake is due to biological, chemical, and physical processes that strip total phosphorus from the water column and deposit it in the sediments. Median total phosphorus values in Lake Mathews were unchanged between the inlet and outlet (0.007 mg/L for both locations). The highest maximum total phosphorus values were measured at the inlets to both Lake Havasu and Lake Mathews, likely the result of periodic storm events in the respective watersheds.

Figure 3-14 shows historical total phosphorus monitoring data within Lake Havasu, Lake Mathews, Lake Skinner, and Diamond Valley Lake. Again, the peaks in the total phosphorus values can be attributed to periodic storm events in the respective watersheds.

Figure 3-15 and **Figure 3-16** show the changes in total phosphorus as the water moves through the CRA system. It should be noted that **Figure 3-16** demonstrates the influence of local urban runoff to the phosphorus loading in Lake Mathews. Total phosphorus levels at Whitsett Intake are consistently lower than the values measures at Lake Mathews inlet. Nutrient concentrations are higher in SWP water due to influences from wastewater dischargers and agricultural drainages in the Delta. Since Diamond Valley Lake is filled exclusively with SWP water, higher concentrations of nutrients have led to greater taste and odor problems and other nutrient-related issues than experienced with blend reservoirs. **Figure 3-14** shows an increasing trend of total phosphorus in Diamond Valley Lake during the drought.

Despite relatively low concentrations, any additions of phosphorus to Colorado River water can result in increased algal growth. As such, low nutrient Colorado River water is relied upon by Metropolitan to blend down the high nutrient SWP water in Metropolitan's blend reservoirs. With population growth expected to continue in the future (e.g., Las Vegas area), Metropolitan continues its involvement with entities along the lower Colorado River seeking to enhance wastewater management (and therefore better manage nutrient impacts) within river communities. Metropolitan continues to work with Las Vegas Valley wastewater dischargers who have enhanced their treatment processes in recent years to reduce the total phosphorus loading into Lake Mead. Further discussion on wastewater management activity in the Las Vegas Valley can be found in **Chapter 6**.

Table 3-14. Total Phosphorus Summary for Source Waters, 2011–2015, mg/L

Site	Minimum	Maximum	Median
Davis Dam	ND (< 0.004)	0.022	0.005
Lake Havasu Inlet	ND (< 0.004)	0.417	0.008
Lake Havasu (Mid-Lake)	ND (< 0.004)	0.022	0.006
Whitsett Intake	ND (< 0.004)	0.011	0.006
Lake Mathews Inlet	ND (< 0.004)	0.437	0.007
Lake Mathews Outlet	ND (< 0.004)	0.023	0.007

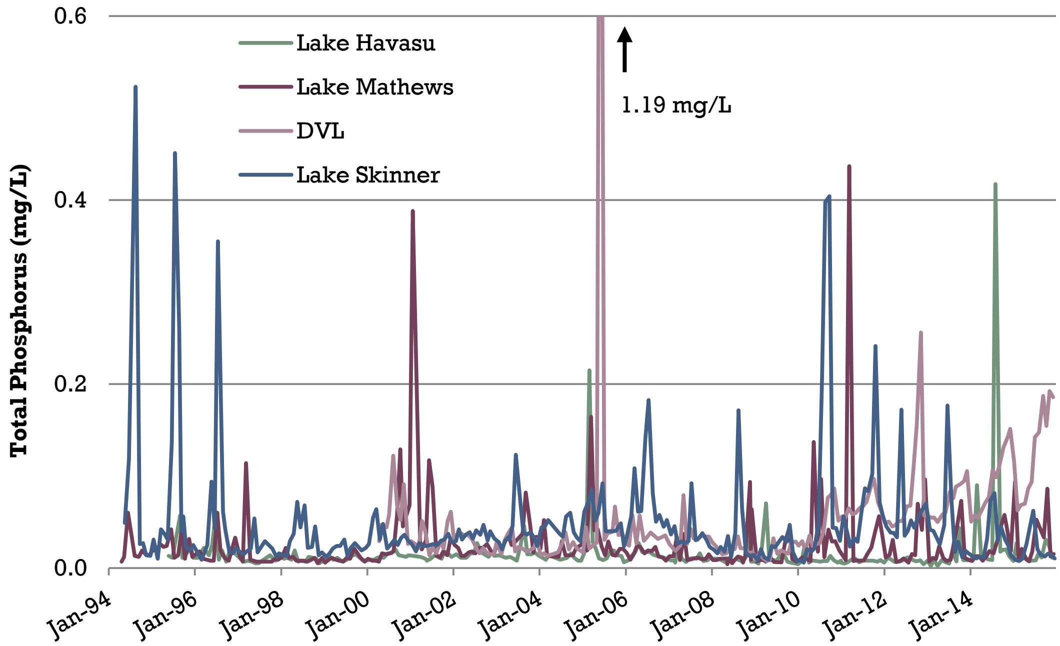
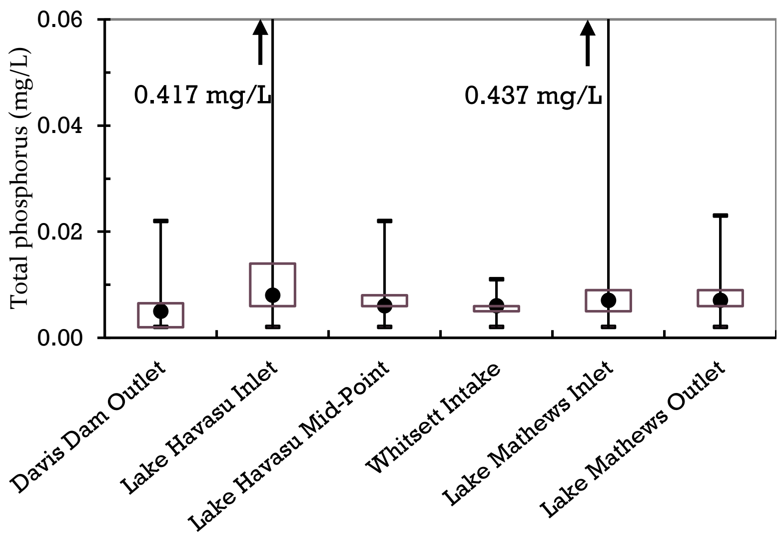


Figure 3-14. Total Phosphorus in Source Waters, 1994–2015



Box-and-whisker plots show minimum and maximum (whiskers), 25th and 75th percentiles (boxes), and median (dots) values.

Figure 3-15. Total Phosphorus between Davis Dam and Lake Mathews Outlet, 2011–2015

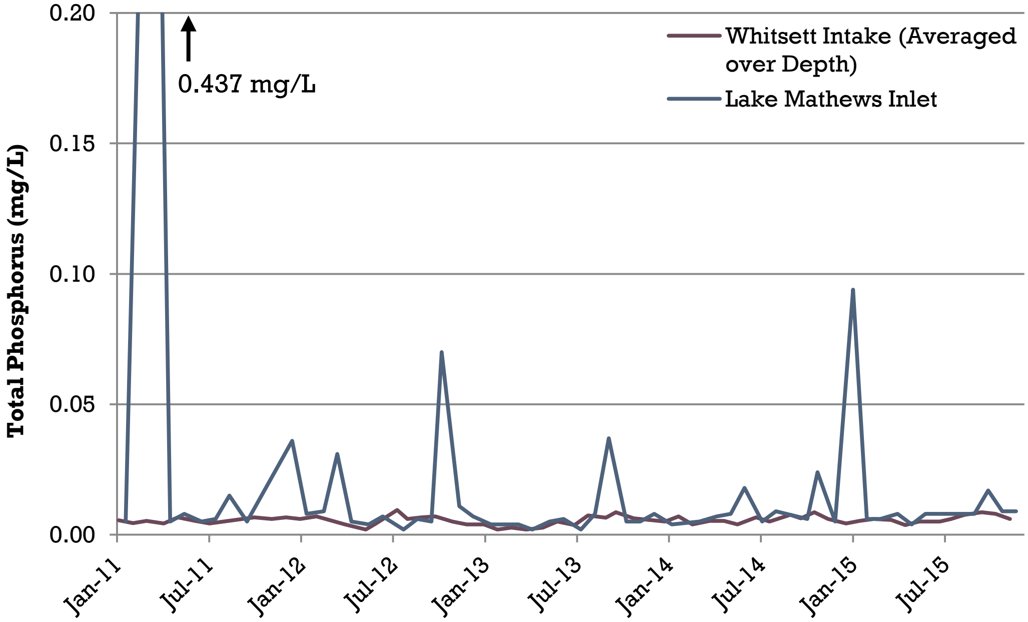


Figure 3-16. Total Phosphorus at Whitsett Intake and Lake Mathews Inlet, 2011–2015

Nitrate

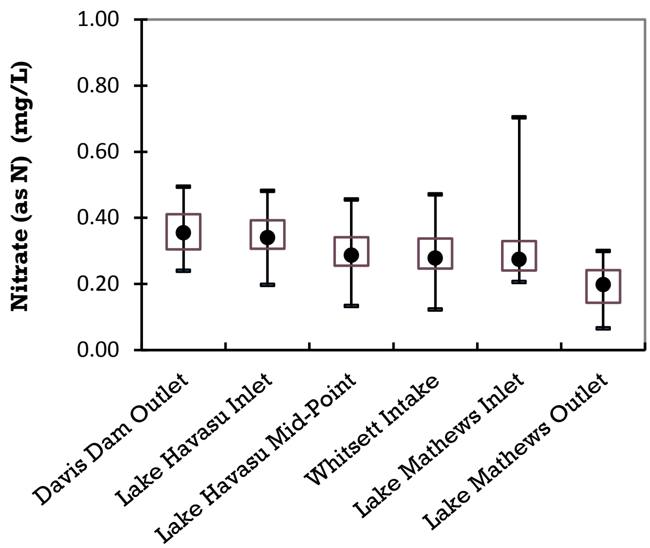
The descriptive statistics for the nitrate values between Davis Dam and Lake Mathews' outlet are displayed in **Table 3-15.** Nitrate values in Colorado River are on the lower end of the scale. Median nitrate values gradually drop from 0.354 mg/L at Davis Dam to 0.198 mg/L at the Lake Mathews outlet.

Figure 3-17 shows a gradual decrease in nitrate along the Colorado River system. A decrease of 0.062 mg/L (as nitrogen) can be seen as the water moves through Lake Havasu. Lake Mathews nitrate values dropped 0.076 mg/L (as nitrogen) between the inlet and outlet structure.

Distinct seasonal patterns can be seen in the nitrate values displayed in **Figure 3-18** and **Figure 3-19**. **Figure 3-18** shows the historical nitrate monitoring data for Lake Havasu, Lake Mathews, Lake Skinner and Diamond Valley Lake. During the initial filling of Diamond Valley Lake in 2000, nitrate levels were high, most likely caused by leaching of nitrate from the soils underlying the reservoir. Prior to Diamond Valley Lake being built, the area was predominantly farm and grazing land. Most other periodic spikes in nitrate, like total phosphorus, were likely the result of periodic storm events in the respective watersheds. **Figure 3-19** demonstrates the influence of local urban runoff and the presence of septic systems contributing to the higher nitrate loading in Lake Mathews during significant rain events. Unlike total phosphorus, spikes in nitrate are unlikely to result in an immediate algal response in Colorado River water.

Table 3-15. Nitrate (as N) Summary for Source Waters, 2011–2015, mg/L

Site	Minimum	Maximum	Median
Davis Dam	0.239	0.494	0.354
Lake Havasu Inlet	0.197	0.481	0.340
Lake Havasu (Mid-Lake)	0.133	0.455	0.287
Whitsett Intake	0.122	0.470	0.278
Lake Mathews Inlet	0.205	0.704	0.274
Lake Mathews Outlet	0.065	0.299	0.198



Box-and-whisker plots show minimum and maximum (whiskers), 25th and 75th percentiles (boxes), and median (dots) values

Figure 3-17. Nitrate (as N) between Davis Dam and Lake Mathews Outlet, 2011–2015

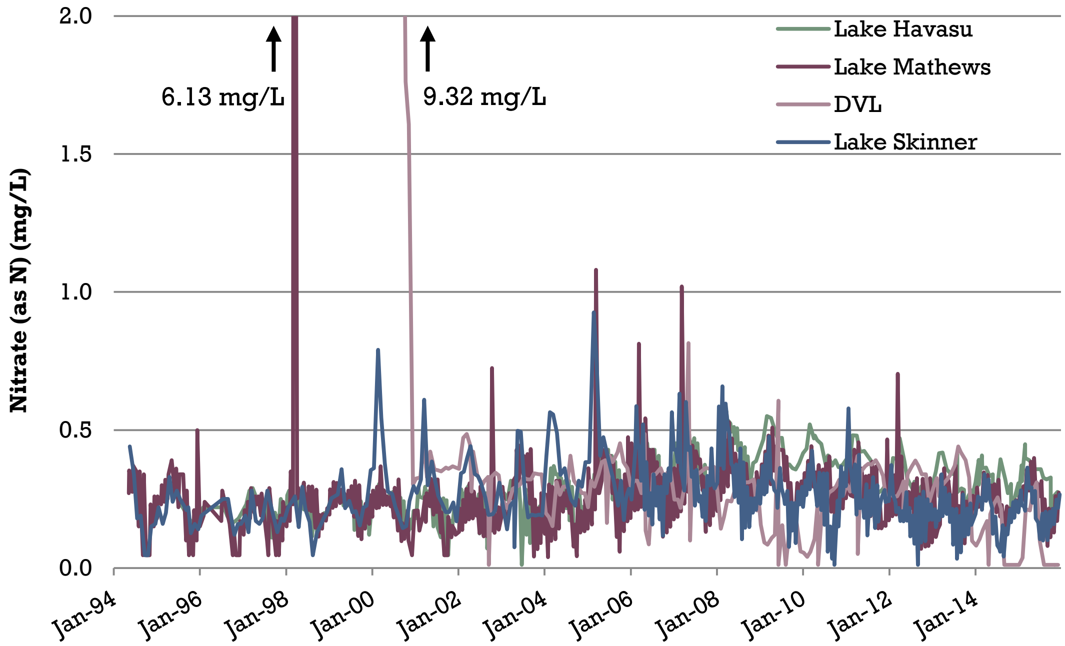


Figure 3-18. Historical Nitrate (as N) in Source Waters, 1994–2015

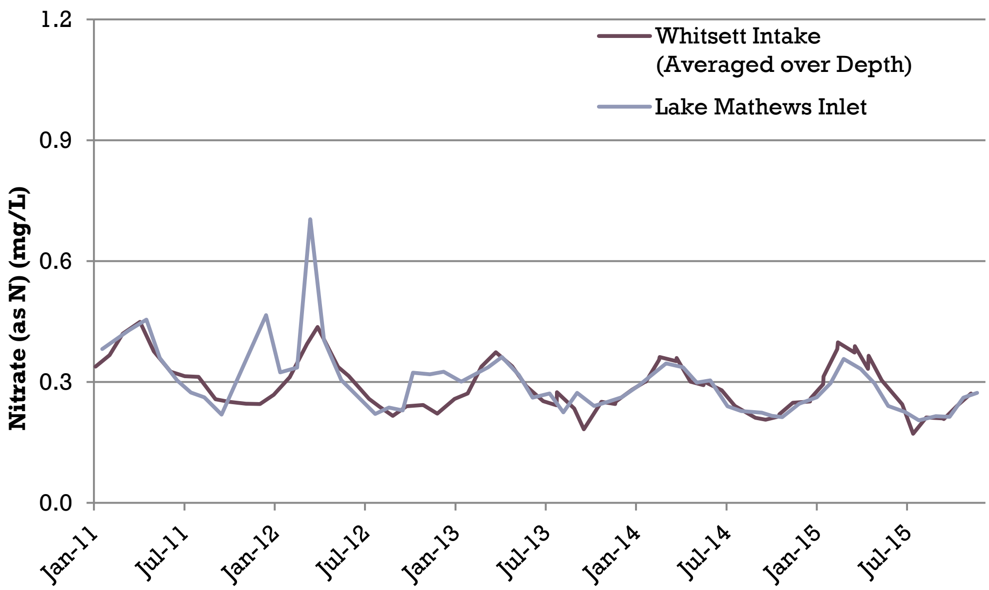


Figure 3-19. Nitrate (as N) at Whitsett Intake and Lake Mathews Inlet, 2011–2015

Storm events have the potential to increase sediment and nutrient loading into the downstream lakes, thereby stimulating algal growth. To provide a buffer and reduce the nutrient loading (as well as other constituents of concern) into Lake Mathews, Metropolitan completed the Lake Mathews Cajalco Creek Dam and Detention Basin project in 2001. In 2012, Metropolitan, in partnership with Riverside County Flood Control and Water Conservation District and Riverside County completed a Lake Mathews watershed study and developed a model to assess the future threat of runoff pollution into Lake Mathews. Metropolitan's source water protection program will continue to focus on preventing increases in future nutrient loading resulting from development activities. Further information on Lake Mathews watershed management and planning is included in **Chapter 6**.

Summary of Findings for Nutrients

- Total phosphorus is the limiting nutrient controlling cyanobacteria and algal growth in Colorado River water.
- Total phosphorus in the Colorado River is relatively stable around 0.010 mg/L, but with seasonal cycles reflecting storm events.
- Water quality issues arise from excessive cyanobacteria or algae growth stimulated by increased total phosphorus loading.
- Some cyanobacteria (blue-green algae) species produce unacceptable levels of MIB and geosmin even at low biomass levels.
- Metropolitan has a clear goal of maintaining the low total phosphorus status of Colorado River water as a mechanism to control cyanobacterial and algal growth in source water reservoirs and conveyance systems.
- Las Vegas area wastewater treatment plants have optimized their treatment processes to reduce the loading of total phosphorus in the Colorado River system in recent years. Phosphorus removal at the plants is now applied year-round.

Radionuclides

Radionuclides were selected for evaluation in the original CRWSS because the Colorado River is vulnerable to contamination from upstream sources. For example, a pile of approximately 16 million tons of uranium mine tailings was left behind from a former uranium mill site adjacent to the Colorado River near Moab, Utah. Moab is approximately 650 miles upstream of Metropolitan's Whitsett Intake on Lake Havasu.

Radionuclides are a group of isotopes whose nuclei are not stable. These nuclei achieve stability by emitting energy and particles collectively called radiation. The alpha particles have lesser penetrating power than the beta or gamma particles. Alpha particles do not cause external damage to humans because they cannot penetrate the skin. However, it causes great bodily harm when inhaled or ingested into the body. The beta and gamma particles can cause both external and internal damage to humans upon exposure.

Alpha emitters are usually naturally occurring. The most important alpha emitters in terms of occurrence and health hazard are uranium and radium-226, both are regulated with primary drinking water standards. While the USEPA MCL for uranium is 27 pCi/L (0.030 mg/L), DDW's MCL is 20 pCi/L. Both USEPA and DDW set their MCLs for radium as the sum of Ra_{226} and Ra_{228} at 5 pCi/L. There is also an MCL of 15 pCi/L for the gross alpha activity minus the uranium activity. Water systems are required to conduct four consecutive quarters of monitoring every three years. Compliance is based on the average results of the four quarters. Radon is not regulated at the present time; however, radon is not typically a concern for surface waters.

A majority of the beta emitters originate from man-made activities such as nuclear power generation, weapons testing, and chemical manufacturing. No specific sources of contamination have been identified in the Colorado River watershed, however, Metropolitan's waters were designated as "vulnerable" to beta emitter contamination by DDW, and monitoring under the Radionuclides Rule is required.

The beta and photon emitters are regulated with an MCL of 4 millirems per year annual effective dose equivalent to the total body or any internal organ. A gross beta concentration of less than 50 pCi/L is considered to be in compliance with the regulation. Two radioactive isotopes are regulated with MCLs: strontium-90 has an MCL of 8 pCi/L and tritium has an MCL of 20,000 pCi/L. Monitoring is required only for systems that are designated as "vulnerable" to contamination, and systems that use waters contaminated by effluents from nuclear facilities. Metropolitan's waters are designated as "vulnerable". Metropolitan conducts quarterly monitoring of gross beta activity and annual monitoring for strontium-90 and tritium. There is a "screening level" for gross beta at 50 pCi/L. If the screening level is exceeded, further testing of the water for beta and photon emitters is needed to characterize the water.

All naturally occurring alpha emitters can be treated. However, different radionuclides require different types of treatment as recommended by USEPA in the *Radionuclides in Drinking Water: A Small Entity Compliance Guide* [25]. Radium can be removed through ion exchange, high pressure membranes, greensand filtration, re-formed manganese hydrous oxide filtration, co-precipitation with barium sulfate, lime softening, and electrodialysis. Removal technologies for uranium includes ion exchange, high pressure membranes, activated alumina, lime softening, and enhanced coagulation.

Moab Uranium Mill Tailings Remedial Action Project

In 2009, the U.S. Department of Energy (USDOE) began moving the 16-million-ton uranium tailings pile away from the banks of the Colorado River to a permanent disposal site 30 miles northwest, near the town of Crescent Junction. This project is called the Moab Uranium Mill Tailings Remedial Action project. The tailings project site is located approximately 3 miles northwest of Moab in Grand County, Utah and includes the former Atlas Minerals Corporation uranium-ore processing facility. The site is situated on the west bank of the Colorado River at its confluence with Moab Wash. The site encompasses 439 acres, of which approximately 130 acres is covered by the uranium mill tailings pile.

Initially, remedial actions at the site were focused on removing contaminated water from the pile and groundwater (1999 to present). Through September 2016, over 4,500 pounds of uranium in contaminated groundwater have been removed. Rail shipment and disposal of the uranium mill tailings pile from the Moab, Utah site began in April 2009. As of September 2016, over half (over 8.3 million tons) of the tailings pile has been moved. However, recent events, such as a rockslide at the site in November 2014 and reduced funding, have resulted in a slowdown of the tailings removal. USDOE estimates completing movement of the tailings pile by 2025 contingent on sufficient federal funding available.

Metropolitan continues to track progress of the remediation efforts, advocate for rapid cleanup, and work with congressional representatives to provide legislative support for increased annual appropriations for the cleanup effort. Additional information about USDOE's remedial efforts for the Moab uranium mill tailings site is discussed in **Chapter 6**.

Monitoring Results for Radionuclides

Gross Alpha/Uranium

Metropolitan has been monitoring gross alpha activities at Lake Powell, Lake Mead, Lake Havasu, and within Metropolitan's system routinely since 1979 (**Figure 3-20**). **Table 3-16** shows the 2011 through 2015 monitoring data for gross alpha activity at Whitsett Intake, San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, and Diamond Valley Lake. As **Table 3-17** shows, uranium levels through quarterly sampling in Metropolitan's source waters were consistently below the MCL of 20 pCi/L. In 2005, sampling for gross alpha at Lake Havasu was reduced from monthly to quarterly. In general, gross alpha emitters patterns are similar between Lake Powell, Lake Mead, and Lake Havasu. Periodic spikes (e.g., 15 pCi/L at Lake Havasu in May 1985) were also detected. However, the cause for these excursions were not determined as no further analysis (e.g., measuring uranium activity) were performed to characterize the alpha emitters because of the time delay when the result became available. Follow-up sampling generally resulted in values within historical trends. Between 1979 and 2015, approximately 325 samples were collected at the Whitsett Intake, and the median gross alpha activity was 3.7 pCi/L; during the reporting period the median gross alpha activity was 3.2 pCi/L.

Table 3-16. Gross Alpha Summary for Source Waters, 2011–2015, pCi/L

	Minimum	Maximum	Median*
Whitsett Intake	ND (< 3)	5.6	3.2
San Jacinto Tunnel West Portal	ND (< 3)	7.6	3.5
Lake Mathews	ND (< 3)	4.7	3.5
Diamond Valley Lake	ND (< 3)	ND (< 3)	ND (< 3)
Lake Skinner	ND (< 3)	5.9	ND (< 3)

* Median values calculated assuming non-detects (NDs) equaled one-half the MRDL
MRDL = 1 pCi/L through April 2008 and 3 pCi/L thereafter

Figure 3-21 shows the gross alpha activities at the San Jacinto Tunnel West Portal and Lake Mathews from 1979 to 2015. The highest gross alpha activity at the San Jacinto Tunnel West Portal and Lake Mathews was 8.7 pCi/L and 10.2 pCi/L, respectively. During this reporting period, the highest gross alpha activity was 7.6 pCi/L for San Jacinto Tunnel West Portal and 4.7 pCi/L at Lake Mathews. Gross alpha emitters were not detected at Diamond Valley Lake and the highest gross alpha activity for Lake Skinner was 5.9 pCi/L during the reporting period.

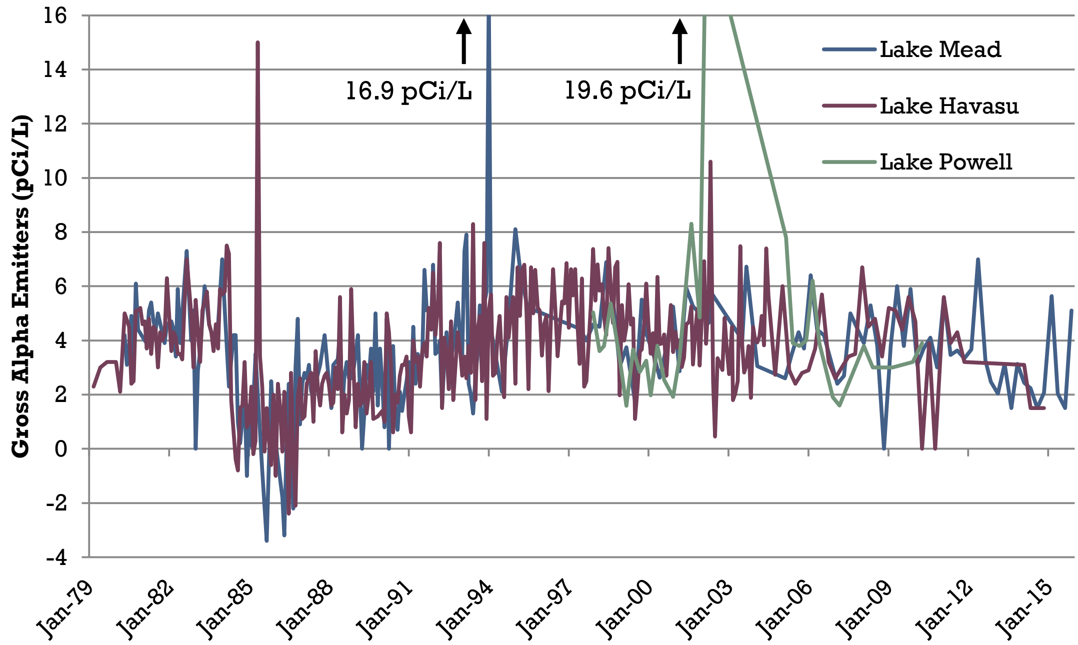


Figure 3-20. Historical Gross Alpha Activity above Parker Dam, 1979–2015

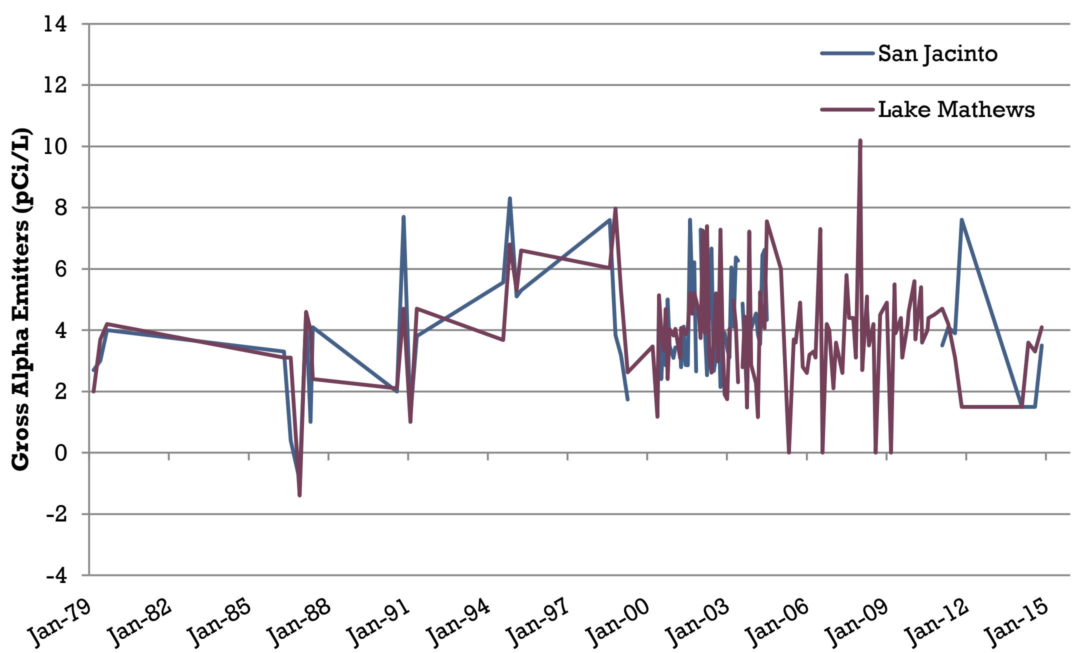


Figure 3-21. Historical Gross Alpha Activity in Source Waters, 1979–2015

Uranium results in the five source waters are summarized in **Table 3-17**. **Figure 3-22** shows the uranium levels at Lake Mead and Lake Havasu between 2011 and 2015. Uranium is the main alpha emitter and constitutes the majority of the gross alpha activities in the Colorado River. Due to the presence of the uranium mill tailings pile near Moab, Utah in close proximity to the Colorado River, monthly monitoring at the Whitsett Intake began in August 1998, and was subsequently reduced to quarterly sampling in June 2004. Similarly, Lake Mathews was monitored monthly from May 2000 (**Figure 3-23**), and was subsequently reduced to quarterly sampling beginning in June 2004. San Jacinto Tunnel West Portal was sampled quarterly in 2011 and 2014 (**Figure 3-23**). Of the five source water monitoring locations, the highest uranium level from 1994 to 2015 was 6.1 pCi/L at Lake Havasu in July 2004. Average uranium values ranged from 2.8–3.3 pCi/L during the 21-year monitoring period.

Table 3-17. Uranium Summary for Source Waters, 2011–2015, pCi/L

	Minimum	Maximum	Median
Whitsett Intake	2.0	2.9	2.4
San Jacinto Tunnel West Portal	2.4	5.1	2.7
Lake Mathews	2.4	3.3	2.8
Diamond Valley Lake	1.0	1.6	1.2
Lake Skinner	ND (< 1)	2.6	2.1

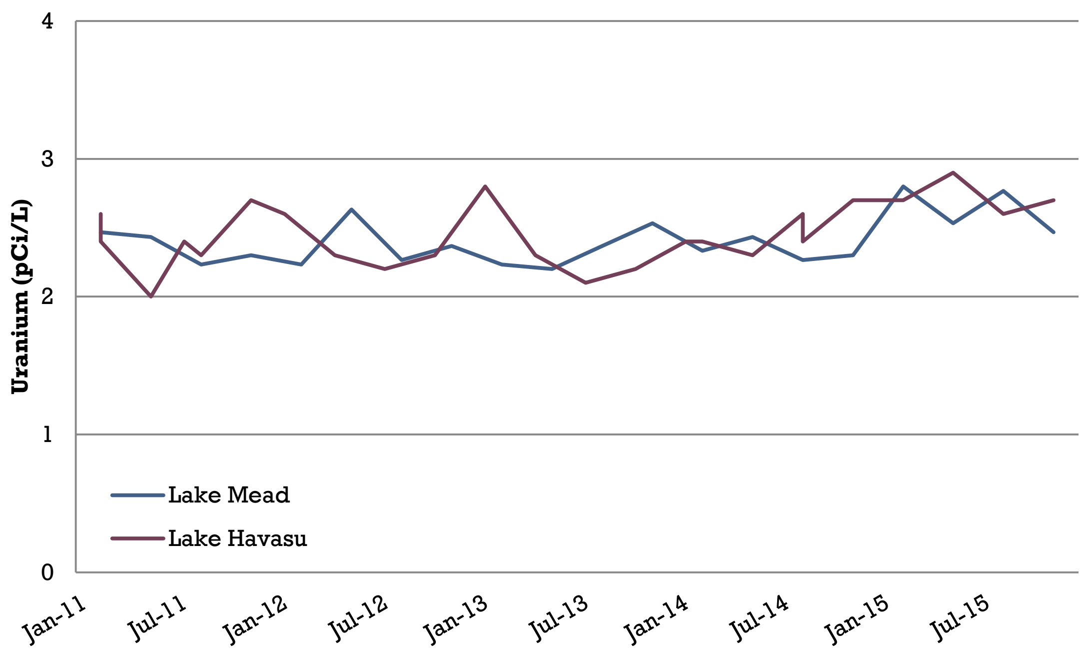


Figure 3-22. Uranium Levels above Parker Dam, 2011—2015

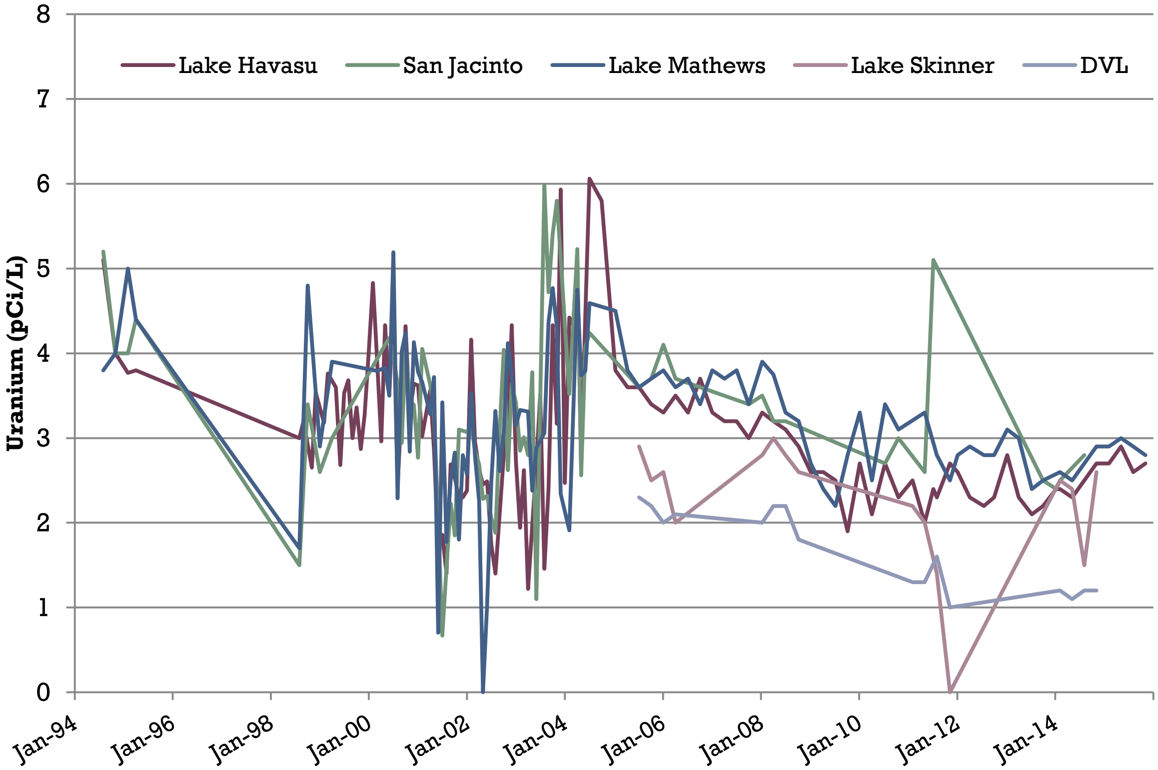


Figure 3-23. Historical Uranium Levels in Colorado River Aqueduct System, 1994–2015

Radium/Strontium-90/Tritium

Radium-226 and radium-228 were monitored every six months at Lake Havasu, San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, and Diamond Valley Lake. The combined radium was less than the state detection limits for purposes of reporting (DLR) of 0.5 pCi/L (**Table 3-18**). The individual quarterly results of radium-226 and radium-228 were also less than 1 pCi/L for all the monitoring locations. Strontium-90 and tritium activities were below the California DLR of 2 and 1,000 pCi/L, respectively, in all the samples collected during the reporting period (**Table 3-18**).

Table 3-18. Maximum Radium, Strontium-90, and Tritium Summary in Source Waters, 2011–2015, pCi/L

	Radium-226 Maximum*	Radium-228 Maximum†	Strontium-90 Maximum‡	Tritium Maximum§
Whitsett Intake	ND (< 1)	ND (< 1)	ND (< 2)	ND (< 1,000)
San Jacinto Tunnel West Portal	ND (< 1)	ND (< 1)	ND (< 2)	ND (< 1,000)
Lake Mathews	ND (< 1)	ND (< 1)	ND (< 2)	ND (< 1,000)
Diamond Valley Lake	ND (< 1)	ND (< 1)	ND (< 2)	ND (< 1,000)
Lake Skinner	ND (< 1)	ND (< 1)	ND (< 2)	ND (< 1,000)

*Radium-226 DLR = 1 pCi/L
† Radium-228 DLR = 0.5 pCi/L from January 2005 to April 2008, and 1 pCi/L thereafter
‡ Strontium-90 DLR = 1 pCi/L from January 2005 to April 2008, and 2 pCi/L thereafter
§ Tritium DLR = = 200 pCi/L from January 2005 to April 2008, and 1,000 pCi/L thereafter

Gross Beta/Beta Emitters

Metropolitan conducted monitoring for gross beta and beta emitters in the source waters, treatment plant influents, and effluents. The highest gross beta activity (7.4 pCi/L) from 2011 to 2015 was detected at Lake Mathews in November 2011. **Table 3-19** summarizes the gross beta activity levels in the five source water locations. Data show that gross beta levels in Colorado River supplies were well below the screening level of 50 pCi/L, a trigger level for further testing to characterize the water.

Table 3-19. Gross Beta Monitoring Summary for Source Waters, 2011–2015, pCi/L

	Minimum	Maximum	Median*
Whitsett Intake	ND (< 4)	6.3	4.5
San Jacinto Tunnel West Portal	ND (< 4)	6.4	5.4
Lake Mathews	ND (< 4)	7.4	5.5
Diamond Valley Lake	ND (< 4)	4.0	ND (< 4)
Lake Skinner	ND (< 4)	5.5	3.2

* Median values calculated assuming non-detects (NDs) equaled one-half the DLR
DLR = 2 pCi/L through April 2008 and 4 pCi/L thereafter

Summary of Findings for Radionuclides

- To date, remediation efforts near Moab, Utah have removed over 50 percent of the uranium mill tailings pile. Contaminated groundwater from the Moab, Utah mill tailings site remains a potential threat to Colorado River water quality. Further discussion can be found in **Chapter 6**.
- Uranium levels in the source waters were consistently below the California MCL of 20 pCi/L.
- Gross alpha levels in the source waters were consistently below the MCL of 15 pCi/L.
- Radium-226 and radium-228 were not detected in any of the monitoring locations.
- Strontium-90 and tritium activities were below the California DLR of 2 and 1,000 pCi/L, respectively, in all the samples collected during the reporting period.
- Gross beta activities in the source waters and treated waters were well below the trigger level of 50 pCi/L. Higher levels would require further characterization of the water.

Turbidity

Turbidity has been selected for evaluation since the original 1996 CRWSS as it is a regulated constituent used to evaluate the efficiency and effectiveness of water treatment processes and is a general indicator of water quality. High turbidity levels are typically caused by erosion and sediment transport during storm events. Other sources include in-river and riparian areas and urban runoff. High turbidity levels are undesirable because they may mask the presence of microorganisms and interfere with their disinfection.

Water treatment plant filter performance and turbidity requirements are regulated under California's Surface Water Treatment Regulations (Chapter 17, California Title 22) and the Federal IESWTR. Turbidity removal may be achieved through the coagulation-flocculation-sedimentation process followed by filtration. Regulatory compliance regarding turbidity removal at Metropolitan's water treatment plants is covered in detail in **Chapter 5**.

Monitoring Results for Turbidity

Turbidity was monitored monthly at Lake Havasu's Whitsett Intake, San Jacinto Tunnel West Portal, Lake Mathews, and the blended storage reservoirs Diamond Valley Lake and Lake Skinner. The monthly data were used to generate a time series plot to identify trends in source water quality (**Figure 3-24**). **Table 3-20** provides maximum, median, and minimum source water turbidity data taken between 2011 and 2015.

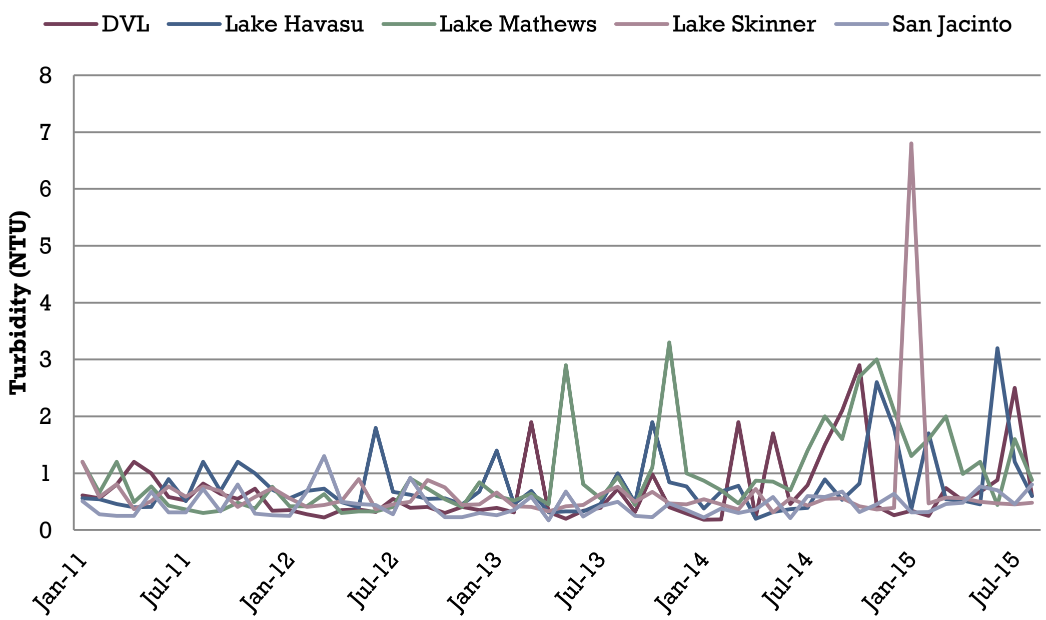


Figure 3-24. Turbidity Levels in Source Waters, 2011–2015

Table 3-20. Turbidity Summary for Source Waters, 2011–2015, NTU

	Minimum	Maximum	Median
Whitsett Intake	0.20	3.20	0.65
San Jacinto Tunnel West Portal	0.17	1.30	0.43
Lake Mathews	0.30	3.30	0.79
Diamond Valley Lake	0.18	2.90	0.44
Lake Skinner	0.31	6.80	0.50

Figure 3-24 shows turbidity trends along the CRA system, as well as the terminal blend reservoirs. In September 2014, Weymouth and Diemer plant influents received elevated turbidity levels (above 3 NTU). From further investigation, Metropolitan observed erosion of exposed shorelines along the Lake Mathews inlet channel (**Figure 3-25**). During this period, Lake Mathews was receiving less flow (750 cfs) than was leaving the reservoir (1,050 cfs) as lake levels continued to decrease. The increased turbidity from the inlet channel led to suspension of fine sediment in the lake's

Figure 3-25. Erosion at Lake Mathews Inlet, September 30, 2014

water column. Lake operations were modified to minimize the turbidity leaving the outlet tower to the receiving treatment plants.

In general, turbidity values in all source waters were low and stable over the evaluation period. The median turbidity values for all source water monitoring locations were less than 1 NTU (**Table 3-20**). Conditions during the reporting period were relatively dry. However, Lake Skinner experienced heavy rainfall in December 2014 resulting in almost 5 inches of precipitation with turbidity spiking to 6.8 NTU in January 2015.

Summary of Findings for Turbidity

- With the exception of one month, when turbidity spiked to 6.8 NTU at Lake Skinner, source water turbidity data from 2011–2015 were less than 4 NTU for all monitoring locations.
- Median source water turbidity levels for all monitoring locations were less than 1 NTU.

Organic Compounds

Total Organic Carbon

Total organic carbon (TOC) has been selected for evaluation since the initial CRWSS as it is regulated under the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rules, it is a DBP precursor, and it is known to be present in Colorado River water. TOC reacts with disinfectants during water treatment to form DBPs. Decayed plant material, algae, and organics from wastewater are potential sources of TOC and can be contributed from the general watershed, urban and agricultural runoff, and wastewater. Another DBP precursor indicator is specific ultraviolet light absorbance (SUVA), which is the ratio of ultraviolet light absorbance at 254 nanometers to dissolved organic carbon (DOC). This is a general indicator of the presence of humic materials in drinking water that may contribute to DBP formation. In general, Colorado River water has less humic materials than SWP water; hence, Colorado River water has a lower carbonaceous DBP formation potential than SWP water.

Water agencies began complying with new regulations to protect against DBP exposure in January 2002. The Stage 1 D/DBP Rule required water systems to comply with new MCLs and a treatment technique (TT) to remove TOC. USEPA then promulgated the Stage 2 D/DBP Rule in January 2006, which makes regulatory compliance more challenging for DBPs as compliance is determined on a locational basis rather than on a distribution system-wide basis. For Metropolitan, Stage 2 compliance began in April 2012.

The USEPA-prescribed TT for TOC is enhanced coagulation. Metropolitan monitors TOC weekly at the water treatment plant influent and combined filter effluent in compliance with the Stage 1 D/DBP Rule. If plant influent TOC is greater than 2.0 mg/L and alkalinity is greater than 60 mg/L then the enhanced coagulation requirement of the Stage 1 D/DBP Rule must be met. As an alternative to enhanced coagulation, if the finished water SUVA is less than 2.0 L/mg-m, then enhanced coagulation is not required. The Stage 1 D/DBP Rule has another alternative compliance criterion, which is conducting jar tests to demonstrate that the source water is non-amenable to enhanced coagulation. See **Chapter 5** for a greater discussion on Stage 1 and 2 D/DBP Rules and Metropolitan's compliance strategies.

Metropolitan has a source and finished water monitoring program for TOC. Source water samples are collected monthly from the Whitsett Intake at Lake Havasu, San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, and Diamond Valley Lake and analyzed for TOC. Generally, the water treatment plant influent and effluent are monitored weekly for TOC.

Monitoring Results for TOC

Table 3-21 provides a summary of TOC data for the source water monitoring sites. TOC concentrations at Whitsett Intake ranged from 2.18–3.44 mg/L. TOC concentrations at the San Jacinto Tunnel West Portal ranged from 2.52–4.30 mg/L. Previous watershed sanitary surveys (2000 and CRWSS 2005 Updates) showed unexplained increases in TOC between Whitsett Intake and the San Jacinto Tunnel West Portal, ranging from 9–39 percent. For the CRWSS 2010 Update, TOC levels did not appear to be increasing from Whitsett to San Jacinto Tunnel West Portal. However, according to TOC levels shown in years 2011–2015 (**Figure 3-26**), there is a slight increase in TOC levels. The highest measurement of TOC in the source waters was 4.30 mg/L, measured at the San Jacinto Tunnel West Portal in August 2014. The average annual TOC levels in the terminal reservoirs are slightly lower than the San Jacinto Tunnel West Portal.

Metropolitan's compliance strategy to meet the enhanced coagulation requirements of the Stage 1 D/DBP Rule have been met by either using the Step 2 method, since 2007, or the 40/30 Alternative Compliance Criteria, when ozone treatment is used. During the reporting period, the Step 2 method was used at Diemer, Skinner, and Weymouth plants until the 3rd quarter of 2011 for Skinner plant and the 2nd quarter of 2015 for Diemer plant, following ozone treatment. With ozone treatment, Diemer and Skinner plants use the 40/30 Alternative Compliance Criteria, which does not require achievement of specified TOC removals when TOC RAA < 4.0 mg/L, alkalinity > 60 mg/L, TTHM RAA ≤ 0.040 mg/L and HAA5 ≤ 0.030 mg/L. Further discussion on Metropolitan's compliance with Stage 1 and 2 D/DBP Rules is provided in **Chapter 5**.

Table 3-21. TOC Summary for Source Waters, 2011–2015, mg/L

	Minimum	Maximum	Median
Whitsett Intake	2.18	3.44	3.00
San Jacinto Tunnel West Portal	2.52	4.30	3.01
Lake Mathews	2.36	3.38	2.97
Diamond Valley Lake	2.18	3.39	2.56
Lake Skinner	2.60	3.34	2.99

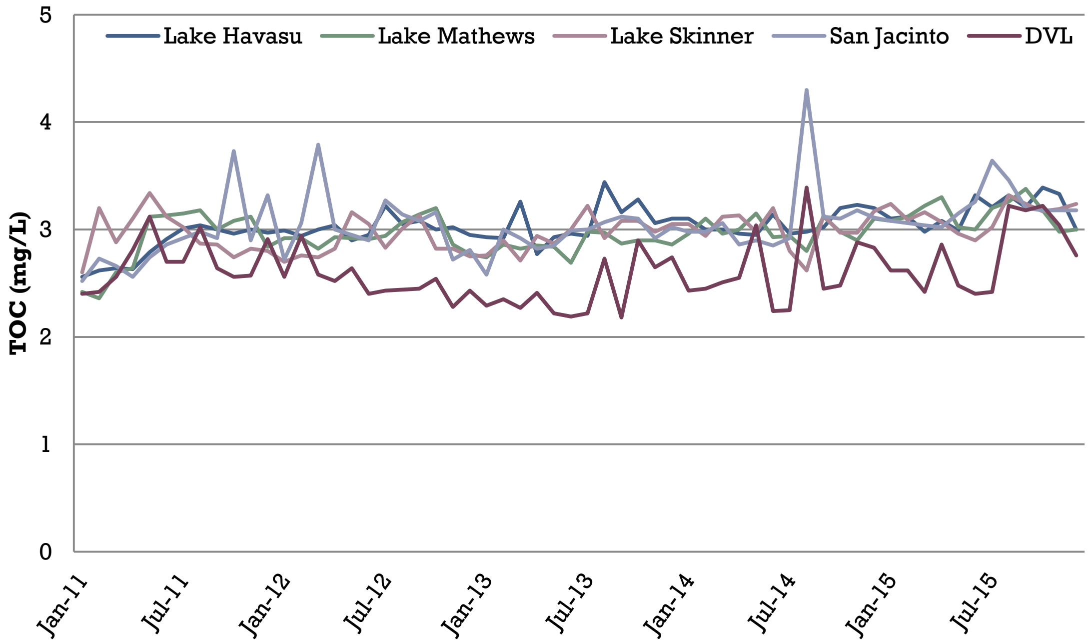


Figure 3-26. TOC Levels in Source Waters, 2011–2015

Summary of Findings for Total Organic Carbon

- The highest measurement of TOC in the source water sampling was 4.30 mg/L measured at San Jacinto Tunnel West Portal in August 2014.
- Median TOC levels within the CRA system ranged between 2.56 and 3.01 mg/L.

N-Nitrosodimethylamine

N-Nitrosodimethylamine (NDMA) has been selected for evaluation since the CRWSS 2005 Update as NDMA is a potential carcinogen that may be regulated by USEPA and DDW in the foreseeable future. NDMA, which is used in the production of rocket fuel, is part of a family of organic chemicals called nitrosamines and is also a byproduct of the disinfection of some natural waters with chloramines. Metropolitan utilizes chloramines as a secondary disinfectant at its treatment plants. Wastewater treatment plant effluent and agricultural runoff can contribute organic material into source waters, which react to form NDMA at water treatment plants. Certain polymers can also contribute NDMA precursor materials. Some NDMA control measures or removal technologies may be required to avoid adverse impacts on southern California drinking water supplies. Metropolitan has been involved in several projects to understand the watershed sources and occurrence of NDMA precursors in Metropolitan source waters, and to develop treatment strategies to minimize NDMA formation in drinking water treatment plants and distribution systems. Special studies conducted at Metropolitan have shown removal of NDMA using advanced oxidation processes. Ultraviolet light-mediated oxidation has shown to be effective in removing NDMA from water.

USEPA considers NDMA to be a probable human carcinogen and placed NDMA in the Unregulated Contaminant Monitoring Regulation 2 (UCMR 2) in 2007, the Contaminant Candidate List 3 (CCL3) in 2009, and the draft CCL4 in 2015. DDW also considers NDMA to be a probable human carcinogen. DDW has not established an MCL for NDMA. However, in 1998 DDW established a notification level of

0.00001 mg/L, or 10 ng/L. Occurrences of NDMA in treated water supplies at concentrations greater than 10 ng/L are recommended to be included in the utility's annual Consumer Confidence Report. In December 2006, OEHHA set a public health goal of 3 ng/L for NDMA.

In April 2009, Metropolitan conducted a study with the Southern Nevada Water Authority and wastewater dischargers in the Las Vegas Valley to determine the occurrence of NDMA and its precursors in lower Colorado River source waters (from the Colorado River and Las Vegas Wash inflows into Lake Mead through Hoover Dam and a few locations between Hoover Dam and Whitsett Intake). NDMA precursors are of concern as Metropolitan utilizes chloramination at its water treatment plants. However, NDMA was not found to be present in any of the samples that were collected over the two-year study. The MRL for NDMA during this period was 2 ng/L.

Monitoring Results for NDMA

Metropolitan monitored its source waters (at treatment plant influents) on a quarterly basis from 1999 to 2011. Metropolitan does not plan to continue monitoring NDMA at plant influents and, therefore, does not intend to include source water NDMA data in future CRWSS updates. Influent samples for Metropolitan's three blend plants (Diemer, Skinner, and Weymouth plants) were all less than 2 ng/L in 2011 (**Table 3-22**). Studies have shown that NDMA is formed when NDMA precursors react with chloramines over time during water treatment and in the distribution system. See **Chapter 5** for NDMA monitoring data from Metropolitan's water treatment plant effluents and distribution system.

Table 3-22. Summary of NDMA Monitoring Data in Source Waters, 2011, ng/L

Location	Minimum	Maximum	Average
Lake Skinner Outlet	ND (< 2)	ND (< 2)	ND (< 2)
Weymouth Plant Influent	ND (< 2)	ND (< 2)	ND (< 2)
Diemer Plant Influent	ND (< 2)	ND (< 2)	ND (< 2)

MRL = 2 ng/L using USEPA Method 521

Summary of Findings for NDMA

- NDMA has not been detected in Metropolitan source waters during this reporting period.
- All plant influent samples were ND, indicating that NDMA is formed as a disinfection byproduct and does not occur in the source water.

Pharmaceuticals and Personal Care Products

Pharmaceuticals and personal care products (PPCPs) have been selected for evaluation since the CRWSS 2005 Update as the occurrence and fate of PPCPs has emerged as an issue for source water quality and as a subject of public concern. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, and cosmetics. PPCPs typically find their way into drinking water source waters via sewage outflows, due to inadequate removal of PPCPs by wastewater treatment plants, although veterinary antibiotics (and subsequent metabolites) can emanate from farm and manure applications.

PPCPs have been detected in the aquatic environment over the past few decades. Reasons for their increased detection include recent advances in analytical methods and higher wastewater treatment plant effluent loadings into receiving waters due to population growth. PPCPs, together with other organic wastewater contaminants (OWCs) such as pesticides and polycyclic aromatic hydrocarbons

(PAHs), are released into the environment after passing through wastewater treatment processes, which are typically not designed to remove these classes of compounds. As such, the broader class of constituents of emerging concern (CEC) is included in this section. Some of these compounds are known or suspected to be endocrine disrupting compounds (EDCs). PPCPs and EDCs have been reported in wastewater-impacted bodies of water throughout the United States at low part-per-trillion (ppt or ng/L) levels [26] [27]. Though these levels of PPCPs and EDCs may affect the aquatic environment and wildlife, the impact on human health is widely considered insignificant [28] [29].

PPCPs are not defined by a specific health effect but rather include all products that are used as pharmaceuticals or personal care products. However, the detection of PPCPs in sources of drinking water presents utilities with public perception issues; therefore, monitoring programs may be needed regardless of the low probability of harmful health effects.

In June 2010, a Science Advisory Panel, convened by the State Water Resources Control Board (SWRCB), provided recommendations for monitoring CECs in municipal recycled water used for groundwater recharge/reuse and landscape irrigation, and for additional research on CEC monitoring [30]. In accordance with the Science Advisory Panel recommendations, SWRCB amended its Recycled Water Policy effective April 25, 2013.

DDW included guidance on monitoring for PPCPs and EDCs for groundwater recharge projects in its Groundwater Recharge Reuse Regulations, effective June 18, 2014 [31]. This regulation requires that recycled water projects monitor for indicator compounds that characterize the presence of pharmaceuticals, endocrine disrupting chemicals, personal care products, and other indicators of the presence of municipal wastewater. Currently, there are no regulatory federal requirements for PPCPs in drinking water.

Monitoring Results for PPCPs

Metropolitan had implemented a monitoring program since 2007 to determine the occurrence of PPCPs in all five of Metropolitan's treatment plant effluents, as well as in source waters from both the Colorado River and SWP systems. The monitoring frequency was semi-annual in 2011, and annual from 2012 to 2015. In 2013, the PPCP monitoring program was expanded to include the analysis of sucralose, an artificial sweetener used in a wide range of foods and beverages. Sucralose was used as a wastewater indicator to estimate the contribution of treated wastewater effluents to Metropolitan's source waters. The PPCP results in the source waters that use either Colorado River water or blended Colorado River water and SWP water are shown in **Table 3-23** from 2011 to 2014, as tested by Metropolitan, and **Table 3-24** for 2015, as reported by the contract laboratory. Results indicate that PPCPs and EDCs are at low ng/L levels in source water samples. The two most commonly detected PPCPs (excluding sucralose) were DEET (detected in 80 percent of samples at maximum concentration of 7.2 ng/L), followed by caffeine (75 percent, 16.8 ng/L maximum). Diuron, which is a common herbicide used in California, had the highest detected concentration among PPCPs (excluding sucralose) of 222 ng/L, with a detection frequency of 60 percent.

In addition to monitoring efforts, Metropolitan was a co-Principal Investigator for a Water Research Foundation project entitled "*Evaluation of Analytical Methods for EDCs and PPCPs via Inter-laboratory Comparison*," which was completed in 2011 [32]. The final project report was published in 2012. Standard Method 6810 for Pharmaceuticals and Personal Care Products, which was based on this project, was approved and published in 2013 [33].

Table 3-23. Detected PPCPs and OWCs in Raw Water Samples, 2011-2014 (n = 4)†*

Analyte	Use	Number of Samples	Detection Frequency (percent)	Minimum Concentration (ng/L)	Maximum Concentration (ng/L)	Median Concentration (ng/L)
Atrazine	Herbicide	12	33	< 1	1.9	< 1
Caffeine	Stimulant	20	75	< 5	17	6.0
Carbamazepine	Anti-convulsant	20	15	< 1	2.4	< 1
DEET (Diethyltoluamide)	Insect repellant	20	80	< 2	7.2	3.0
Diuron	Herbicide	20	60	< 5	220	11
Primidone	Anti-convulsant	20	50	< 2	3.2	< 2
Sulfamethoxazole	Antibiotic	20	35	< 1	8.7	< 1
Sucralose‡	Artificial sweetener	8	100	300	800	600
TCEP (tris 2- chlorethyl)-phosphate	Flame retardant	20	20	< 3	5.7	< 3

* Those analytes that were not detected are not shown in this table. Nineteen PPCPs and OWCs were analyzed in 2011, 20 were analyzed in 2012, and 11 were analyzed in 2013 and 2014.

† The four sites were San Jacinto Tunnel West Portal from the CRA, Lake Mathews, Diamond Valley Lake, and Lake Skinner.

‡ Sucralose was added to the list of analytes in 2013.

Table 3-24. Detected PPCPs and OWCs in Raw Water Samples, 2015 (n = 7)†*

Analyte	Use	Number of Samples	Detection Frequency (percent)	Minimum Concentration (ng/L)	Maximum Concentration (ng/L)	Median Concentration (ng/L)
Acesulfame-K	Artificial sweetener	7	100	84	210	92
Caffeine	Stimulant	7	43	<5	17	<5
Propylparaben	Anti-bacterial	7	14	<5	5	<5
Sucralose	Artificial sweetener	7	100	290	830	710

* Those analytes that were not detected are not shown in this table. Ninety-five PPCPs and OWCs were analyzed in 2015 by a contract laboratory.

† The seven sites were San Jacinto Tunnel West Portal from the CRA, Lake Mathews, Diamond Valley Lake, Lake Skinner, Diemer plant influent, Skinner plant influent, and Weymouth plant influent.

Summary of Findings for PPCPs

- Metropolitan's PPCP monitoring program found PPCPs and OWCs at low ng/L levels in source water samples; much lower than applicable MCLs and orders of magnitude lower than therapeutic doses, which are in milligrams per dose.
- The two most commonly detected PPCPs (excluding sucralose) were DEET (detected in 80 percent of samples at maximum concentration of 7.2 ng/L), followed by caffeine (75 percent, 16.8 ng/L maximum). Diuron, which is a common herbicide used in California, had the highest detected concentration among PPCPs (excluding sucralose) of 222 ng/L, with a detection frequency of 60 percent.

- Sucralose data from 2013 to 2015 indicated that treated wastewater discharges comprised approximately one to three percent of Metropolitan's source waters, based on a previously published average value of 27,000 ng/L in treated wastewater effluents [34].
- The impact of these extremely low PPCP levels on human health is widely considered insignificant, though toxicological studies to support that assumption have not been conducted.

Microbiological Constituents

Coliforms

Coliforms have been selected for evaluation since the original CRWSS because they are indicative of the general microbial quality of water. *E. coli* and fecal coliforms are more specific than total coliforms as indicators of fecal contamination from humans and other warm-blooded animals. Principal sources of potential fecal contamination include runoff (i.e., stormwater, urban, and agricultural), body contact recreation, wastewater discharges, and migratory bird deposits. Total coliforms are also used as surrogates for pathogenic microorganisms, although their correlation may be poor.

In March 2008, California Title 22 required monthly reporting to DDW of total coliforms and fecal coliforms or *E. coli* levels in the raw water entering the treatment plants. Metropolitan initially monitored all three constituents but discontinued fecal coliform monitoring in 2010. Although total coliform levels are being analyzed and reported, only *E. coli* levels are used to make operational decisions. Metropolitan assesses microbiological data based on acceptable levels to reduce potential impacts to human health. For *E. coli*, an action level is triggered at or above 100 CFU per 100 mL, per Metropolitan's operational permit. An action level may result in operational changes to reduce the *E. coli* levels or increase the level of treatment conducted to achieve 4-log removal of *Giardia* and 5-log removal of viruses.

Monitoring Results for Coliforms

The total coliform levels indicated in this report update cannot be compared with the total coliform levels reported in the CRWSS 2010 Update because the former MTF analytical method produces lower total coliform results than the current MF-MI method. The methods were switched in July 2006.

Lake Havasu at Whitsett Intake

Metropolitan conducted monthly sampling at the Whitsett Intake influent on the CRA. The depth at which samples were collected at the Whitsett Intake monitoring site switched from 12 m to 3 m in 2015. Summary data for total coliform and *E. coli* are presented in **Table 3-25**. **Appendix D** shows the dataset from 2011–2015. **Table 3-25** shows that the five-year 90th percentile for total coliform and *E. coli* levels were 1,400 CFU and 1 CFU per 100 mL, respectively. The 5-year median total coliform level was 210 CFU per 100 mL.

Table 3-25. Bacteriological Summary for Lake Havasu at Whitsett Intake, 2011–2015, CFU per 100 mL

	Total Coliform	*E. coli*
No. of Samples	60	60
Minimum	3	< 1
10th Percentile	14	< 1
Median	210	< 1
90th Percentile	1,400	1
Maximum	13,000	2

Lake Mathews

Metropolitan conducted monthly source water monitoring downstream of the Lake Mathews outlet tower, prior to the chlorination point at the headworks. Summary data for total coliform and *E. coli* are presented in **Table 3-26**. **Appendix D** shows the data set from 2011–2015. The data shows that the overall *E. coli* levels were well below the action level for *E. coli* of 100 CFU per 100 mL at the outlet with the five-year median of 3 CFU per 100 mL and the 90th percentile of 43 CFU per 100 mL. This is similar to the *E. coli* levels reported in the CRWSS 2010 update where the five-year median for *E. coli* was 4 CFU per 100 mL and the 90th percentile was 50 CFU per 100 mL. Seasonal trends for *E. coli* were pronounced for the lake outlet (**Figure 3-27**) with higher elevations during winter and spring periods; one elevated *E. coli* level (410 CFU per 100 mL) was observed in December 2014 at the lake outlet. Moderate populations of gulls have been observed at times roosting on the lake; however, the gull presence has not correlated with any fluctuations in *E. coli* levels. Metropolitan noted an influx of gulls at Lake Mathews in January 2014 and February 2015 but was not able to confirm a watershed source.

Local runoff or in-reservoir operational changes may have disrupted some of the natural seasonal trending for total coliform and *E. coli* at the lake. Under drought conditions and low SWP allocations, Metropolitan relied on storage reserves to meet water demands. During the reporting period, storage in Lake Mathews was gradually depleted and in late 2014 reached the lowest elevation level, which coincided with the high *E. coli* concentration in December 2014. Any increases in total coliform counts could potentially be attributed to increases in water temperature, soil erosion (as experienced with lower lake levels during dry periods), or watershed runoff.

Table 3-26. Bacteriological Summary for Lake Mathews Outlet, 2011–2015, CFU per 100 mL

	Total Coliform	*E. coli*
No. of Samples	60	60
Minimum	< 1	< 1
10th Percentile	38	< 1
Median	450	3
90th Percentile	3,100	43
Maximum	47,000	410

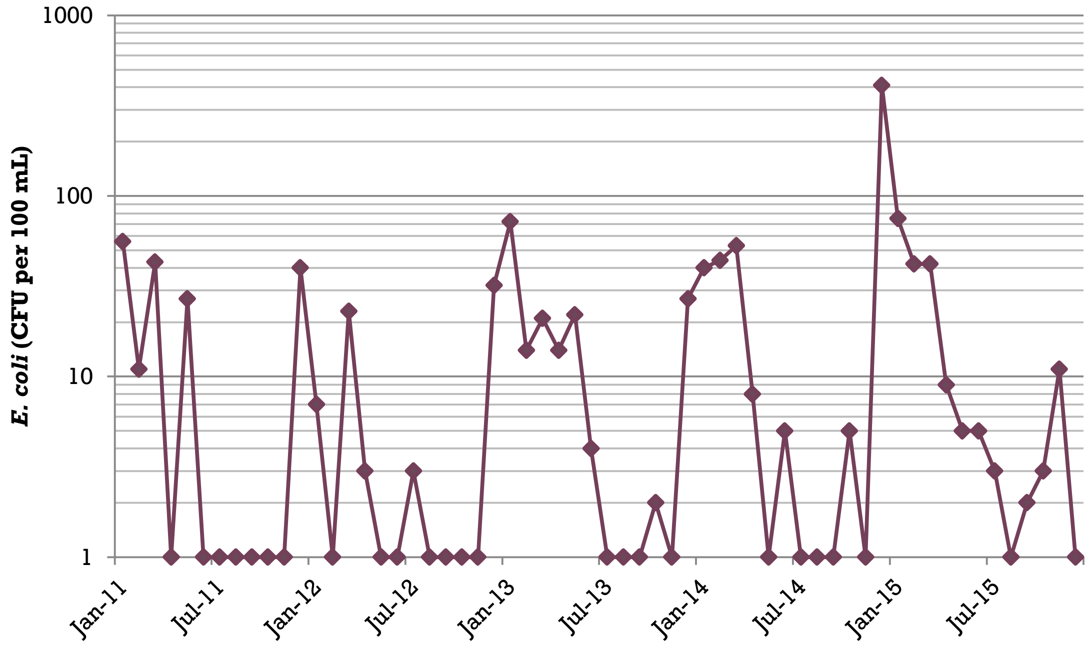


Figure 3-27. E. coli Levels at Lake Mathews Outlet, 2011–2015

Diamond Valley Lake

Bacteriological samples were collected monthly at either Diamond Valley Lake's Inlet/Outlet Tower tap or at the West Basin Center at a depth of 12 meters to capture the outlet of the lake. Summary data for total coliform and *E. coli* are presented in **Appendix D**. **Table 3-27** and **Appendix D** shows the data set from 2011–2015. The 5-year data shows that the median *E. coli* levels were well below the action level for *E. coli* of 100 CFU per 100 mL. The 5-year median total coliform level was 120 CFU per 100 mL. As discussed, the increase in total coliform counts may be attributed to dry conditions with increasing lake water temperatures. During the reporting period, Diamond Valley Lake experienced record-low storage levels resulting in increased water temperatures. Warmer temperatures can lower dissolved oxygen levels, which support algal activity and increase organic decomposition, both of which can increase the survival and growth of bacteria.

Table 3-27. Bacteriological Summary for Diamond Valley Lake Inlet/Outlet Tower, 2011–2015, CFU per 100 mL

	Total Coliform	*E. coli*
No. of Samples	59	59
Minimum	1	< 1
10^{th} Percentile	17	< 1
Median	120	< 1
90^{th} Percentile	1,700	3
Maximum	79,000	17

Lake Skinner

Table 3-28 provides a summary of the total coliform and *E. coli* samples taken at the Lake Skinner outlet tower prior to chlorination. Overall, the median and 90th percentile *E. coli* levels were low at the Skinner plant influent (**Table 3-28**). The median total coliform level of 550 CFU per 100 mL and *E. coli* level of 2 CFU per 100 mL, were recorded at the Lake Skinner outlet tower.

Table 3-28. Bacteriological Summary for Lake Skinner, 2011–2015, CFU per 100 mL

	Total Coliform	***E. coli***
No. of Samples*	140	140
Minimum	21	< 1
10th Percentile	50	< 1
Median	550	2
90th Percentile	4,400	6
Maximum	49,000	32

* Samples taken prior to chlorination

Diemer, Skinner, and Weymouth Water Treatment Plant Influents

Coliform samples are collected weekly at the water treatment plant influents. A summary of bacteriological test results at the influents of the Diemer, Skinner, and Weymouth plants are presented in **Table 3-29**, **Table 3-30**, and **Table 3-31**, respectively. Results of coliform tests performed from January 2011 through December 2015 at the plants indicate that influent *E. coli* levels were well below the action level for *E. coli* of 100 CFU per 100 mL. Median influent total coliform levels of 14, 650, and 200 CFU per 100 mL and *E. coli* levels of < 1, 2, and < 1 CFU per 100 mL were recorded for the Diemer, Skinner, and Weymouth plants, respectively. Chlorination of the CRA and lakes began in January 2008, thereby reducing the median *E. coli* levels to non-detectable to low levels. The LT2ESWTR Round 2 monitoring for *Cryptosporidium*, *E. coli*, and turbidity began April 2015 and will continue through March 2017.

Table 3-33 shows the April 2015 to December 2015 mean *E. coli* results are < 1, 2, and < 1 CFU per 100 mL for Diemer, Skinner, and Weymouth, respectively.

Table 3-29. Bacteriological Summary for Diemer Plant Influent, 2011–2015, CFU per 100 mL

	Total Coliform	***E. coli***
No. of Samples	259	259
Minimum	< 1	< 1
10th Percentile	< 1	< 1
Median	14	< 1
90th Percentile	1,100	< 1
Maximum	65,000	3

Table 3-30. Bacteriological Summary for Skinner Plant Influent, 2011–2015, CFU per 100 mL

	Total Coliform	*E. coli*
No. of Samples	261	261
Minimum	21	< 1
10th Percentile	70	< 1
Median	650	2
90th Percentile	2,700	6
Maximum	49,000	32

Table 3-31. Bacteriological Summary for Weymouth Plant Influent, 2011–2015, CFU per 100 mL

	Total Coliform	*E. coli*
No. of Samples	260	260
Minimum	< 1	< 1
10th Percentile	< 1	< 1
Median	200	< 1
90th Percentile	3,000	< 1
Maximum	34,000	13

Summary of Findings for Coliforms

- The primary indicator of the microbial quality of water is *E. coli* for Metropolitan's source waters; total coliform levels may provide general trending of the microbial quality of water.
- Overall, the median *E. coli* levels were low (< 10 CFU per 100 mL) for Metropolitan's source waters.
- The median total coliform levels were slightly higher than levels reported in the CRWSS 2010 Update. This may be partially due to the switch in analytical method in 2006 from MTF to MF-MI. However, dry conditions during this period could also have contributed to increased total coliform and *E. coli* levels. In the summers of 2013, 2014, and 2015, monthly total coliform levels were observed to be lower at Diemer and Weymouth influents possibly due to lake chlorination.

Pathogens

Cryptosporidium and *Giardia* have been selected for evaluation since the original CRWSS as they are regulated in drinking water under the IESWTR and Colorado River water is known to be vulnerable to numerous potentially contaminating activities, such as recreation, urban runoff, and wastewater discharges. *Cryptosporidium* is regulated under the IESWTR, requiring 2-log reduction, and under the LT2ESWTR, with a potential requirement for additional treatment determined by source water concentrations of *Cryptosporidium*. The IESWTR also requires that treatment, in combination with disinfection, consistently achieve 3-log removal/inactivation of *Giardia*.

Monitoring Results for Pathogens

During the period covered by this report, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples. *Giardia* was detected once, at a concentration of 1 cyst per 10 L, in the Weymouth plant influent sample collected in September 2011.

During the period from April 2015 to December 2015, monthly monitoring of treatment plant influents was mandated and reported under the LT2ESWTR Round 2 monitoring. The Round 2 monitoring will continue through March 2017. As required by LT2ESTWR, *Cryptosporidium* concentrations, turbidity, and *E. coli* concentrations were monitored. *Cryptosporidium* oocysts were not detected in any of the treatment plant influents receiving Colorado River water.

Summary of Findings for Pathogens

Table 3-32 shows one *Giardia* cyst was detected in the Weymouth plant influent in September 2011; none were detected in the Weymouth plant effluent.

Table 3-32. Protozoa Summary at Water Treatment Plant Influents, 2011–2015

Treatment Plant	No. of samples	No. of *Cryptosporidium* positive samples	No. of *Giardia* positive samples	Concentration
Diemer	60	0	0	NA
Skinner	60	0	0	NA
Weymouth	60	0	1[a]	1 per 10 L

NA, Not applicable
[a] Occurred in September 2011

Table 3-33 shows the intermediate results from April 2015 to December 2015 of the LT2ESWTR Round 2 monitoring; monitoring will continue through March 2017. The mean *E. coli* results are < 1, 2, and < 1 for Diemer, Skinner, and Weymouth, respectively.

Table 3-33. LT2ESWTR Round 2 Monitoring Results for Metropolitan's Water Treatment Plant Influents, April 2015–December 2015

Treatment Plant	*Cryptosporidium* RAA[a] (oocysts/L)	Estimate Bin classification[b]	Mean recovery[c]	Mean turbidity (NTU)	Mean *E. coli*
Diemer	0	Pending	41%	1.00	< 1
Skinner	0	Pending	61%	0.44	2
Weymouth	0	Pending	51%	0.80	< 1

[a] Running annual average
[c] Based on average of duplicate matrix spike samples for each treatment plant

This page intentionally left blank

4 Potential Contaminant Sources

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Chapter 4 Potential Contaminant Sources

Introduction

For the 2015 Colorado River Watershed Sanitary Survey (CRWSS) update, nine potential contaminant sources (PCSs) have been selected for review. These PCSs are as follows: 1) *Erosion, Urban and Stormwater Runoff*, 2) *Recreation*, 3) *Municipal and Industrial Dischargers*, 4) *Spills*, 5) *Landfills*, 6) *Leaking Underground Storage Tanks*, 7) *Septic Systems*, 8) *Agriculture,* and 9) *Fires*. Due to the large area covered by the Colorado River watershed, the PCS discussions will be separated into the following geographical regions and watersheds: Lake Mohave and Lake Havasu, the Colorado River Aqueduct (CRA), Lake Mathews, Diamond Valley Lake, and Lake Skinner. Although the focus of the PCS discussion is on the 5-year reporting period (2011–2015), updates through the writing of this report are included for completeness in summarizing discussions regarding regulatory oversight of PCSs and key studies that are relevant to the contaminant source.

The PCS discussion for each geographical region includes *Occurrence in Watershed*, *Regulation and Management*, and *Studies and Monitoring* (when available). Each geographical region's section closes with a *Summary* discussion and provides *Recommendations*, as appropriate. This chapter begins with a brief discussion of each of the PCSs, their primary constituents of concern, and any applicable federal regulations. As noted above, each geographical region will include *Regulation and Management* as regulations may be region specific. Follow-up actions and recommendations to minimize the impact of PCSs are also summarized in **Chapter 7**.

As covered in the CRWSS 2010 Update, the CRWSS 2015 Update will continue to focus on watershed areas below Hoover Dam. The area above Hoover Dam will continue to be monitored for any significant water quality issues, but will not be included in this chapter for discussion as an independent geographical region. Currently, Metropolitan closely coordinates with Colorado River stakeholders on critical water quality issues in the Lake Mead and Upper Colorado River watershed areas. These issues include the Colorado River Basin Salinity Control Program; uranium mill tailings removal near Moab, Utah; energy exploration and development in the Colorado River basin; perchlorate remediation in Henderson, Nevada; wastewater management in the Las Vegas Valley; and Las Vegas Wash stabilization program. **Chapter 6** discusses these projects and other major watershed management activities that Metropolitan is currently involved with related to preserving the quality of its source water supplies.

This chapter will focus on the watersheds along the Colorado River downstream of Hoover Dam and upstream of Metropolitan's Whitsett Intake on Lake Havasu, the area along the CRA between Lake Havasu and Lake Mathews, and local watersheds of Metropolitan's reservoirs receiving Colorado River water.

Contaminant Sources

As previously described, nine PCSs have been selected for review: Erosion, Urban and Stormwater Runoff; Recreation; Municipal and Industrial Dischargers; Spills; Landfills; Leaking Underground Storage Tanks; Septic Systems; Agriculture; and Fires. Not all PCSs will be discussed for each geographical region as the contaminating activity does not occur or does not pose a potential water quality threat to Metropolitan at this time. **Table 4-1** provides a summary of the PCSs reviewed for each geographical area.

Table 4-1. Summary of PCSs and Geographical Regions Reviewed

Watershed	Erosion, Urban and	Recreation	Municipal and Industrial	Spills	Landfills	Leaking Underground	Septic Systems	Agriculture	Fires
Lake Mohave and Lake Havasu	✓	✓	✓	✓	✓	✓	✓	✓	✓
Along CRA	✓		✓	✓	✓	✓		✓	
Lake Mathews	✓	✓		✓	✓	✓	✓	✓	✓
Lake Skinner	✓	✓		✓		✓	✓	✓	✓
Diamond Valley Lake	✓	✓		✓					✓

Erosion, Urban and Stormwater Runoff

Erosion, urban and stormwater runoff all occur by surface water flows. In the context of this sanitary survey, erosion is the transport of solids (sediment, soil, rock, and other particulate matter) from various locations in the watershed into streams, rivers, and lakes. Erosion is a natural process, but it has been increased dramatically by human land use, especially agricultural practices and urban sprawl. Land that is used for agriculture generally experiences a significantly greater rate of erosion than that of land under natural vegetation or land used for sustainable agricultural practices.

The source of dry weather urban runoff is predominantly from irrigation of lawns, car washing, and hosing of hardscape. In most urbanized areas, runoff flow is continuously generated. Stormwater runoff is of relatively short duration and can have highly variable pollutant concentrations. The magnitude of storm events is a factor in the quantity of pollutants entering waterbodies. The first storm of the rain season produces the "first flush," which is typically the time at which maximum concentrations of contaminants are transported through the watershed. Urban and stormwater runoff are the primary mechanisms that transport pollutants originating from the other contaminant sources (recreational activities, spills, agriculture, and fires) into water storage reservoirs.

Constituents of concern that may erode naturally into the Colorado River include aluminum, boron, total dissolved solids (TDS), sulfate, nutrients, turbidity, and radionuclides (such as uranium and gross alpha). The occurrence of these constituents in Colorado River water is discussed in **Chapter 3**. Urban and stormwater runoff can contain nutrients, pesticides, herbicides, oil and grease, surfactants, bacteria and pathogens from human and animal sources, and other pollutants picked up from city streets, saturated turfs, and other surface areas. These pollutants can then impact the downstream waterbody and pose a risk to human health and the environment. Typical levels of total coliform and fecal coliform in urban stormwater runoff range from 10,000–10,000,000 CFU per 100 mL and 10,000–1,000,000 CFU per 100 mL, respectively [35].

Water pollution degrades surface waters making them unsafe for drinking, fishing, swimming, and other activities. As authorized by the federal Clean Water Act (CWA), the U.S Environmental Protection Agency (USEPA) governs point source and nonpoint source pollution in the watersheds. The National Pollution Discharge Elimination System (NPDES) Stormwater Program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. In developed areas, polluted stormwater runoff from industrial, municipal, and other facilities is commonly transported through municipal separate storm sewer systems (MS4s), from which it is often discharged untreated into local waterbodies. The NPDES Program regulates stormwater discharges from MS4s, construction activities, and industrial activities. To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a permit.

The MS4 regulations were developed in two phases: The Phase I regulation was promulgated in 1990 for cities or contiguous unincorporated urban areas with populations greater than 100,000 people and the Phase II regulation was promulgated in 1999 for cities with populations less than 100,000 people (typically small municipalities).

The NPDES Program is designed to control pollutants associated with stormwater discharges through the issuance of permits that specify the conditions under which discharges to surface waters are allowed. The six MS4 program elements include the following [36]:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Runoff Control
- Pollution Prevention/Good Housekeeping

In California, the requirements of the MS4 permit are established by the Regional Water Quality Control Boards (RWQCB), under direction of the State Water Resources Control Board (SWRCB). The RWQCB jurisdictions are based on watershed boundaries. The SWRCB adopted the Phase II Small MS4 General Permit (Order No. 2013-0001-DWQ) on February 5, 2013, which became effective July 1, 2013.

In contrast to point source pollution, nonpoint source pollution does not originate from direct identifiable sources and instead consists of polluted runoff from diffuse and distributed sources over a watershed landscape. However, as with point source pollution, nonpoint source runoff is often conveyed through municipal storm drain systems and discharged into surface waters. Under these conveyance conditions, nonpoint source pollution is regulated in the same manner as point source pollution.

Under Section 303(d) of the CWA, USEPA requires states to identify impaired waterbodies and to develop a total maximum daily load (TMDL) for the pollutants not meeting the water quality standards. A TMDL specifies the maximum amount of a pollutant, or loading capacity, that a waterbody can receive and still safely meet water quality standards. The allowable loads are assigned appropriately for point and nonpoint sources. As described above, the NPDES Program manages point source and nonpoint source contributions to pollutant loadings. In addition, nonpoint source pollution is also managed through the development of state-managed nonpoint source pollution control programs, water quality management plans for critical areas, and other source water protection planning efforts.

Recreation

There are extensive and varied recreational activities occurring throughout the entire Colorado River watershed. Recreation occurs throughout the year in the watershed, with the highest concentration during the summer months and includes both body contact and non-body contact activities. Body contact recreation includes swimming, fishing, personal watercraft, and rafting. Non-body contact recreation includes boating, picnicking, camping, trail use, horseback riding, biking, off-highway vehicle use, and special public events.

Body contact recreation can result in direct transmission of microbial contamination to source water through pathogens in human waste discharges. Contaminants of concern from body contact recreation include microbial constituents such as bacteria, viruses, and protozoa. Human exposure to microbial contamination can cause gastrointestinal disorders, infections, and the risk of other illnesses.

Non-body contact recreation may result in indirect transmission of contamination to source water. Activities associated with the use of boats or personal watercraft can introduce petroleum products, wastewater, and human waste into the water. In addition, equestrian use can result in the leaching of nutrients and microorganisms into surface water and groundwater when water runoff seeps through horse manure. General recreational uses can also impact water quality by introducing pollutants such as pharmaceuticals and personal care products (PPCPs), cleaning products, and dishwater (greywater).

Similar to landfills, recreation parks are a concern as they can provide primary food sources for bird species, such as gulls, which tend to feed at the landfills and parks during the day and roost on surface waters at night. Gull roosting can cause bacterial and viral contamination of source waters.

Municipal and Industrial Discharges

Municipal and industrial dischargers are located throughout the Colorado River watershed primarily above Metropolitan's Whitsett Intake. The majority of discharges are from wastewater treatment plants, which can impact surface water supplies. Key constituents are pathogenic organisms, nutrients (such as ammonia and phosphorus), oxygen demanding substances, and PPCPs. Municipal and industrial discharges can also increase salinity of receiving waters and introduce disinfection byproduct (DBP) precursors that are carried to downstream water treatment plants.

Wastewater effluents can cause undesirable water quality conditions in the phosphorus-limited Colorado River. An increase in phosphorus levels would stimulate cyanobacteria and algae growth, potentially causing taste and odor issues, filter and intake clogging, toxins, and organic carbon formation.

Much attention has focused recently on PPCPs, which are received by wastewater treatment plants from urban and industrial discharges. Wastewater treatment plants use a variety of treatment processes with varying removal efficiencies, such that in some cases these compounds are not completely removed by the treatment process and are ultimately discharged into surface waters.

Other constituents of concern in wastewater effluent are *N*-nitrosodimethylamine (NDMA) and NDMA precursors. NDMA is a suspected carcinogen that is produced during chlorine disinfection when chloramines react with dimethylamine or other nitrogen-containing compounds in wastewater effluent [37]. NDMA is difficult to remove through the conventional treatment process and can remain in wastewater effluent along with NDMA precursors. NDMA precursors lead to the formation of NDMA through chloramination at water treatment plants downstream of the wastewater effluent discharged into source waters.

Industrial dischargers can impact surface waters by discharging process waters directly into surface water, stormwater runoff from their property into surface water, or indirectly by dumping into ponds that may impact groundwater and ultimately surface water. Key contaminants are specific to the type of industry.

As discussed within the *Erosion, Urban and Stormwater Runoff* PCS, USEPA's NPDES permit program also controls municipal and industrial discharges from point sources if their waste discharge goes directly into surface waters.

Spills

Although toxic or hazardous material spills have occurred throughout the Colorado River watershed, along the CRA, and in the vicinity of Metropolitan's reservoirs, the impact of the spill will depend on its quantity and proximity to the receiving waterbodies. Spills of toxic or hazardous materials are normally associated with industrial operations and/or from accidents on highways, railroads, or other transportation systems. Key spilled constituents in the Colorado River watershed are mainly gasoline, diesel fuel/oil, and various acids.

The National Response Center (NRC) Incident Summaries database was utilized to compile data for the 2015 CRWSS. The NRC is the sole national point of contact for reporting all oil, chemical, radiological, biological, and etiological discharges into the environment in the United States and its territories. The 1990 Federal Oil Pollution Act requires that petroleum product spills causing a sheen on the waterway be reported to the NRC [38]. Chemical spills are regulated by USEPA under the Superfund Amendment Reauthorization Act, the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), the Clean Air Act, and the CWA. The criteria for reporting oil and hazardous substance spills are listed in the Code of Federal Regulations (CFR). Depending on the substance, the reportable quantity ranges from 1 pound to 5,000 pounds.

Accidental raw sewage spills can occur due to leaks in sewer lines, blockages in sewer lines, undercapacity sewer lines, excessive inflows during storms, and power failures at lift stations. Raw sewage can lead to contamination of surface waters with pathogens and coliforms. Typical levels of fecal coliform and total coliform in raw sewage are 6,400,000 CFU per 100 mL and 23,000,000 CFU per 100 mL, respectively [39].

Landfills

Landfills are of concern within a watershed if they are located close to surface waterbodies, and if the operation and maintenance of the landfill has led to contaminated soil and groundwater. Even if soil and groundwater have been contaminated, surface waters may not be impacted unless they are downgradient of the contamination. Leachate from solid and hazardous waste disposal facilities can contain a variety of key contaminants such as iron, lead, copper, dissolved solids, nutrients, and a variety of organic chemicals. Similar to recreation parks, landfills are a concern as they can provide primary food sources for bird species, such as gulls, which tend to feed at the landfills and parks during the day and roost on surface waters at night. Gull roosting can cause bacterial and viral contamination of source waters.

In 1993, USEPA published the *Municipal Solid Waste Landfill Criteria Technical Manual* (revised in 1998) to ensure that landfills address location restrictions, facility design and operation standards, groundwater monitoring and corrective action measures, closure and post-closure care, and financial responsibility requirements [40]. In compliance with the CWA, runoff from landfills is required to be collected and managed. Oversight and implementation of the federal regulations is governed through states and local jurisdictions with approved programs.

Leaking Underground Storage Tanks

A leaking underground storage tank (LUST) is an underground storage tank (UST) that has leaked hazardous substances into the soil or groundwater. USTs leak for a variety of reasons such as faulty installation, negligence, or inadequate operation and maintenance. Additionally, some tanks are made of steel, which can corrode over time. Although leakage from USTs primarily affects groundwater, there is potential for surface water contamination if the contaminated groundwater is hydrogeologically connected to surface water. Once surface water is contaminated, contaminants will be diluted based on fate and transport factors including the tank site's proximity to the drinking water intake, the magnitude of the spill, and method of transport (surface or groundwater flow) to Metropolitan's water treatment facilities.

Contaminants of concern from LUSTs likely include hydrocarbons from gasoline and other petroleum-based products. Benzene is a major concern because of carcinogenic health effects, and has been the focus of LUST cleanup efforts in Arizona. Methyl *tert*-butyl ether (MTBE) is now less of a concern since it was banned in California fuel supplies in January 2004.

Under guidance of the CFR, states and territories are responsible for implementing LUST programs within their boundaries and coordinating with USEPA to manage tank leak prevention and tank cleanup programs. According to USEPA, there are approximately 6,000 to 7,000 UST releases reported nationwide every year, some of which can impact drinking water supplies through groundwater contamination [41].

Septic Systems

Although leakage from septic systems primarily affects groundwater, there is potential for surface water contamination if the contaminated groundwater enters a surface water source through a natural spring or groundwater well pumping. Septic systems are generally located away from surface water, and there will be attenuation of the contaminants through fate and transport mechanisms based on the proximity to the receiving waterbodies, the magnitude of the leak, natural degradation, and the mode of conveyance to Metropolitan's water treatment facilities.

A conventional septic system consists of two treatment steps: (1) a septic tank to separate solids from the liquid wastewater, and (2) a soil absorption field to treat the liquid waste (leach field) through filtration, adsorption, and microbial degradation. Due to rapid population growth in much of the lower watershed, the capacity of many of the current septic systems has been exceeded. If the leach field is overloaded, constituents like nitrate and coliforms might not be removed and could migrate into the groundwater.

A failed or overloaded septic system can lead to the release of pathogens and coliform bacteria to the groundwater. Typical levels of fecal coliform from a failed septic system range from 10,000–1,000,000 CFU per 100 mL [39].

In recent years, new technologies have been developed for advanced septic systems that can treat sewage to meet secondary treatment standards established by USEPA. Types of treatment methods for the advanced treatment systems include dosed-flow systems, mound systems, sand filters, gravel filters, and wetlands. USEPA supports these treatment methods and other programs related to onsite treatment systems, which are subject to regulation by state and local governments.

Agriculture

There are extensive and varied agricultural activities occurring throughout the entire Colorado River watershed. Agriculture includes croplands, livestock grazing, and animal feeding operations (AFO) such as dairies. Agriculture usually results in a non-point source of pollution. However, concentrated animal feeding operations (CAFOs) are point sources and may be regulated through the USEPA NPDES Stormwater Program, per 40 CFR Parts 9, 122, 123, and 412.

Contaminants of concern from agriculture include chemical constituents such as pesticides and fertilizers, physical constituents such as turbidity and TDS, and microbial constituents such as bacteria, viruses, and protozoa. As an example, herd animals such as cattle may carry *Cryptosporidium parvum* in their intestines and shed *Cryptosporidium* oocysts through waste, which can contaminate source water. A single calf can produce 50 billion oocysts within a one-week period [35]. Ingestion of the oocysts through drinking water causes a cryptosporidiosis infection in the small intestine.

The wastes generated by AFOs include manure from corrals, process wastewater (primarily washwater from a milk barn), and stormwater runoff from manure areas. Wastes produced at AFOs contain high levels of bacteria, biochemical oxygen demand, ammonia, nitrate, phosphorus, and other salt compounds.

Contaminants, such as protozoa, shed directly into the river system, or shed shortly before transport to the river, present a higher risk than protozoa shed onto the land throughout the long dry season. Feces deposited on land are subject to desiccation and inactivation by heat. The risk of loading viable *Cryptosporidium parvum* oocysts into the river system from cattle in the watershed appears to be highest during spring storm events when runoff from confined and non-confined AFOs is more likely to occur. Also, an AFO's waste management system is most vulnerable to exceeding its capacity and spilling into nearby watercourses during storm events.

Storms will also cause sheet flow over rangeland areas that can pick up fecal matter from grazing livestock. During the calving season, storm runoff from rangeland grazing areas is likely to carry *Cryptosporidium* since calves are more likely to be infected with the pathogen than adult cows.

While irrigated agricultural areas have the potential to be a chronic source of runoff water and nutrient loading in a watershed, not all agricultural lands are irrigated at the same intensity or with the same duration. Some land classified as "agriculture" may be non-irrigated ranch or pasture while other land with the same classification may be continually irrigated and fertilized to grow high-value crops.

Another agriculture-related issue is the land application of biosolids. Biosolids are the nutrient-rich organic materials resulting from the treatment of sewage sludge and are applied to land to either condition the soil or to fertilize crops grown in the soil. Biosolids may be sprayed or spread on the soil surface, tilled into the soil, or injected directly below the surface.

On irrigated crop lands, inefficient irrigation practices that produce runoff from the fields have the ability to dissolve naturally occurring salinity found in soil and transport it to surface waters, making salinity in the Colorado River a long-standing water quality concern. The river carries an estimated 9 million tons of salts past Hoover Dam annually and the lower Colorado River reaches have high salinity concentrations ranging between 500 and 800 mg/L. According to the Colorado River Basin Salinity Control Forum's *Water Quality Standards for Salinity Colorado River System 2014 Review*, much of the salt is picked up in the Upper Colorado River Basin, where irrigation accounts for 37 percent of the human-caused salt loading in the river [42]. Further discussion on the Colorado River Basin Salinity Control Forum is included in **Chapter 6**.

Pesticides (i.e., herbicides, insecticides, etc.) can also be used to control non-native vegetation or to protect plants and crops from damaging pests in agricultural or urban areas. The U.S. Geological Survey (USGS) has found that the use of pesticides is more than four times greater than it was 50 years ago, resulting in a growing concern over the potential adverse effects of pesticides on environmental and human health [43]. Without the proper safeguards, pesticides can potentially contaminate source waters through runoff from treated areas. USEPA is primarily responsible for pesticide regulation, while states and local agencies also enforce specific use and application requirements to protect the urban and agriculture environment and those exposed to pesticide risk.

Fires

One of the major concerns with drought conditions is the increase of wildfire threats. In California alone, California Department of Forestry and Fire Protection (CAL FIRE) reported 6,335 fires burning a total of 307,598 acres in 2015 [44]. In comparison to the 5-year (2011-2015) average, this was a 38 percent increase in the number of wildfires and 180 percent increase in acres burned. Per BLM, wildfires have also become a growing concern due to dry conditions along the Colorado River in Arizona.

The aftermath of a wildfire can alter source water quality. Fire has the potential to dramatically increase the stormwater sediment yield from a watershed through modification of the land cover density and type of vegetation. In addition, the load of dissolved substances to streams will increase following a wildfire, due to increased runoff. Increased runoff can occur following a fire because the formation of a hydrophobic organic layer in the soil increases the water repellency of soils [45]. A 2004 USGS study found that measurable effects of fires on stream water quality are most likely to occur if the fire was severe enough to burn large amounts of organic matter, if windy conditions were present during the fire, if heavy rain occurred following the fire, and if the fire occurred in a watershed with steep slopes and soils with little cation-exchange capacity [46].

The magnitude of the effects of fire on water quality is dependent on how fire characteristics (frequency, intensity, duration, and spatial extent of burning) interact with watershed characteristics (weather, slope, soil type, geology, land use, timing of regrowth of vegetation, and burn history). This interaction is complex and highly variable so that even fires in the same watershed can burn with different characteristics and produce variable effects on water quality. Typically, stormwater runoff from burned forested areas contains high concentrations of phosphorus, nitrogen, dissolved organic carbon, sediment, and metals such as mercury, lead, and arsenic. Post-fire runoff can increase turbidity in receiving source waters, affecting treatment plant performance. Turbidity typically results from ash, silt, and other natural debris found in post-fire runoff.

Ammonia, phosphate, and sulfate compounds may be introduced to the watershed if fire retardants are utilized to extinguish a fire. These constituents are primary components of common fertilizers. Impacts on waterbodies depend on composition and longevity of retardant compounds at the soil surface, soil transformation and fixation rates, pathways of water movement (affected by storm intensity, soil permeability, and terrain), distance between retardant drop and waterways, and the population and diversity of life forms in the aquatic system and their sensitivities to the retardant and breakdown products. The propensity for these constituents to stimulate and support algae blooms in the source water reservoirs is of particular concern.

Since fires may have long-lasting runoff and erosion impacts, fire information is reported for a 10-year period, overlapping with information provided in the CRWSS 2010 Update.

Lake Mohave and Lake Havasu Watersheds

The PCSs discussed for the Lake Mohave and Lake Havasu watersheds include Erosion, Urban and Stormwater Runoff; Recreation; Municipal and Industrial Discharges; Spills; Landfills; Leaking Underground Storage Tanks; Septic Systems; Agriculture; and Fires. Fires in the watersheds were not discussed in prior sanitary surveys since this reach of the Colorado River is located a substantial distance away from Metropolitan's service area facilities and fires in the reach do not pose an immediate threat to water quality. However, due to an increase in wildfires across the southwestern United States attributed to drought and climate changes, fires were investigated and discussed in the CRWSS 2015 Update.

Erosion, Urban and Stormwater Runoff

Occurrence in Watershed

The Lake Mohave and Lake Havasu watersheds encompass 583,000 and 6,140,000 acres, respectively, in the tri-state region of Arizona, Nevada, and California. The watersheds are characterized by the drainage surrounded by multiple mountain ranges. The eastern boundary of the watersheds is comprised of the Black, Bill Williams, and Mohave mountains including the El Dorado, Castle, Black, Old Woman, Hualapai, Juniper, Santa Maria, Whipple, Buckskin, and Weaver mountain ranges.

The largest single land use category in the watersheds is rangeland, which accounts for 90 percent of the watershed. The majority of the area is federally owned and managed by either the U.S. Bureau of Land Management (BLM) or U.S. National Park Service (NPS). The Lake Mohave watershed contains portions of two wilderness areas in developed open space land use—the 112,400-acre Warm Springs Wilderness and the 27,660-acre Mt. Nutt Wilderness. The primary land uses for the remaining developed open space within the watersheds include recreation and grazing. Developed urban land accounts for less than 1 percent of the watershed area. In the Lake Mohave watershed, the majority of the private land is located in the vicinity of Bullhead City, Laughlin, the city of Needles, and Mohave Valley, adjacent to the Colorado River. In the Lake Havasu watershed, the majority of the private land is also contiguous to the Colorado River in Lake Havasu City. The primary private land uses in the watersheds are domestic, commercial, and farming.

Figure 4-1 shows the land use distribution in the Lake Mohave and Lake Havasu watersheds. The varied land use, including geographic features and urban communities in the watersheds, directly influences the quantity of stormwater runoff and the type of contaminants in the runoff. As discussed in **Chapter 3,** a stormwater runoff concern in the Lake Havasu watershed results from the Bill Williams River. Although the Bill Williams River is downstream of the Whitsett Intake, water backs up in Lake Havasu during large storms.

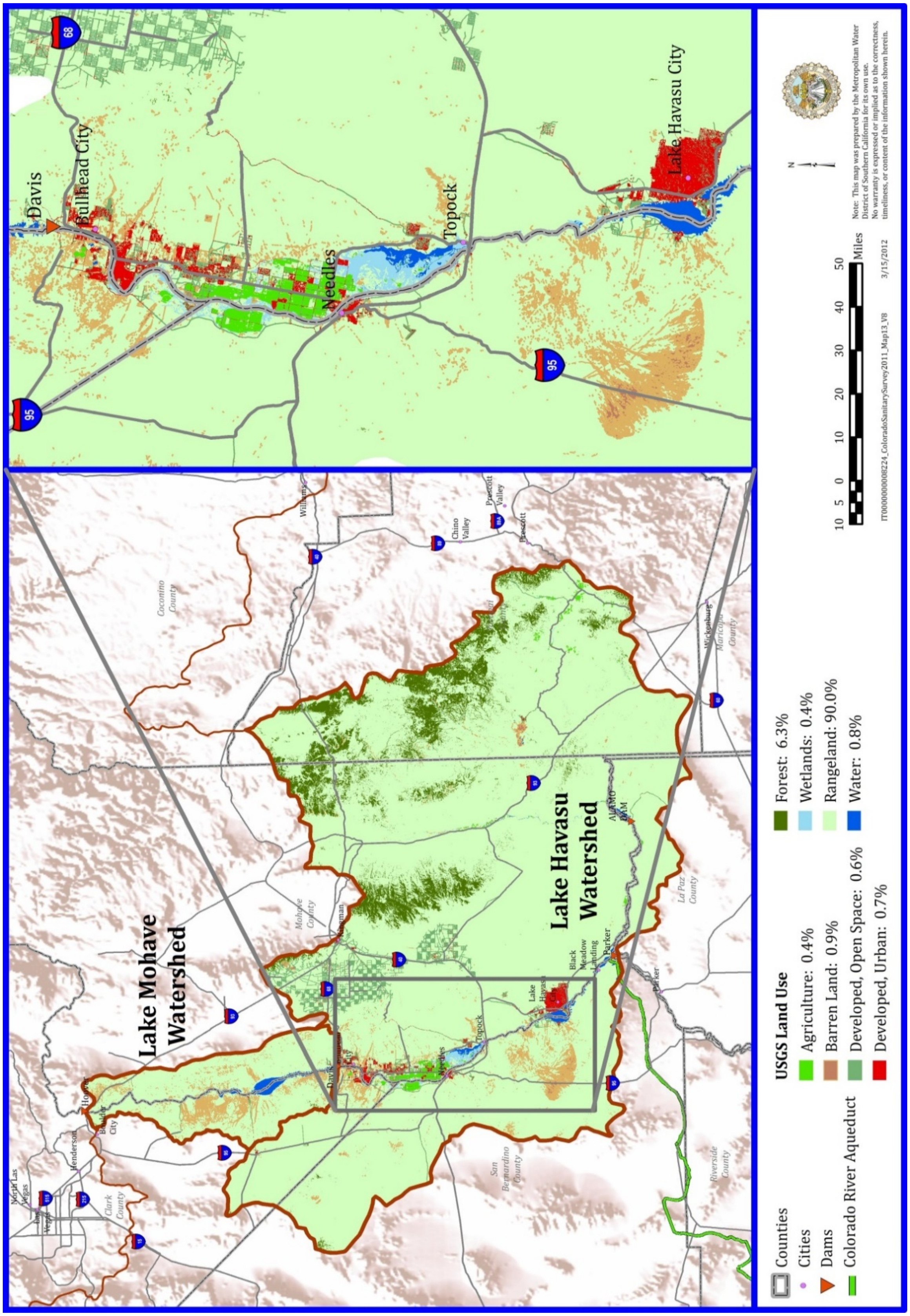


Figure 4-1. Lake Mohave and Lake Havasu Watershed Land Uses

Regulation and Management

As this region covers the three states of California, Nevada, and Arizona, three regulatory agencies (RWQCB-Colorado River Basin Region, Arizona Department of Environment Quality [ADEQ], and Nevada Division of Environmental Protection [NDEP]) were contacted regarding their respective stormwater programs.

Because there are no municipalities within this reach along the Colorado River above Parker Dam with populations greater than 100,000 people, there are no stormwater monitoring programs currently required by the Phase I regulations. However, there are three municipalities within the reach that are regulated under the Phase II Small MS4 General Permit: Lake Havasu City, Mohave County and Yavapai County. As these municipalities are in Arizona, their stormwater management program is regulated by ADEQ. ADEQ also issues individual and general Arizona Pollution Discharge Elimination System permits for other municipalities such as Bullhead City, within Mohave County, but does not require specific stormwater management programs from the municipalities. In 2013, RWQCB-Colorado River Basin Region determined that a stormwater management program is not required for the city of Needles per the designation criteria set in Board Order No. 2013-0001-DWQ [47]. The RWQCB will reevaluate this determination in 2018 when the Board Order is renewed.

The Bill Williams River Corridor Steering Committee, comprised of federal and Arizona agencies, identifies and addresses a wide range of issues pertaining to the Bill Williams River. Of interest, the Steering Committee is currently addressing potential issues from USBR's Alamo Dam releases. While releases to date have been minor, large releases have the potential to bring sediments and nutrients into Lake Havasu and impact water quality. The Steering Committee is also working with USFWS to study and identify the cause of dead riparian vegetation along the Bill Williams River, which can lead to fires and the brush clearing can potentially result in higher flows into Bill Williams River during rain events.

Studies and Monitoring

The Storm Water Management Program (SWMP) for Lake Havasu City was submitted in 2003 and was approved by ADEQ. Lake Havasu City submitted a revised SWMP in 2014, which builds upon the earlier versions. The SWMP includes the six minimum control measures outlined in the ADEQ General Permit (AZG2002-002) for small MS4s, which are 1) public education and outreach, 2) public involvement/participation, 3) illicit discharge detection and elimination, 4) construction site runoff controls, 5) post-construction site runoff control, and 6) pollution prevention/good housekeeping. The targeted pollutants for the Lake Havasu City SWMP are floatables, sediment, greases, oils and other pollutants including trash, sewage, and illicit discharges [48].

Per Lake Havasu City's 2014 SWMP report, some notable stormwater management achievements include the following [48]:

- Distribution of educational materials via brochures and pamphlets about stormwater management to residents and availability of stormwater materials on the City's website,
- Information on the City website on Household Hazardous Waste handling and disposal,
- Annual Keep Havasu Beautiful Spring Clean Up events to provide recycling for furniture, wood, tree brush trimmings, and appliances,

- Annual Neighborhood Clean Up and River/Wash Clean Up events to cleanup outfall areas and washes,
- Annual dry weather outfall inspections of all known stormwater outfalls and immediate investigation of illicit discharges,
- Draft erosion and sediment control ordinance to form the basis for Lake Havasu City's construction site management control program,
- Technical guidance materials on design requirements for stormwater runoff control measures including *Development & Permitting Policies & Procedures* (2013) and *Ordinance 8.28 STORMWATER* (2014),
- Ongoing review of plans for sites that result in a land disturbance of one acre or more,
- Ongoing inspection of construction sites for compliance with stormwater runoff controls, and
- Ongoing evaluation of Lake Havasu City's operations and facilities to reduce potential pollutant loading to stormwater.

Currently, Lake Havasu City does not plan to conduct any monitoring of stormwater flows.

The SWMP for Yavapai County was submitted in 2003 and was approved by ADEQ. Although the western portion of Yavapai County is within the Colorado River watershed, the urbanized areas of Prescott and Prescott Basin for which the SWMP is primarily targeted, is not within the watershed. Therefore, further details regarding the Yavapai County SWMP are not discussed, as they are not applicable.

Stormwater management in Mohave County is governed by five documents, which include:

- Mohave County Flood Control Ordinance (2000)
- Mohave County Engineering Design Standards, Specifications and Details (2002)
- Mohave County Land Division Regulations (2004)
- Mohave County Zoning Ordinance (2005)
- Drainage Design Manual for Mohave County (2014)

The Drainage Design Manual was approved and adopted by the Mohave County Board of Supervisors on May 19, 2014 [49]. The document, which is referenced in Lake Havasu City's Stormwater Management Program, provides stormwater pollution prevention criteria for addressing stormwater issues associated with new and existing development.

Recreation

Occurrence in Watershed

Lake Mohave

Lake Mohave is located within the southern end of the Lake Mead National Recreation Area (Lake Mead NRA), which is managed by NPS. The Lake Mead NRA encompasses approximately 1.5 million acres of land and water. The primary recreational facilities located on Lake Mohave are shown in **Table 4-2**.

Table 4-2. Recreational Facilities Located on Lake Mohave

Name	Ownership	Sewage Pump-Out	Fuel Available
Willow Beach	Public	Yes	Gasoline, Propane, Boat Fuel
Cottonwood Cove Campground	Public	Yes	Gasoline, Propane, Boat Fuel
Cottonwood Cove Resort and Marina	Private	No	Gasoline, Propane, Boat Fuel
Princess Cove	Public	No	None
Nevada Telephone Cove	Public	No	None
North Arizona Telephone Cove	Public	No	None
South Arizona Telephone Cove	Public	No	None
Lake Mohave Resort (Katherine Landing)	Private	No	Gasoline, Propane, Boat Fuel
Katherine Landing	Public	Yes	Gasoline, Propane, Boat Fuel

There are numerous opportunities for recreation in this part of the watershed, including swimming, rafting, power boating, house boating, and on-shore activities. The NPS map (**Figure 4-2**) highlights the recreational areas with public use amenities between Hoover Dam and Bullhead City.

NPS does not track boat use, but estimates that peak summer use results in nearly 2,500 boats per day on Lake Mohave [50]. Average summer boat use is about half of the peak daily use and is significantly lower during the winter months. In 2016, NPS began collecting data from weekend boat use (May to September) to update boat statistics from an intensive 1993–1994 study. Average summer boat use is about half of the peak daily use and is significantly lower during the winter months.

The boat launches and marinas at Willow Beach, Cottonwood Cove, and Katherine Landing provide free wastewater pump-out facilities. Lake Mohave also has three on-water sanitation stations, which serve as a restroom facility for boaters, a sewage pump-out for boats, and a porta-potty dump station for boats that do not have a built-in sanitation device. One sanitation station is located upstream of Cottonwood Cove while the remaining two are located in the high-use area of Lake Mohave (upstream from Katherine Landing to the narrow point of Lake Mohave).

In summer 2011, NPS completed a $20 million upgrade of the facilities at Willow Beach including the addition of a new wastewater treatment system, a new drinking water system, new store and restaurant, marina, fuel system, campground, housing, picnic shelters, parking, and shoreline trail system. In 2016, NPS approved a Record of Decision for the Final Environmental Impact Statement for the Development of Concept Plans for Katherine Landing and Cottonwood Cove, which will provide flood protection and recreational improvements (i.e., new day-use areas, motel expansion, etc.) [51].

In addition to the recreational activities supported by NPS, Lake Mohave also attracts various special events. Most notable, Bullhead City held an annual River Regatta event in August. The event was considered the world's largest river float and was attended by approximately 30,000 people. Bullhead City has identified trash-cleanup as the major challenge for events on Lake Mohave and typically includes a cleanup plan in their Incident Command System as well as employing a river clean-up crew, increasing security, and marketing for river users to "Pack it in, Pack it out". However, following the 10th annual River Regatta held on August 13, 2016, local residents complained about the amount of trash left along the banks of the river and launched an initiative to cancel future River Regattas. The Bullhead City council voted on September 20, 2016, in favor of cancelling the River Regattas.

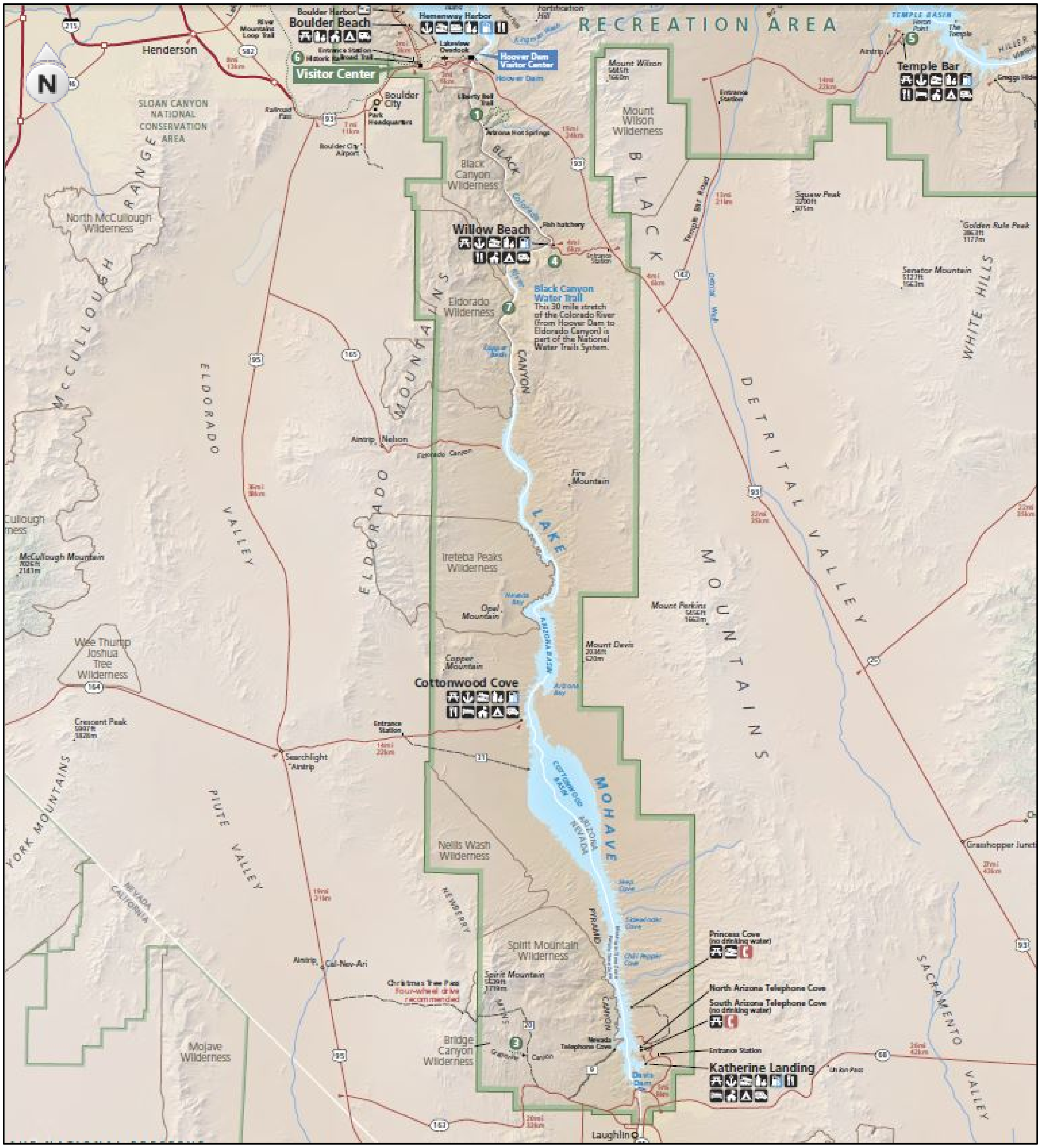


Figure 4-2. Lake Mead NRA Recreation Areas [52]

Lake Havasu

Recreational activities include swimming, water skiing, boating, fishing, wildlife viewing, camping, off-highway vehicles (OHV) use, and hiking. There are numerous parks, campgrounds, RV resorts, and marinas located along the Colorado River from Davis Dam to Parker Dam. There are also multiple entry points for boats to enter the Colorado River. The California Department of Boating and Waterways (DBW) has developed a Boating Trail Guide, which provides a list of both public and private facilities where a boat can be launched [53]. Due to limited resources, DBW has not updated the Boating Trail Guide since 2002. **Table 4-3** identifies boating entry points from upstream to downstream, where the first facility is just downstream of Davis Dam and the last facility is at Parker Dam. There is no primary park or recreation area within the Lake Havasu watershed and there are multiple agencies with recreational facilities. Therefore, there is no precise accounting of the number of visitors per year. However, BLM estimates that Lake Havasu serves about a million visitors per year [54].

There are no on-water sanitation facilities (restrooms or dump stations for boats) on Lake Havasu similar to those on Lake Mead and Lake Mohave [55]. BLM manages 71 developed shoreline campsites in the watershed from Davis Dam to Parker Dam, similar to the one shown in **Figure 4-3**. These sites are only accessible by watercraft. Most sites have a picnic table, shade awnings, barbeque grill, pit toilet, and trash can. A few of the campsites have no restrooms and portable toilets must be brought when using these sites. These camps are available on a first-come first-served basis. New restroom facilities have been constructed at many shoreline campsites; approximately 42 of the 71 campsites either have or share block vault restrooms.

Figure 4-3. Typical Arizona Shoreline Campsite [56]

BLM also manages three concession leases for Havasu Springs Resort, Black Meadow Landing, and Needles Marina Park as they are located on leased BLM lands along the Colorado River [57]. These resorts have facilities including boat ramps and marinas, swim beach, stores, restaurants, and longer-term mobile home spaces. BLM operates a boat launching facility, Take Off Point, at Parker Dam, which is the only free launch ramp in this stretch of the river.

Metropolitan's Whitsett Intake is located at the shoreline of Lake Havasu, approximately two miles upstream from Parker Dam. In the past, boaters commonly anchored or tied-up their boats directly in front of the pumping station. A buoy line now keeps boaters away from the immediate vicinity.

Similar to special events held on Lake Mohave, Lake Havasu City also hosts a number of events involving Lake Havasu including balloon festivals, jet ski competitions, and boat shows. For these types of special events, the city requires vendors to maintain the Lake Havasu grounds clear of all debris following the event. The city also engages their land and boat patrol units to monitor recreational activities and prevent illegal dumping on beaches and water.

Table 4-3. Boating Entry Points from Davis Dam to Parker Dam [53]

		Amenities														
Facility Name	**Ownership**	Paved Boat Launch	Other Launch Type	Ranger	Drinking Water	Restrooms	Picnic area	Camping	RV hookup	Beach	Public Phone	Gas	Boat Slips	Dump Station	Rental Boats	Motel
Sportsman Park	Clark County Parks and Recreation	•		•	•	•	•	•	•		•					
Davis Camp	Mohave County Parks	•		•	•	•	•	•	•	•	•			•		
Fisherman's Access Area	State of Nevada Department of Wildlife	•			•	•	•									
Bullhead Community Park	Bullhead City Parks and Recreation	•			•	•	•			•						
River Bend, Sunshine Marina	Private	•				•	•			•	•	•	•			
Bullhead City Watercraft Launching Facility	Bullhead City Parks and Recreation	•				•				•	•					
Section 10 Recreation Area	Bullhead City Parks and Recreation		•				•			•						
Boundary Cone Road	Fort Mojave Indian Reservation		•			•	•	•		•						
Rainbow Beach Marina	Private	•			•	•	•	•	•	•	•	•				
Needles Marina Park	Private	•			•	•	•	•	•	•	•	•	•			
Jack Smith Memorial Park	City of Needles Parks and Recreation	•			•	•	•			•						
Pintail Slough / North Dike	Havasu National Wildlife Refuge		•													
5-Mile Landing Marina	Havasu National Wildlife Refuge	•			•	•	•	•	•		•		•		•	
Catfish Paradise	Havasu National Wildlife Refuge		•													
Golden Shores Marina	Private	•				•			•		•					
Moabi Regional Park and Marina	San Bernardino Co. Regional Park Dept.	•		•	•	•	•	•	•	•	•	•		•	•	
Castle Rock Bay	Havasu National Wildlife Refuge		•													
Havasu Landing Resort	Chemehuevi Indian Reservation	•		•	•	•	•	•	•	•	•	•	•	•		
Windsor Beach	Lake Havasu State Park	•			•	•	•	•	•	•	•	•		•		
Crazy Horse Campgrounds	Private	•			•	•	•	•	•	•	•		•	•		
Lake Havasu Marina	Private	•			•	•					•	•	•		•	
Site 6 – Public Launch	Lake Havasu City Parks and Recreation	•				•	•			•						
Havasu Palms	Private	•			•	•	•			•	•	•	•			
Black Meadow Landing	Private	•			•	•	•	•	•	•	•	•				•
Sand Point Marina	Private	•			•	•	•	•	•		•	•	•	•	•	
Cattail Cove	Lake Havasu State Park	•		•	•	•	•	•	•	•	•			•		
Havasu Springs Resort	Private	•			•	•			•	•	•	•	•	•	•	•
Take Off Point	BLM	•				•		•								

Regulation and Management

Lake Mohave

Since the CRWSS 2005 Update, there have been several updates to NPS management policies for the Lake Mead National Recreation Area.

The 1964 enabling legislation that established Lake Mead as the nation's first National Recreation Area charged management to "preserve, develop, and enhance the recreation potential, and in a manner that will preserve the scenic, historic, scientific and other important features of the area… (while providing for) general recreation use, such as bathing, boating, camping and picnicking." NPS managers reaffirmed the purposes found within guiding legislation and policy in the 2014 Lake Mead NRA Foundation Document. The Foundation Document states that "the purpose of Lake Mead National Recreation Area is to provide diverse public recreation, benefit and use on Lakes Mead and Mohave and surrounding lands in a manner that preserves the ecological, geological, cultural, historical, scenic, scientific, and wilderness resources of the park."

Significance statements found within the Foundation Document state "Lake Mead National Recreation Area offers dramatic scenery and diverse array of land and water-based recreational opportunities in close proximity to several large urban centers of the southwestern United States. With approximately seven million visitors each year, the park supports some of the nation's highest levels of water recreation and backcountry use." The importance from the above guidelines of providing a quality water-based recreation experience has been distilled within the Lake Mead NRA Mission Statement: "We provide diverse inland water recreation opportunities in a spectacular desert setting for present and future generations."

In 2015, park management adopted Recreational Suitability Guidelines for Lake Mead National Recreation Area to assess water quality conditions related to public health and enjoyment of Lakes Mead and Mohave that includes selection of appropriate water quality indicators, identification of monitoring needed to assess indicators, documentation of thresholds for water quality indicators that require management response, and suggested public information messages.

A significant achievement in protecting water quality is the installation of porta-potty dump stations within the Lake Mead NRA beginning in January 2011. A porta-potty dump station is intended to serve smaller boats that do not have a built-in sanitation device. Lake Mohave porta-potty dump stations are located at the boat launch ramps for Katherine Landing, Princess Cove, Willow Beach, and Cottonwood Cove. With the installation of the new porta-potty dump stations, NPS plans to develop a rule to require all boaters to have a marine head or portable toilet on-board.

As stated in the 2005 CRWSS, NPS prepared a 2003 Record of Decision for the Final Environmental Impact Statement concerning the management of recreational use on the waters of the Lake Mead NRA. NPS requires all engines to be in compliance with the 2006 USEPA emission standards, effective December 31, 2012 [58]. Generally, this requires exclusive use of four-stroke engines, direct injection two-stroke engines, or equivalent for motorized vessels. These new regulations are expected to decrease volatile organic compounds (VOC) concentrations.

The CWA prohibits untreated wastewater discharge in waters of the United States, including the Colorado River. Each state has a regulatory agency that has the primary authority and responsibility for enforcing the CWA, but often they do not have the resources to operate a program to inspect or enforce their authority with respect to acts of dumping from boats.

NPS also has regulatory authority to inspect boats through a memorandum of understanding (MOU) with the U.S. Coast Guard (USCG). Inspections are conducted to ensure that overnight boats with treatment systems on board have the "Y" valve (which allows direct dumping) in a closed or locked position. According to NPS, boats are typically only inspected if requested by the marina operator. The marina operator, as a concessionaire to NPS, is required to report/monitor boats that may be illegally discharging or leaking waste or oil into the water. Generally, there has not been a problem with direct waste discharges as the marinas have free wastewater pump-out facilities.

Lake Havasu

Numerous agencies administer recreation in the Lake Havasu area, including BLM, USCG, state wildlife agencies, county sheriff departments, and tribes. BLM Needles Field Office does not manage recreation along the Colorado River corridor, even on the California side, as this responsibility is delegated to the BLM Lake Havasu Field Office. Most agencies concentrate on specific areas related to their basic program authorities, and overall recreation administration is fragmented with only select areas of water and shoreline being managed. For example, USCG is responsible for authorizing whether or not a particular area of the lake's surface can be closed or partitioned off for a special boating event, but they do not perform regular patrols of boating activity on the lake. Regular patrols are conducted by county sheriff departments, state wildlife agencies, and BLM during the summer months. Moreover, administering agency regulations are not consistent in all respects, and some common-sense practices to avoid water pollution are not backed by specific regulations and, therefore, are not enforceable.

The BLM Lake Havasu Field Office manages recreation on all BLM-administered public lands from Davis Dam to Parker Dam. BLM only has limited authority for the lake surface, but has authority for the lake bottom and the shoreline. BLM works cooperatively through separate MOUs, under the CWA authorities of both ADEQ and SWRCB, to manage public lands in a way that minimizes non-point source pollution.

In May 2007, BLM finalized the *Record of Decision and Lake Havasu Field Office Approved Resources Management Plan* (RMP) [59]. The RMP addresses BLM's role in the management of Lake Havasu, which covers all land-based activities such as recreation, grazing, etc. Some aspects of how BLM currently manages recreation in this watershed include management of the 71 shoreline campsites, management of resort concession leases, performing daily law enforcement patrol along the shoreline in marked vessels, issuance of special recreational permits for commercial and/or competitive activities or for organized groups, and developing travel management plans for OHV use.

Some notable items that BLM is working to complete under the RMP include the following:

- Participation with more than 25 separate jurisdictions on and adjacent to the lake to develop a Coordinated Lake Management Plan;
- Continuing with current lake and shoreline operations and increasing BLM's presence of both staff and facilities, as visitor demand and preference already exceed BLM's capacity to manage with current resources;
- Detailed monitoring for potential recreational impacts to soil, water, and air resources along the Colorado River, which will be addressed through the Lake Havasu Special Recreation

Management Area implementation plan and/or the Lake Havasu Regional Management Plan. Monitoring will be accomplished through partnerships.

- Photo points will be initiated at popular boat-in campsites, dispersed camping areas, and OHV areas to document potential impacts, such as erosion, at a minimum of 20 BLM sites each year. Additionally, as many as five aquatic locations adjoining recreational facilities will be sampled annually during periods of high use to determine compliance with appropriate state standards for primary contact recreation and warm water fish habitat.
- Remote sensing techniques using satellite and low-level imagery to be used to document total boats on the water at one time on a summer holiday weekend along the shoreline. This will be repeated at 5-year intervals to understand use patterns, measure compliance with prescribed recreation settings, and document growth within the watershed.

Although BLM has site rules for the 71 shoreline sites, there are only a few that pertain to water quality. The rules that apply to BLM-managed lands within 1,000 linear feet of the high water mark of Lake Havasu require that the sites be kept free of litter and trash; that pet waste be removed from the site or disposed of in trash receptacles; and that provisions of Arizona and California boating laws not be violated [60].

Studies and Monitoring

The Lake Mead NRA includes Lake Mead and Lake Mohave and studies completed for the Lake Mead NRA generally include both lakes. Though the intent of this section is to report on Lake Mohave and Lake Havasu, some Lake Mead references are included to preserve continuity of the study data. Further, some of the studies identified in this section address multiple water quality objectives in addition to recreational uses. Studies for both lakes are generally shared with the Lake Mead Ecosystem Monitoring Workgroup discussed in **Chapter 6**.

Lake Mohave Studies

Beginning in 2014, NPS at Lake Mead National Recreation Area partnered with the University of Nevada-Reno to complete a Limnological and Riparian Resource Condition Assessment (LRCA) of Lake Mead National Recreation Area, expected to be completed at the end of 2017. The LRCA is an interdisciplinary synthesis of existing scientific information from multiple sources intended to assess limnological and riparian resource priorities and needs, complementing the park's Natural Resource Condition Assessment.

In 2012, the U.S. Geological Survey (USGS) published "A Synthesis of Aquatic Science and Management of Lakes Mead and Mohave." The document analyzed data for Lakes Mead and Mohave relative to parameters set forth within the USEPA National Lakes Assessment. For most USEPA National Lake Assessment parameters, Lakes Mead and Mohave scored within the "good" category. The 2012 USGS report also reviewed human pathogen indicator bacteria data from 2003 through 2010. Of 649 samples analyzed, only 0.6 percent exceeded acceptable standards for *E. coli* indicator bacteria. Additionally, chlorophyll-*a* levels from 2002 through 2010 were also reviewed for the USGS 2012 report. Chlorophyll-*a* is generally utilized as an indicator of lake productivity or algae growth. The chlorophyll-*a* values from 2002 through 2010 were well within Nevada state standards published to be protective of the existing high water quality of Lake Mead. By all standard measures utilized to characterize water quality for a recreation experience and setting, both Lakes Mead and Mohave provide outstanding water quality.

In 2007, the non-native quagga mussel (*Dreissena bugensis*) was found in Lake Mead. Although a correlation to quagga mussels was not confirmed, cyanobacteria growth was noted on Lake Mohave in 2011, 2012 and 2013. Cyanobacteria growth was noted on Lake Mead during the fall-winter of 2014-15, and cyanobacteria growth persisted through March 2015, with associated cyanotoxins noted for the first time. The finding of cyanotoxins necessitated the issuance of public advisories to protect public and pet health. Park managers adopted Recreational Suitability Guidelines for Lake Mead National Recreation Area in 2015 to assess water quality conditions related to public health and enjoyment of Lakes Mead and Mohave that includes selection of appropriate water quality indicators, identification of monitoring needed to assess indicators, documentation of thresholds for water quality indicators that require management response, and suggested public information messages.

Since 2007, NPS has monitored *E. coli* and fecal coliform at 21 sites across Lake Mead (14 sites) and Lake Mohave (7 sites) weekly from May to September as shown in **Figure 4-4**. The seven monitoring stations at Lake Mohave are AZ Telephone Cove South, Cottonwood Cove, Katherine Landing, Placer Cove, Six Mile Cove, Three Mile Cove, and Willow Beach. There have been no beach closures during the reporting period. Data provided by NPS indicates that *E. coli* levels are at non-detect levels (< 2 CFU per 100 mL).

Long-term water quality monitoring also occurs on both Lakes Mead and Mohave, through partner agency efforts. This work includes a total of 31 sites across Lake Mead NRA, including 5 sites on Lake Mohave (directly below Hoover Dam, Willow Beach, Placer Cove, Cottonwood Cove, and Katherine Landing). The majority of these sites have more than 15 years of data; currently 24 parameters are sampled at these long-term monitoring sites including water temperature, total dissolved solids, total organic carbon, total phosphorus, soluble orthophosphate, pH, perchlorate, total nitrogen, total nitrate (as nitrogen), and total ammonia. Sites are sampled either continuously, weekly, monthly, or quarterly depending on the site.

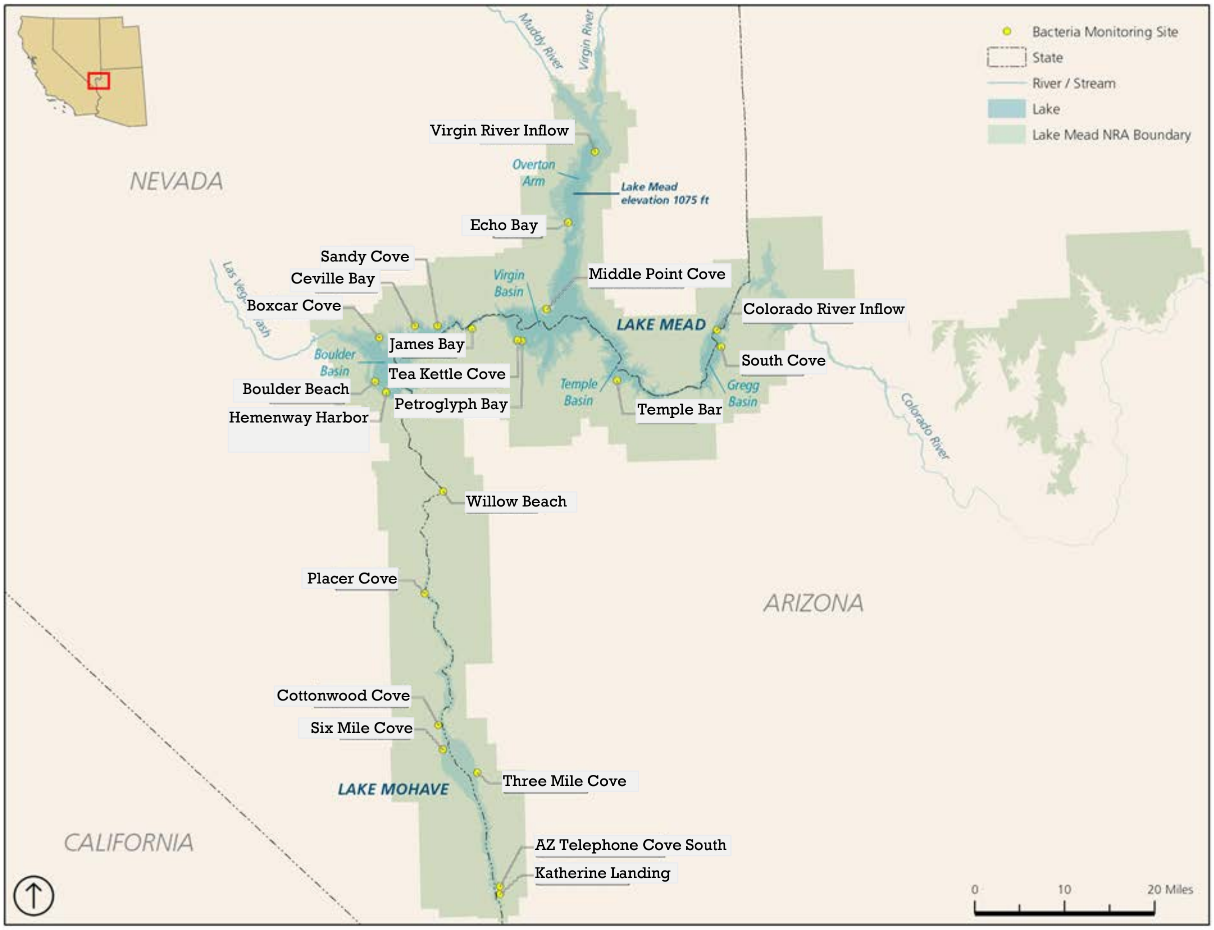


Figure 4-4. NPS Bacteria Monitoring Sites – Lake Mead and Lake Mohave [50]

2003 Lake Mead NRA Lake Management Plan

The *2003 Lake Mead NRA Management Plan* states that the Lake Mead NRA will seek funding for monitoring of pathogens and contaminants associated with both greywater and black water releases, and work with the USGS to further study the distribution and impact of contaminants associated with personal care products released in greywater [61]. In 2012, USGS received funding through the NPS/USGS Water Quality Partnership program to examine emerging contaminants released in greywater, with an emphasis on endocrine disrupting compounds. Preliminary results and reports from this work are expected in late 2016.

Long-term Limnological and Aquatic Resources Monitoring and Research Plan for Lake Mead and Lake Mohave

A *Long-term Limnological and Aquatic Resources Monitoring and Research Plan* for Lake Mead and Lake Mohave was finalized in February 2010 and updated in April 2011 [62]. The CRWSS 2010 Update discusses the plan's proposed long-term monitoring and research framework for the limnological resources and drinking water quality of Lake Mead and Lake Mohave within the Lake Mead NRA. Overall, the Plan recommended that information from research efforts carried out by various entities should be consolidated, organized, and presented on the Internet. As a result, the webpage *Long-term*

Limnological and Aquatic Resource Monitoring for Lakes Mead and Mohave was created and is being maintained by NPS to archive data summaries, key management documents, and public outreach information as it pertains to water quality in Lake Mead and Lake Mohave [63].

Lake Mohave Monitoring Activities

2003–2011 Lake Mead NRA Surface Water Monitoring for Indicator Bacteria

In 2012, UNLV presented findings from an 8-year monitoring (2003–2011) study of high-use areas within the Lake Mead NRA to the Lake Mead Water Quality Forum Ecosystem Monitoring Workgroup [64]. Ten locations were monitored, including three locations along Lake Mohave. Samples were collected 20–30 feet from the shoreline, twice a month and after holidays in May through September, during high-use months. SNWA processed the collected samples and reported results for four indicator bacteria including enterococci, *E. coli*, fecal coliform, and fecal streptococci. For Lake Mohave, the bacteria indicators (enterococci, fecal coliform, and fecal streptococci) exceeded water quality standards, based on USEPA's recommended limits, in 23 of 197 samples (11.7 percent). UNLV evaluated potential factors that could increase bacterial indicator levels including the number of visitors, water temperature, and wind and concluded that overall monitoring was identifying problem areas and specific high-use coves are at risk for bacterial counts exceeding water quality standards. The study recommended an education program for the public on the hazards of fecal waste into the lake's recreational areas.

United States Geological Survey Lake Mead NRA Water Quality Monitoring

In cooperation with NPS and SNWA, USGS collects water quality data in Boulder Basin of Lake Mead and in Lake Mohave [65]. Water quality data, collected in near-real time, includes water temperature, specific conductance, dissolved oxygen, pH, and turbidity. The information is being used to improve and expand the limited baseline data for Lake Mohave. This will provide a better understanding of potential effects downstream from Lake Mohave and help support the future development of hydrodynamic water quality models.

SNWA Lake Mohave Monitoring

SNWA began monitoring five locations at Lake Mohave in January 2013 to supplement limited lake water quality data. In addition to basic instrument-based parameters, SNWA samples for nutrient and biological parameters. SNWA has found that water quality is generally reflective of Lake Mead with low phosphorus, high nitrogen, and low chlorophyll levels. During the monitoring period, SNWA reported that *Microcystis*, which was usually observed to peak in the fall, was observed in high concentrations during winter 2014-15. Other entities including Central Arizona Project, USBR, and the Lake Mead NRA also reported observations of *Microcystis* in March-June, 2015 at Lake Mohave and Lake Havasu [66]. **Figure 4-5** indicates a *Microcystis* bloom at Cottonwood Cove along Lake Mohave in March 2015. The Lake Mead NRA continued to receive reports of *Microcystis* and illness from Lake Mohave visitors. Lake Mead NRA issued a swimming advisory for Lake Mead and Lake Mohave on March 13, 2015 and updated the advisory on

Figure 4-5. Microcystis Observed at Cottonwood Cove, March 25, 2015 [66]

June 5, 2015, advising visitors to avoid swimming in areas where green scum is seen on the water surface [67].

United States Bureau of Reclamation Monitoring

Although not solely related to recreation, information on USBR's water quality monitoring efforts is included for continuity with other water quality studies in the Lake Mohave Watershed and the downstream Colorado River. As discussed in the CRWSS 2010 Update, Phase I of the Lower Colorado River Contaminant Monitoring Program, which was conducted from 2003 to 2006, attempted to determine the relationship between population growth and increases in contaminant concentrations. For Phase I, the only sampling points downstream of Hoover Dam were Willow Beach and Topock Marsh. There were no water samples with detectable levels of volatile or semi-volatile organic compounds, pesticides, or polychlorinated biphenyls (PCBs).

As part of the Phase II Lower Colorado River Contaminant Monitoring Program, USBR monitored the eleven sampling locations shown in **Figure 4-6** biannually in August and December of each year. Phase II sampling began in February 2008 and was completed in December 2014. Samples were collected for field-measured parameters (dissolved oxygen, pH, temperature, electrical conductivity, specific conductance, and turbidity), perchlorate, nutrients (ortho-phosphate, total phosphorus, dissolved inorganic nitrogen, ammonia nitrogen as N), trace metals (zinc, aluminum, arsenic, barium, selenium, PCB congeners, and manganese), sodium and chloride, and contaminants of emerging concerns [68].

Major conclusions from the Phase II (2008–2014) sampling indicated the following:

- In the stretch of the Colorado River from Hoover Dam (CR342.5) to just below Parker Dam (CR184.3), specific conductance ranged from 870.5–1057 μS/cm, total dissolved solids ranged from 529–642 mg/L, orthophosphate phosphorus ranged from less than 0.001–0.0046 mg/L, total phosphate phosphorus ranged from less than 0.0017–0.020 mg/L, and dissolved inorganic nitrogen ranged from less than 0.249–0.660 mg/L.
- USBR decided to monitor for emerging contaminants in 2013 based on the increased availability of instrumentation and laboratory services. Between 2013 and 2014, USBR added analysis for 94 emerging contaminants to the monitoring program in the lower Colorado River. Notably, sucralose and acesulfame potassium, which are synthetic calorie-free sweeteners, had measurable amounts in nearly every sample tested and are indicators of wastewater entering the lower Colorado River.
- The goal of correlating contaminant concentrations with urban growth along the Colorado River was not fulfilled for various reasons. Concentrations of many contaminants were non-detectable, there was considerable scatter in data, and no discernable trends were displayed by much of the data. However, the data collected in the study serve as a solid baseline for future monitoring.
- USBR recommends extending the monitoring program to conduct sampling during December each year, when Colorado River flows are low and contaminants may be presumably most concentrated. Additional monitoring could be conducted during high-use periods in July or August.

Figure 4-6. USBR Water Quality Sampling Locations – Lower Colorado River Contaminant Monitoring Program [69]

Lake Havasu Monitoring Activities

As discussed above, USBR manages a Lower Colorado River Contaminant Monitoring Program, which includes the Lake Havasu reach of the river.

In 2011, ADEQ began conducting annual water quality monitoring in one of three regions of the state of Arizona, such that the entire state would be completed within a three-year cycle [70]. ADEQ began monitoring the Colorado/Lower Gila watershed in 2013 and both field and laboratory samples were collected. Field measurements included general chemistry (pH, TDS, dissolved oxygen, water temperature, specific conductivity, turbidity, discharge, and bacteria) and *E. coli* samples.

Figure 4-7 presents the monitoring results for *E. coli* from sampling conducted between 2013 and 2016 in Lake Havasu. The Arizona recreational water quality standard for body-contact is that the 30-day log mean for *E. coli* must be ≤ 126 CFU per 100 mL and the single value for *E. coli* must be < 235 CFU per 100 mL. With such a small sample set, only the single value standard can be used for data analysis. The maximum detected *E. coli* level was 167 CFU per 100 mL from a sample collected on April 25, 2013, at the South Rotary Beach location. ADEQ plans to continue quarterly monitoring at Lake Havasu for its Ambient Lake Program during Fiscal Year 2017 and focus on sampling for *E. coli* as part of a new recreational beach monitoring program from May to September.

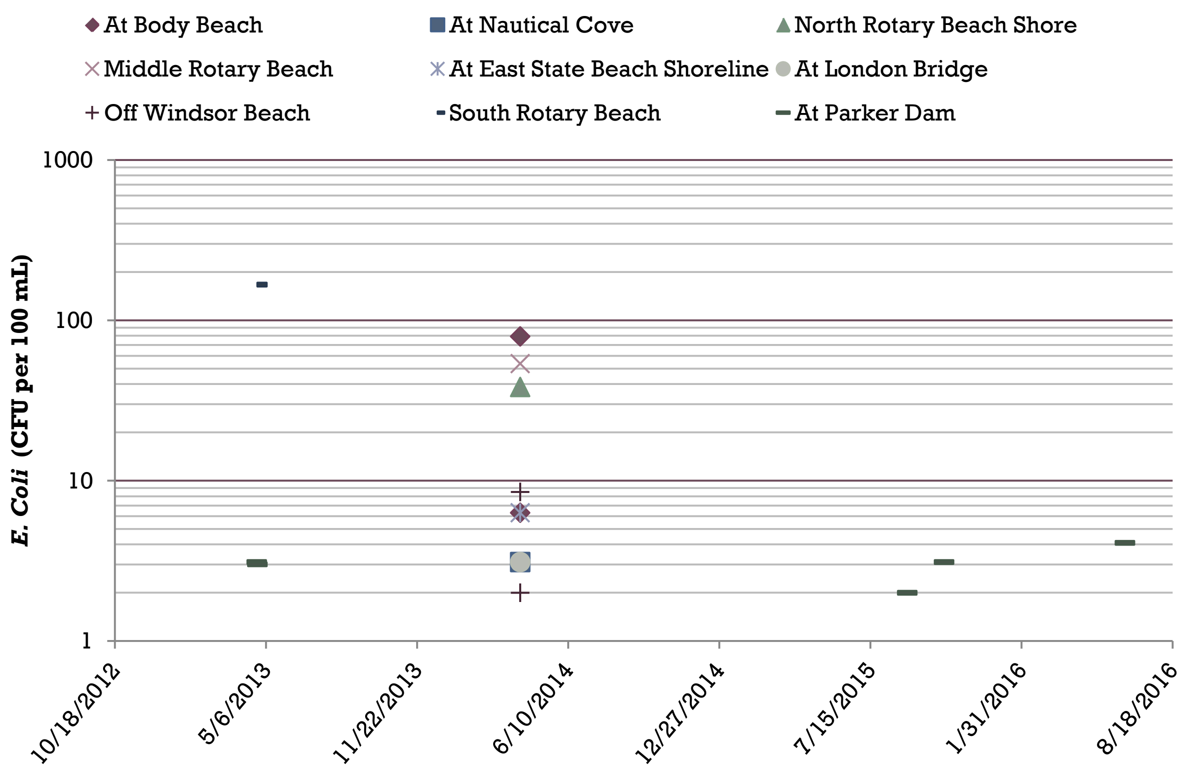


Figure 4-7. ADEQ E. coli sampling of Lake Havasu, 2013-2016 [70]

Municipal and Industrial Discharges

Occurrence in Watershed

There are 9 municipal and industrial NPDES permits authorizing discharges totaling 16.3 MGD, either directly to the Colorado River or to tributaries of the Colorado River (see **Appendix E**) within and adjacent to the Lake Mohave and Lake Havasu watersheds. NPDES permits expired for two facilities during the reporting period as shown in **Appendix E**. Current NPDES-permitted facilities with potential to impact the Colorado River, within this reach of the Colorado River, are shown in **Figure 4-8**. No permitted facilities were found in the southern part of Lake Havasu Watershed. The majority of NPDES permits are for wastewater treatment; however, the watersheds have permits for other types of discharges such as mining, electrical services, fish hatcheries, and automotive related industries (gas stations and car washing). It should be noted that the majority of flow values reported in **Appendix E** are permitted flows; actual flows could be much lower. Information was reviewed from the USEPA Enforcement and Compliance History Online (ECHO) database [71], the USEPA Permit Compliance System (USEPA PCS) database [72], and actual NPDES permits for the Laughlin Wastewater Reclamation Facility, Willow Beach National Fish Hatchery, Hilltop Wastewater Treatment Plant (WWTP), and the Hoover Dam WWTP.

Some facilities found in USEPA's ECHO and PCS databases had an NPDES ID with a "U" in the ID number. According to USEPA, this indicates that the facility was inspected by USEPA, but does not hold an NPDES permit; three facilities fall into this category. Although these facilities do not have an NPDES permit, they are included in **Appendix F** as other potential facilities of concern.

The USEPA Tribal Water Quality Program indicated that there are no wastewater treatment plants operated on tribal lands and no tribal discharges from Hoover Dam to Parker Dam [73]. The tribes treat wastewater flows using sewage lagoons, which do not discharge to Colorado River and tributaries, or send their sewage to non-tribal sewage collection facilities.

There are two major dischargers permitted to discharge 5 MGD or greater to the Colorado River within the Lake Mohave and Lake Havasu watersheds:

- Willow Beach National Fish Hatchery in Willow Beach, Arizona discharging 7.4 MGD
- Laughlin Wastewater Reclamation Facility in Laughlin, Nevada discharging 8 MGD

The U.S. Fish and Wildlife Service (USFWS) in Mohave County operates a fish hatchery at Willow Beach. Water from the Colorado River is circulated through the hatchery ponds then discharged. In fall 2013, USFWS ceased operations at the fish hatchery after losing its cold-water intake system. According to ADEQ, USFWS continued to comply with the NPDES permit provisions and did not have any compliance issues since the last reporting period [74]. ADEQ renewed the NPDES permit for the fish hatchery in May 2016 and continues to require effluent monitoring for pH, total suspended solids, settleable solids flow, and TDS.

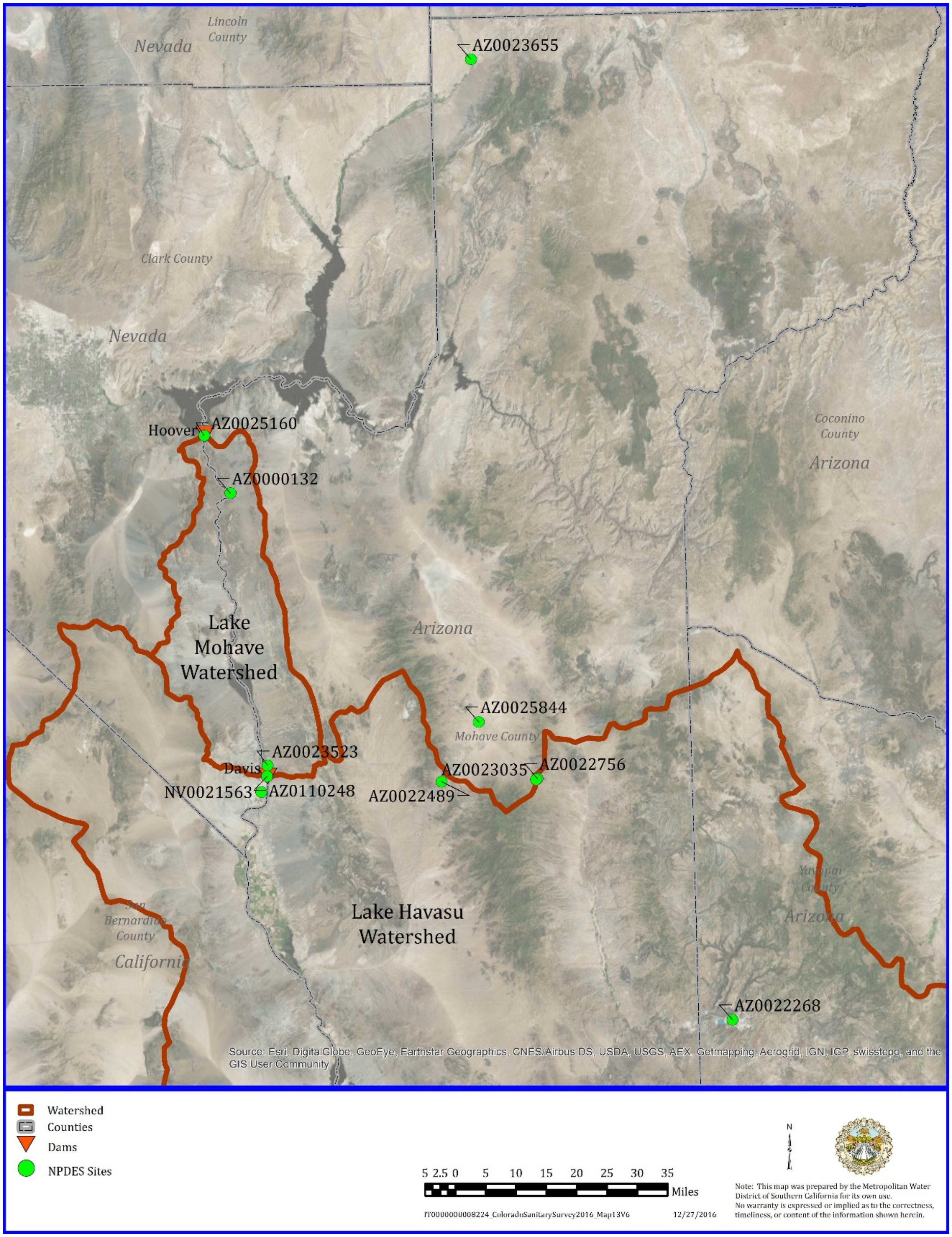


Figure 4-8. NPDES-Permitted Facilities in the Lake Mohave and Lake Havasu Watershed Areas

The city of Laughlin is served by one wastewater plant with a design capacity of 8 MGD, operated by the Clark County Water Reclamation District (CCWRD). The plant normally discharges tertiary treated effluent to the Colorado River in the winter, and reuses their effluent for irrigation of golf courses in the summer. Because this treatment plant has excess capacity, no additional wastewater improvements are planned. According to NDEP, there have been no compliance issues within the last five years [75]. The NPDES permit was renewed in April 2013 and continues to require effluent monitoring for flow, biological oxygen demand (BOD), total suspended solids (TSS), pH, fecal coliform, total phosphorus, nitrate, total Kjeldahl nitrogen, ammonia, temperature, and chlorine residual. Downstream river samples are also required for nitrate, ammonia, un-ionized ammonia temperature, and dissolved oxygen.

USBR operates a small wastewater treatment plant (with a design capacity of 0.03 MGD) at Hoover Dam, primarily to service the tourist population during the summer months and employees who work at the dam. Approximately 30,000 gallons per day of both tertiary treated effluent and filter backwash water is discharged to the Colorado River downstream of Hoover Dam [76]. The NPDES permit requires effluent monitoring for flow, total residual chlorine, ammonia, arsenic, copper, selenium, TDS, pH, BOD, TSS, and *E. coli*.

During the reporting period, the city of Kingman completed construction of the Hilltop WWTP and the Downtown WWTP. These new wastewater treatment plants replaced older existing plants, which employed lagoon technology. Per the NPDES permit, the Hilltop WWTP will discharge into Mohave Wash, located in the Colorado Grand Canyon River Basin, which drains into the dry Red Lake not connected to the Colorado River [77]. Hilltop WWTP may also discharge into a non-body of water-effluent dependent wetlands and has the capacity to discharge treated water through a tertiary system. The Downtown WWTP will discharge effluent into a local wash, the Sacramento Wash, before reaching the Colorado River. The Hilltop WWTP has a rated capacity of 5 MGD with normal flows projected to be 1–1.5 MGD. The Downtown WWTP has a rated capacity of 0.62 MGD, with normal flows projected to be 0.3 MGD.

The following wastewater treatment plants are mentioned only to identify their presence in the Lake Mohave and Lake Havasu watersheds. They do not hold NPDES permits and do not discharge to surface water:

- Bullhead City's existing centralized wastewater system consists of two wastewater treatment plants (Section 10 and Section 18) with a combined capacity of 6 MGD. The Section 10 WWTP, located approximately 1 mile east of the Colorado River, has a permit capacity of 4 MGD and is a conventional secondary wastewater plant with the capability to provide tertiary treatment levels. The Section 18 WWTP, located approximately 1.75 miles east of the Colorado River, was upgraded in 2007 to a 2.0 MGD membrane bioreactor wastewater plant. Currently, the Section 10 WWTP and Section 18 WWTP respectively treat an average of 2.4 MGD and 0.7 MGD of wastewater flows [78]. There are no impacts to the Colorado River, as the effluent is mostly used for reuse under reclaimed water permits or discharged to rapid infiltration basins.
- The city of Needles operates a wastewater treatment plant utilizing sequential batch reactor system technology. The wastewater treatment plant has a design capacity of 1.2 MGD. A sequencing batch reactor is an activated sludge process designed to operate under non-steady state batch conditions. The effluent from this wastewater treatment plant does not discharge directly to the Colorado River, located 3,000 feet to the east of the treatment plant, but to percolation ponds. The city of Needles ceased discharge of tertiary treated and disinfected wastewater into the Colorado River in early 2000. In March 2015, the RWQCB-Colorado River Basin Region adopted updated Waste Discharge Requirements (Order No. R7-2015-001) for the city of Needles' disposal of their effluent to percolation ponds [79]. The city has considered the

possibility of a future package wastewater treatment plant for a private residential development in the northern portion of Needles. However, no plans have been submitted to the city to date.

- The city of Lake Havasu's existing centralized wastewater system consists of three wastewater treatment plants (Island WWTP, Mulberry WWTP, and North Regional WWTP) with a combined capacity of 8.2 MGD. The Island WWTP and the Mulberry WWTP utilize secondary treatment with nitrate removal. The North Regional WWTP (NRWWTP) came online in September 2008 and employs membrane bioreactor technology. There are no direct impacts to the Colorado River, as the effluent is discharged into percolation ponds or reused.

Lake Havasu City is utilizing vadose zone injection wells to store excess treated wastewater effluent in the unsaturated sediments above the groundwater table. In 2008, the city completed installation of four, 4-foot diameter pilot injection wells, each 180 feet deep, which store 180 acre-feet of treated effluent. The injection site is adjacent to the North Regional Wastewater Treatment Facility, near the Lake Havasu Regional Airport, and about 2.5 miles away from the Colorado River. The life expectancy of the vadose wells is five to 10 years. In 2014, Lake Havasu City abandoned Vadose Well #3 and replaced it with Well #5 at the treatment facility. The City has current plans to replace Vadose Wells #2 and #4 with Wells #6 and #7 in 2017 [80].

As of mid-2015, the City had recharged 2,400 acre-feet of effluent. However, initial attempts to recover water in 2012 indicated that local geology was not conducive to yielding more than 5 gpm [81]. Lake Havasu is currently exploring other options for effluent storage and reuse including constructing large underground reservoirs, distribution system effluent storage pipelines, and constructing surface ponds at customer sites. Lake Havasu City plans to store more treated effluent, due to the ongoing conversion of residential individual septic systems to the city's centralized sewer system and envisions that the stored water would be used for irrigation purposes. As the treated effluent will eventually mix with the native groundwater, which flows towards Lake Havasu, there may be an indirect impact to Colorado River water quality. The mound front is estimated to move between 6 and 7 feet per day [82]. Chemical sampling is being conducted to trace the water mound front and to monitor chemical changes within the water mound. Water analyses include monthly determinations of nitrate, microbiology, pH, temperature, conductivity, quarterly analyses of metals and fluoride, and biannual tests for VOCs. Pharmaceuticals have been monitored in the treated effluent, the native groundwater, and Lake Havasu water.

A key area of concern within the Lake Havasu watershed is the Pacific Gas and Electric (PG&E) Topock Compressor Station, which is located one-half mile west of the Colorado River in eastern San Bernardino County. The compressor station, which compresses natural gas for transport, involves a cooling process that generates cooling tower wastewater. Between 1951 and 1968, the wastewater containing chromium-6 was discharged into the ephemeral Bat Cave Wash resulting in contamination of the groundwater. Chromium-6 has typically been at non-detectable levels in the Colorado River, downstream of the contaminated site, with isolated low-level detections. Environmental investigations and clean-up activities have been underway since 1997 and interim measures include groundwater extraction and reduction of chromium-6 levels through a treatment facility. The California Department of Toxic Substances Control (DTSC) is the lead agency overseeing the cleanup through the Resource Conservation and Recovery Act, and has coordinated the selection of a final remedial action with the U.S. Department of the Interior (DOI). In 2000, DTSC established a Consultative Workgroup (CWG) to provide consultation and recommendations to DTSC in its oversight of the project. Metropolitan is part of the CWG, which is comprised of federal, state, and local agencies, tribal governments, and other stakeholders that meet quarterly.

In accordance with the CERCLA, DOI finalized the Groundwater Record of Decision in December 2010, which presented the remedial action. In January 2011, DTSC certified the Final Environmental Impact Report and adopted a Final Remedy. The final design for the long-term treatment remedy was completed in November 2015 and DTSC determined that a Subsequent Environmental Impact Report was required to address project changes that were not addressed in the 2011 EIR. **Chapter 6** provides a detailed update on the Topock Compressor Station chromium-6 clean-up efforts.

Another area of concern in the city of Lake Havasu, less than one mile from Lake Havasu, is a chromium-6 plume that has extended from the former McCulloch Corporation (McCulloch). The chromium contamination is approximately 350 feet wide and extends about a third of a mile downgradient from the McCulloch plant in two overlying plumes, both below the local water table level, which is about 140 feet below ground surface. The downgradient extent of the plume is less than a mile from the lake.

Beginning in 1966, McCulloch conducted various manufacturing activities including machining, die casting, metal finishing, and chrome plating. McCulloch primarily manufactured gasoline powered equipment, such as chainsaws, for Black & Decker and Shop Vac Corporation (ShopVac). McCulloch disposed of process chemicals including acids and bases, cyanide compounds, oxidizers, petroleum-based fuel, and various solvents to the nearby disposal ponds (Kiowa Ponds) for an unknown period of time. In 1992, a leaking underground storage tank was removed and remedial activities detected VOCs and chromium-6 in the soil and groundwater beneath and northwest of the facility. McCulloch ceased manufacturing at the site and filed for bankruptcy in 1998.

ADEQ is currently developing a remedial action plan to clean up the site. In May 2016, ADEQ began the process to list the site on the Water Quality Assurance Revolving Fund site registry, which will provide resources for conducting site surface and groundwater monitoring, perform emergency remedial actions, and conduct long-term remedial action programs. As part of the remedial investigations, ADEQ will proceed with a data gap investigation, which will include rehabilitating monitoring wells and installing additional monitoring wells to characterize the nature and extent of the contamination. ADEQ will also develop an early response action plan and is considering options such as capping in the shallow vadose zone and in situ gaseous chemical reduction in the deep vadose zone.

Regulation and Management

Pollutants associated with municipal and industrial discharges are managed through the NPDES permit system. NPDES permits specify the conditions under which discharges to surface waters are allowed. The regulation and management of wastewater treatment in the Lake Havasu watershed are handled by three separate agencies:

- RWQCB-Colorado River Basin Region issues the NPDES permits for facilities in California
- ADEQ and USEPA Region IX issue NPDES permits for facilities in Arizona
- NDEP issues NPDES permits for facilities in Nevada

No enforcement action was taken against CCWRD's Laughlin plant in the last five years and no sewage spills were reported.

ADEQ is in the process of issuing an amendment to the city of Lake Havasu's Aquifer Protection Permit from ADEQ (Permit #P-105478) for water quality compliance monitoring and injection well disposal at the NRWWTP site. A public notice of the preliminary decision to issue an amendment to the Aquifer Protection Permit was published in January 2016 [83]. ADEQ is also overseeing the groundwater cleanup of the McCulloch site and is currently developing a remedial action plan to clean up the McCulloch contaminated groundwater site. In May 2016, ADEQ began the process to list the site on the Water Quality Assurance Revolving Fund site registr,y which will provide resources for conducting site surface and groundwater monitoring, perform emergency remedial actions, and conduct long-term remedial action programs. As part of the remedial investigations, ADEQ will proceed with a data gap investigation, which will include rehabilitating monitoring wells and installing additional monitoring wells to characterize the nature and extent of the contamination. ADEQ will also develop an early response action plan and is considering options such as capping in the shallow vadose zone and in situ gaseous chemical reduction in the deep vadose zone.

The cleanup activity for the PG&E's Topock Compressor Station is subject to both Resource Conservation and Recovery Act (RCRA) and CERCLA regulations. Under these regulations, DTSC (for RCRA) and DOI (for CERCLA) provide oversight of the Corrective Action Process. **Chapter 6** provides additional information regarding the regulatory cleanup process.

Studies and Monitoring

Pharmaceutical Monitoring in Colorado River

In 2007 to 2008, the city of Lake Havasu collected pharmaceutical data at two locations in the Colorado River as discussed in the CRWSS 2010 Update and does not have current plans to continue monitoring for pharmaceuticals in the Colorado River [84].

CCWRD has developed an educational outreach program "Pain in the Drain – Medicine Disposal Program," which manages the safe disposal of unused medication to keep it from reaching wastewater treatment plants, which eventually discharge to the Colorado River. CCWRD has partnered with the Cities of Las Vegas, Henderson, and North Las Vegas to encourage residents to participate in the program. Metropolitan contacted CCWRD to investigate opportunities for expanding awareness of the Pain in the Drain program, such as linking the program website (www.paininthedrain.com) to the Clark County and incorporated cities' websites. Due to limited resources, only the city of Henderson includes a link to the Pain in the Drain program on their website. Clark County provides educational resources to local cities upon request while continuing to serve as the primary agency providing awareness of the environmental concerns with flushing medication. During the reporting period, Clark County completed coordinating the installation of secure drug drop-off boxes at all twenty local police stations [85].

Metropolitan also contacted Mohave County to investigate whether a similar outreach program could be developed to encompass the City of Lake Havasu and Bullhead City. Due to limited resources Mohave County is not planning to develop a similar awareness program and defers to the state of Arizona to provide awareness and resources through the Prescription Drug Reduction Initiative. In February 2012, the Arizona Criminal Justice Commission kicked off the Initiative with a focus on reducing drug abuse and providing an environmentally safe alternative to disposing drugs in landfills or sewer systems. The Initiative has resulted in the installation of secure drug drop-off boxes at numerous locations throughout Arizona including Bullhead City, city of Kingman, Mohave Valley (Fort Mohave) and Lake Havasu City [86].

Contamination Investigations at the McCulloch Site

ShopVac, a major stakeholder, conducted investigative and remedial activities until 2008. In March 2014, ADEQ sampled 37 groundwater monitoring wells at the site and documented results in a report [87]. The results indicate that the primary contaminants of concern (COCs) detected in the groundwater samples include trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), total chromium, chromium, and nitrate. TCE was detected above the MCL (0.005 mg/L) with a maximum concentration of 0.031 mg/L in well MW-1; PCE was detected above the MCL (0.005 mg/L) with a maximum concentration of 0.06 mg/L in well MW-20; 1,1-DCE was detected above the MCL (0.006 mg/L) with a maximum concentration of 0.009 mg/L in well MW-13; 1,2-DCA was detected above the MCL (0.0005 mg/L) with a maximum concentration of 0.018 mg/L in well MW-13; chromium-6 was detected above the MCL (0.010 mg/L) with a maximum concentration of 0.68 mg/L in well MW-20; and nitrate was detected above the MCL (10 mg/L as N) with a maximum concentration of 14 mg/L in well MW-12. **Figure 4-9** shows the results of chromium-6 monitoring in out-of-service Lake Havasu City production wells adjacent to Lake Havasu, west of the site. Chromium-6 levels in the Lake Havasu City wells were as high as 0.044 mg/L and indicate that the plume is migrating towards Lake Havasu.

Figure 4-9. Chromium-6 Monitoring from McCulloch Site near Lake Havasu, 2015 [90]

Spills

Occurrence in Watershed

The primary threats of spills to the Colorado River result from accidents over road crossings or vessel accidents in recreational areas. Hazardous material haulers use river crossings and traffic corridors adjacent to the Colorado River and Lake Havasu. River crossings occur at Parker Dam (Parker Dam Road off of Highway 95 bypass), Topock (Interstate 40), Needles (Harbor Avenue from Interstate 40), Laughlin/Bullhead City Bridge (Bullhead City Parkway), and Davis Dam (Highway 68/163). Truck and trailer traffic is prohibited on Parker Dam.

Appendix G indicates that from 2011 to 2015 there were 33 spills reported to the NRC, with potential to impact water quality. Most spills were caused by sunken vessels (8), transportation related incidents (4), operator error (3), or were unknown sheens reported (3) in the water. Although there were many vessel-related spills, the highest reported spill volume directly into water occurred in July 2013 due to one traffic accident involving multiple vehicles on the Arizona/California bridge in Lake Havasu City. Approximately 100 gallons of diesel was discharged into the Colorado River. Incident response teams were able to apply absorbents and contain the spilled material

Another notable spill involved 40 gallons of unleaded gasoline released from a pleasure craft that caught fire at the boat launch near Parker Dam. Most of the fuel burned in the fire before the boat sank into the Colorado River.

Regulation and Management

USBR is required to report any spills at or near Parker Dam or Davis Dam to ADEQ, NDEP, and NRC. The reports are typically passed on to a federal On-Scene Coordinator (OSC) from USEPA for inland areas or USCG for coastal and major navigable waterways. The OSC coordinates all federal containment, removal, disposal efforts, and resources during an incident. In 2009 under the direction of USEPA, a steering committee (Lower Colorado River Area Committee) was tasked with developing an emergency response plan for the lower Colorado River (Hoover Dam to the United States/Mexico border). The Lower Colorado River Geographic Response Plan was completed in February 2014 and included the following objectives [88]:

- Describe the overall emergency response organization for hazardous materials incidents occurring within the Lower Colorado River response area;
- Delineate the responsibilities of local, state, tribal, and federal agencies in the event of a hazardous materials incident within the Lower Colorado River response area;
- Establish lines of authority and coordination for hazardous materials incidents;
- Facilitate mutual aid to supplement local resources; and
- Describe procedures for accessing outside funding (e.g., state and federal funding) for the mitigation of, and recovery from, hazardous materials incidents.

The CRWSS 2010 Update recommended that Metropolitan coordinate with other agencies such as CCRSCo members to consider opportunities for establishing notification protocols to obtain timely information regarding spills that may impact Colorado River water quality. Since the protocols have been established under USEPA's direction, Metropolitan worked with USBR to ensure that Metropolitan was included in the Lower Colorado River Geographic Response to receive spill notifications as an affected downstream water utility. USBR has been designated as the lead response agency and is coordinating with CCRSCo members to ensure an effective notification process with all members.

Landfills

Occurrence in Watershed

As shown in **Figure 4-10**, there are three landfills near the Colorado River between Bullhead City and Parker Dam: Needles Landfill, Lake Havasu City Landfill, and Mohave Valley Sanitary Landfill.

The Lake Havasu City Landfill, in operation since 1971, is owned by Lake Havasu City, but it is operated by Allied Waste. It is located approximately 3 to 4 miles from the Colorado River and covers approximately 200 acres. According to Allied Waste, the landfill applied for and was granted a variance for groundwater monitoring due to a groundwater depth of over 500 feet. The landfill is also not required by law to have a liner.

The Mohave Valley Sanitary Landfill is owned by Mohave County, but is operated by Allied Waste. The 160-acre landfill is located approximately 6 miles from the Colorado River and has been in operation since 1989. Similar to the Lake Havasu City Landfill, the Mohave Valley Sanitary Landfill was given a variance for groundwater monitoring and, by law, does not require a liner.

The Needles Landfill is located approximately 5 to 10 miles from the Colorado River. The landfill began operation as a sanitary landfill in 1967 when BLM issued a Temporary Use Permit to San Bernardino County. In August 1982, the city of Needles, under an agreement with San Bernardino Waste System Division, began operating the landfill. The landfill ceased accepting waste on October 7, 1994.

Beginning in 1970 and ending in 1984, chromium hydroxide sludge was dumped by PG&E into the Needles Sanitary Landfill. The discharger reports that over a 10-year period, from 1973–1983, an estimated 166,500 gallons of chromium hydroxide sludge was disposed of at the landfill. When the city of Needles took over the operation of the landfill, the pit containing the chromium hydroxide sludge was demolished, leaving the sludge to spread. Trace amounts of chromium-6 were found in the soil, raising concern about possible contamination of the groundwater. No groundwater contamination has been found to date, and construction of a final cover system has been completed. The disposal areas for this landfill are not lined and there is no leachate collection and removal system.

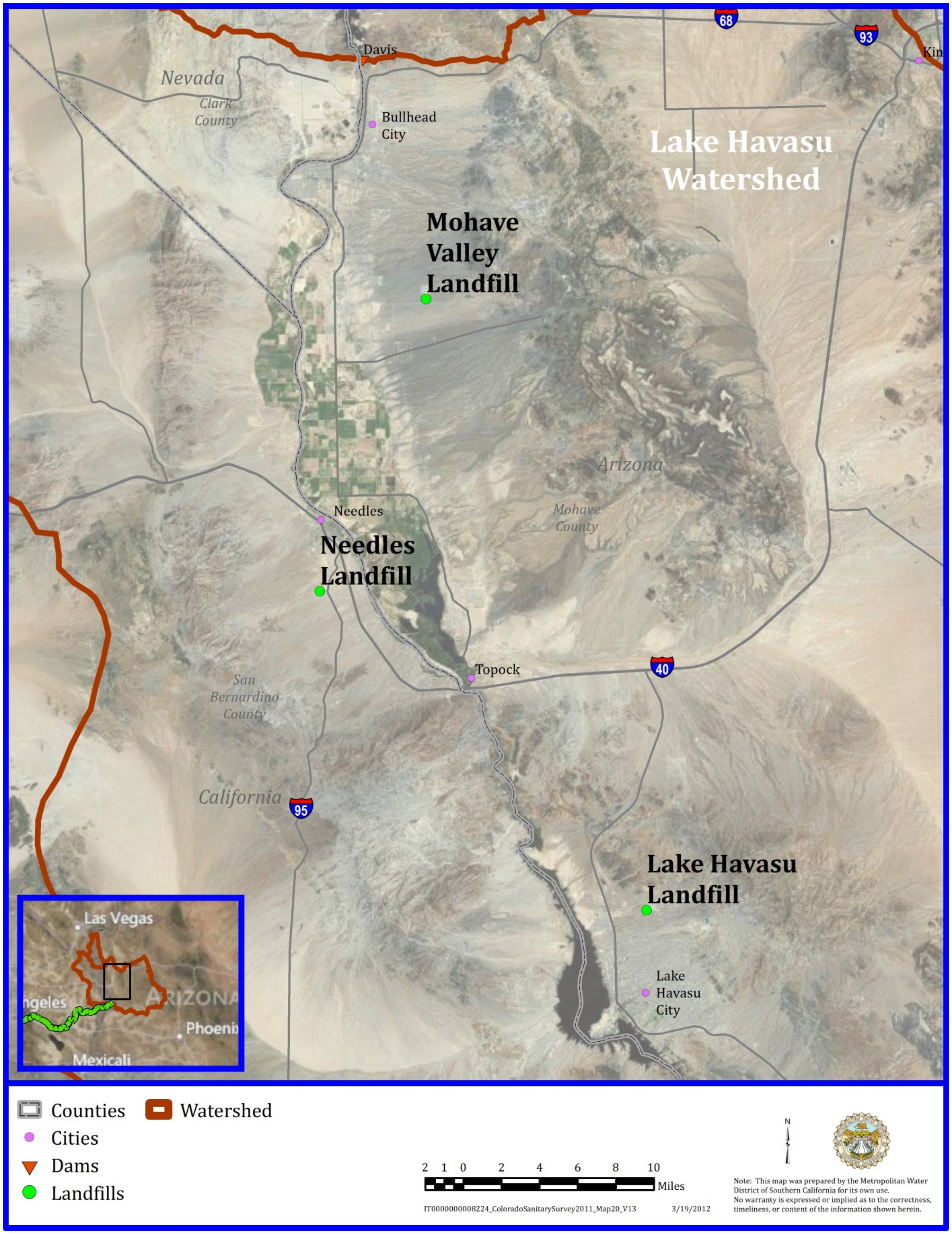


Figure 4-10. Landfills in Lake Mohave and Lake Havasu Watersheds

Regulation and Management

ADEQ's Solid Waste Inspections and Compliance Unit is the regulatory agency for the Lake Havasu City and Mohave Valley Sanitary Landfills.

The management of the Needles Landfill, located in San Bernardino County, is overseen by the RWQCB-Colorado River Basin Region and the San Bernardino County Department of Public Health's Division of Environmental Health Services. The RWQCB's responsibilities include permitting, monitoring, and enforcement of waste discharge requirements mandated by state regulations (Title 27) and federal regulations (Subtitle D) for the disposal of waste to land. The RWQCB's goal is to protect the ground and surface water quality via these regulations. The County of San Bernardino Department of Public Health's mission is to protect public health and safety from migration of landfill gases off-site. The county inspects active landfills once a month and closed landfills quarterly.

Studies and Monitoring

The Needles Landfill was issued a cleanup and abatement order (CAO 97-111) in August 1997 due to a release from the landfill. Tetrachloroethene (PCE) and dichlorodifluoromethane were detected in groundwater samples at 0.00043 mg/L and 0.00031 mg/L, respectively. A final cover was constructed over the landfill and was completed on May 28, 1999. Closure certification for the landfill was granted on March 26, 2002, and the CAO was rescinded in February 2003. In a letter from February 2003, the RWQCB-Colorado River Basin Region states "a review of groundwater monitoring reports for the past several years indicates that concentrations of VOCs and indicator metals tend to be consistently below maximum contaminant levels for drinking water … It appears the work done … [has] been successful in reducing the impact of pollutants to the groundwater as well as reducing the potential for further contamination. Therefore, CAO 97-111 is hereby rescinded." Site activities are now limited to monitoring until evidence of a release to groundwater is identified. As shown in **Appendix H,** there are four monitoring wells: N-1, N-2A, N-4, and N-5. N-1 is considered the background well and the rest are considered downgradient of the landfill. In July 2014, the County of San Bernardino submitted a letter to RWQCB-Colorado River Basin Region requesting a reduction in the monitoring frequency. Per Tentative Order No. R7-2015-0037, the RWQCB proposes to deny the request due to levels of concern of tetrachlorethene in monitoring well N-4 and the exceedance of regulatory levels for total chromium in monitoring well N-1 [89].

A review of the 2011 to 2015 groundwater monitoring data shows that concentrations of monitored VOCs are below MCLs for drinking water. VOC levels have remained relatively static during the last five years, with the exception of observed changes in the downgradient well N-4. The PCE concentration in well N-4 has increased slightly over time. PCE levels are highest in the downgradient well N-4 compared to N-1, N-2A, and N-5. As discussed in the CRWSS 2010 Update, a new maximum of 0.0014 mg/L was measured in February 2007 in well N-4. During this reporting period, a new maximum concentration of 0.0017 mg/L was measured for PCE in well N-4 in December 2012. This trend indicates that some localized landfill impacts to groundwater have occurred in the vicinity of well N-4. However, PCE concentrations have never exceeded the MCL for PCE of 0.005 mg/L and there is no indication that the Colorado River has been impacted.

A review of the 2011 to 2015 groundwater monitoring data shows that concentrations of metals are generally below MCLs, with the exception of total chromium. Samples taken from 2012 to 2014 for total chromium at well N-1 were above the MCL with a maximum concentration of 1.5 mg/L in December 2013. High levels of total chromium for this same well were noted in the CRWSS 2010 Update. An anomalously high concentration of 3.8 mg/L for total chromium was measured at well N-5 in December 2014; retest samples in January 2015 indicated that total chromium was within the historical analytical range. Chromium-6 concentrations are generally below the MCL. Historically, a maximum concentration of 0.04 mg/L was measured in wells N-4 and N-5 in 1998 but levels have decreased, since 2000, to below 0.01 mg/L for all wells.

Notably, TDS concentrations in wells N-2A, N-4, and N-5 have increased slightly over time. Maximum concentrations exceeding the 500 mg/L secondary MCL were measured in well N-2A (570 mg/L) and well N-5 (520 mg/L) in December 2014.

Pursuant to RWQCB Order No. R7-2003-0046: *County of San Bernardino Needles Waste Management Facility Class III Landfill Class II Surface Impoundments*, adopted on May 7, 2003, groundwater sampling and reporting continue to be performed on an annual basis at the Needles Sanitary Landfill [90]. However, if Tentative Order No. R7-2015-0037 is adopted, the County of San Bernardino would require sampling and reporting to be completed on a semi-annual basis.

Leaking Underground Storage Tanks

Occurrence in Watershed

Arizona

There are an estimated 10 facilities with open LUST cases in Lake Havasu City, Mohave Valley, and Bullhead City (**Figure 4-11** and **Table 4-4**). The CRWSS 2010 Update reported 15 facilities with open LUST cases; 5 of the previous cases are now closed, 9 cases remain in active remediation, and there is one new case in active remediation. The ADEQ's database on LUST sites was searched to obtain this information [91]. The majority of the sites are retail gasoline facilities located within 0.5 miles of the Colorado River. The closest site is located approximately 250 feet from the Colorado River in Bullhead City, Arizona.

California

SWRCB maintains an internet-accessible database system, GeoTracker, for managing sites that impact groundwater, LUSTs, and land disposal sites [92]. According to the GeoTracker database, there are an estimated 5 facilities with open LUST cases in Needles (**Figure 4-11** and **Table 4-5**). The CRWSS 2010 Update reported 15 facilities with open LUST cases. The majority of the LUST sites are retail gasoline facilities or railway facilities located less than a mile from the Colorado River.

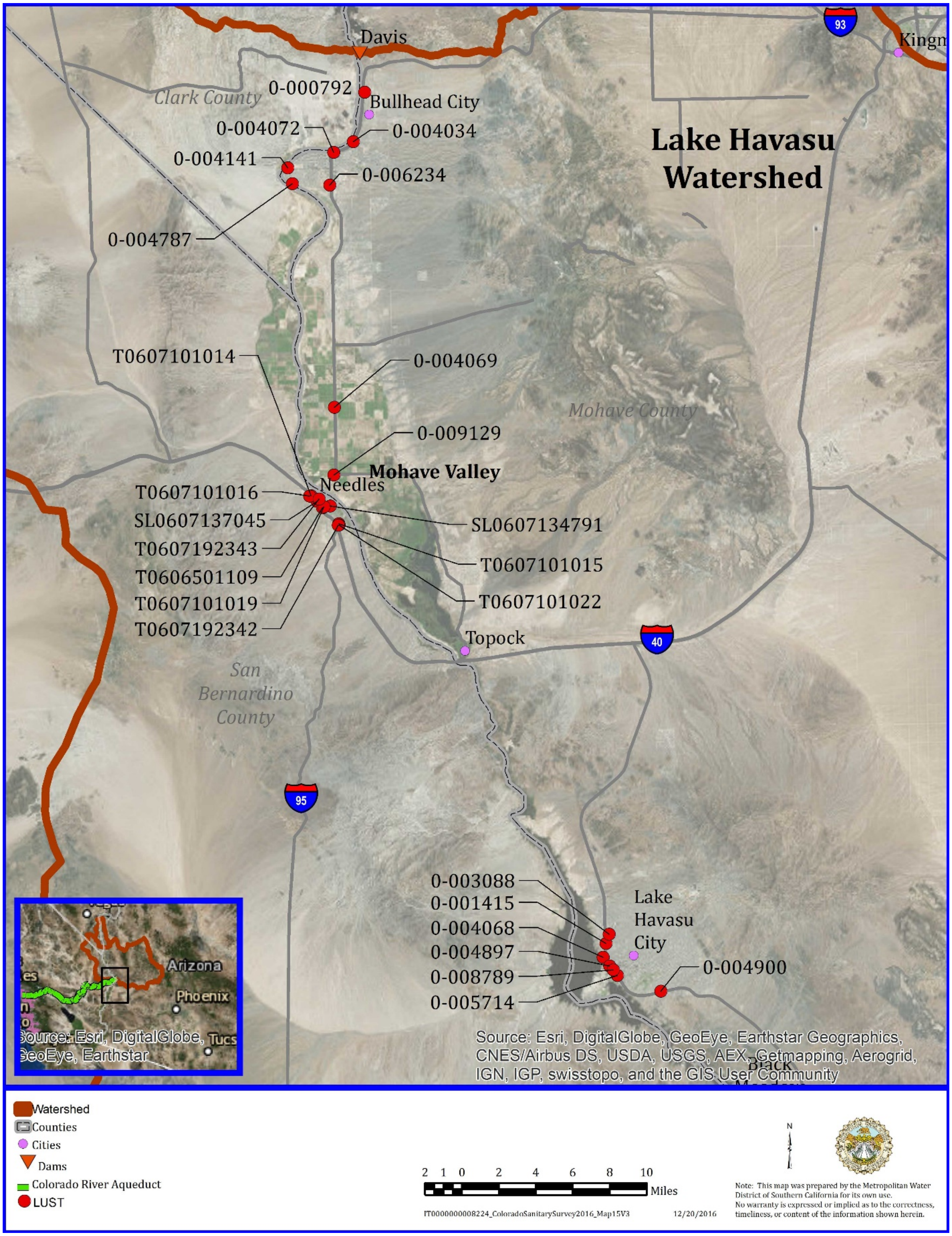


Figure 4-11. Active and Inactive LUSTS along Colorado River between Davis Dam and Parker Dam

Table 4-4. Summary of LUST Information for Lake Havasu City, Bullhead City, and Mohave Valley Arizona [94]

Site ID	Report Date	Facility Name	Address	Distance to Colorado River (miles)	Status
0-000792	5/4/2005	Laughlin/Bullhead International Airport	600 Highway 95 Bullhead City	0.15	Active remediation.
0-001415	11/26/2012	Circle K #2701473	1731 Industrial Blvd Lake Havasu City	0.40	Closed: Mar. 6, 2015
0-003088	12/17/1992	McCulloch Corporation Plant – Former	900 Lake Havasu Ave N Lake Havasu City	0.91	Closed: Jul. 18, 2012
0-004034	5/30/2003	Rainbow Haven Mobile Home Park	1619 Highway 95 Bullhead City	0.10	Active remediation
0-004068	2/16/1989	Ray Bell #440 – Hoggs Kountry Kuzins	416 London Bridge Rd Lake Havasu City	0.28	Active Remediation
0-004069	1/18/1996	Ray Bell #442	8045 S Highway 95 MOHAVE VALLEY	1.90	Closed: Jun. 7, 2012
0-004072	2/3/1999	Soper Market #445	1901 Highway 95 Bullhead City	0.13	Closed: Nov. 21, 2013
0-004141	7/22/2013	Dockside Mini Market	416 Hancock Rd Bullhead City	0.15	Active remediation since 2007
0-004787	10/4/1996	Lazy Harry's Saloon & Marina	2170 Rio Grande Rd Bullhead City	0.05	Active remediation
0-004897	4/30/1991	Terrible Herbst #101	60 Lake Havasu Ave N Lake Havasu City	0.30	Active remediation
0-004900	11/19/1996	Terrible Herbst #148	1040 Acoma Blvd S Lake Havasu City	1.35	Active remediation
0-005714	3/19/1990	Trailside General Store	283 Lake Havasu Ave S Lake Havasu City	0.47	Active remediation
0-006234	3/6/2014	Jacksons Food Store #103	2540 Highway 95 Bullhead City	1.12	Active remediation
0-008789	10/27/1999	Ken & Mel's EXXON	52 Lake Havasu Ave S Lake Havasu City	0.27	Active remediation
0-009129	3/8/2010	ARCO AM/PM #81414	1001 S Harbor Ave Mohave Valley	0.61	Closed: Aug. 28, 2014

Table 4-5. Summary of LUST Information for Needles, California [94]

Site ID	Report Date	Facility Name	Address	Distance to Colorado River (miles)	Contaminant	Status
SL0607134791	6/15/1998	BNSF Railway Company	South East of the Intersection	0.3	Diesel	Open - Remediation as of 3/25/2014 Above ground storage tank (AST) demolished and removed in 2005. Construction and operation of the Biocell was completed in 2008. Quarterly soil sampling is ongoing at the site.
SL0607137045	11/1/2003	BNSF Railway Company	1701 Eagle Pass Road	0.57	Petroleum, Oils	Open - Remediation as of 3/26/2014 Site remediation (free product removal) ongoing since 2003. Additional Site Investigation Work Plan completed in 2015.
T0606501109	8/12/1994	Griswold Enterprises	219 I Street	0.68	Gasoline	Closed - As of 5/10/2011 Leak discovered and reported in 1994. Physical and mechanical damage to the tank was the cause of discharge.
T0607101014	9/4/1992	Whiting Bros West	2402 West Broadway Ave.	0.50	Gasoline, Diesel, Waste Oil	Closed – As of 2/10/2015 Eleven USTs removed in 1992. Soil and groundwater treatment completed.
T0607101015	9/4/1992	Whiting Bros West	901 Broadway East	0.69	Fuel oxygenates, gasoline	Open - Remediation as of 5/20/2015 Contamination discovered in 1992. Soil vapor extraction pilot test conducted in 1994. A remedial action plan for vapor extraction/air sparging was approved in 2010.
T0607101016	12/20/1995	G & M Oil #26	2321 Broadway Ave W	0.54	Petroleum	Closed – As of 6/26/2014 Four USTs removed in 1997. Soil and groundwater treatment completed in 2007 and 2013, respectively.

Table 4-5. Summary of LUST Information for Needles, California continued [94]

Site ID	Report Date	Facility Name	Address	Distance to Colorado River (miles)	Contaminant	Status
T0607101019	1/13/1988	Shell Mini-Mart	1219 Broadway	0.57	Fuel oxygenates, gasoline	Closed - As of 6/27/2013 Initial unauthorized release of hydrocarbons was reported 1997. Soil and underground remediation occurred from 2001 to 2010. A "Low Threat Closure Policy Review" performed in 2013.
T0607101022	8/13/1999	I-40 TEXACO	916 E. Broadway Street	0.70	Fuel oxygenates, gasoline	Open - Eligible for closure as of 9/9/2013 Soil vapor extraction (SVE) and In Situ Physical/Chemical Treatment (other than SVE) in 2005. Pump & Treat (P&T) Groundwater in 2009.
T0607192342	11/27/2000	Mohave Oil Company	917 E. Broadway Street	0.74	Gasoline	Closed - As of 4/1/2014 The UST system was removed from the site in 2000. The site was adequately assessed and remediated.
T0607192343	11/6/2000	Ten Four Corporation Property	1621 N St.	0.41	Diesel	Open – Inactive as of 5/15/2012 Site assessment not completed. Low threat closure policy review completed in 2013.

Nevada

Per NDEP's online LUST database, there were six reported incidents associated with the former Mojave Generating Station in the City of Laughlin [93]. Clean-up was completed of these incidents involving diesel, hydraulic oil, mineral oil, lube oil, lead, and hydraulic fluid. According to NDEP, there was no impact to groundwater or to the Colorado River. Also, according to NDEP, the Mojave Generating Station has likely impacted the Colorado River through a mineral plume of elevated TDS originating from the site. It is important to note that clean-up efforts to address this concern have already been completed. Elevated levels of TDS in groundwater were found below the site in the early 1990s as a result of cooling water stored in unlined ponds. In order to address this issue, contaminated groundwater was extracted and stored in double-lined evaporation ponds for over 15 years, from 1992 to 2007. Since TDS levels in the groundwater were eventually reduced from 10,000 mg/L to 600 mg/L, extraction and clean-up efforts ended in 2007. The Mohave Generating Station plant closed in 2005, and decommissioning began in 2009 and was completed in 2013. Ongoing monitoring will continue every six month until 2019 [94].

Other reported LUSTs included the removal of an underground storage tank at Hotel Dam in Boulder City in February 2014 and a mineral oil spill related to a Nevada Energy transformer in Laughlin. Clean-up was completed for these incidents. There is one active case, since June 2012, involving active remediation of spilled gasoline at the South Pointe Market in Laughlin, approximately half a mile from the Colorado River.

Regulation and Management

USEPA

USEPA issued updated UST regulations on July 15, 2015, which increase the emphasis on properly operating and maintaining UST systems (i.e., updated design and construction requirements, increased equipment testing and inspections, and operator training requirements). The new federal UST regulations became effective on October 13, 2015 in Indian Territory and states, including California, that do not have State Program Approval [95].

Arizona

Spills and leaks from USTs are reported by the tank owner/operator to ADEQ. The owner/operator of the facility is responsible for conducting the remediation. ADEQ monitors for all contaminants when a direct release occurs and monitors remediation of all LUST sites. They also perform inspections of leak detection equipment, tank operations, and installation compliance.

California

While California has a UST program regulated through the California Code of Regulations Title 23 Chapter 16, California has not been granted state program approval from USEPA and does not have the lead role in UST program enforcement. As a result, USEPA Region 9 works cooperatively with the SWRCB UST Cleanup Unit to coordinate UST enforcement actions and improve the efficiency of LUST cleanups. On a local level, RWQCBs provide state oversight of local agency UST programs. On August 20, 2015, the SWRCB notified California UST owners and operators that they are required to comply with the new federal UST regulations.

The San Bernardino County Fire Department and the RWQCB-Colorado River Basin Region share the responsibility of overseeing the remediation of LUST sites along Lake Havasu. They manage the site investigation that determines the levels of contamination in soil and groundwater and provide guidelines to the responsible party to achieve successful remediation. Only the RWQCB has the authority to officially close a site once remediation is complete.

Neither California nor Arizona has regulations as to the location of USTs. Some of the underground tanks at marina sites and gas stations are in close proximity to the Colorado River.

Nevada

NDEP administers the UST Program for the State of Nevada. Clark County Health District also performs UST inspections in their jurisdictions via inter-local contracts with NDEP.

Studies and Monitoring

The SWRCB completed the *California Leaking Underground Fuel Tank Guidance Manual* (LUFT Manual) in September 2012 and updated the LUFT Manual in December 2015. The LUFT Manual is intended to provide technical guidance to regulators, responsible parties, and consultants [96]. The LUFT Manual describes "best practices" for the remediation process from discovery to closure, and provides a flowchart of alternatives for the remediation process. The LUFT Manual provides information to improve efficiency, control costs, and reduce the overall time for remediation. Some LUST cases have been open for over 20 years. The LUFT Manual can be used to facilitate management of these active LUST sites to expedite remediation.

Septic Systems

Occurrence in Watershed

Historically, most of the cities located in this reach of the watershed have relied on septic systems for wastewater treatment. As discussed in the CRWSS 2010 Update, CCRSCo (formerly CRRSCo) and USBR have previously documented the occurrence of septic systems and resources needed to improve water quality along the lower Colorado River. These septic system assessments have not been updated since 2007. Metropolitan contacted entities along the Colorado River and was able to obtain limited updated information on the extent of septic systems within their jurisdiction.

Arizona

Due to growing concerns with water quality, significant progress has been made in eliminating septic tanks in the Lake Havasu City and Bullhead City area [97]. In 2011, Lake Havasu City completed a 9-year wastewater expansion program and removed over 22,000 septic tanks from service [81]. Approximately 85 percent of Lake Havasu City is connected to a sewer system with 5,000 to 6,000 septic tanks remaining [98]. Updated information is not available for Bullhead City; however, as of 2009, Bullhead City had reduced the number of septic tanks from 8,900 to 2,000 [99].

The CRWSS 2010 Update reported septic information from an assessment conducted for Mohave County between January 2008 and December 2010. Based on the previous study, 40 sewage complaints were received - 22 were reported in the Lake Havasu area and 18 were reported in the Bullhead City/Fort Mohave/Mohave Valley area. Mohave County indicated that 274 sewage complaints were logged between January 2011 and December 2015; however, updated information for the specific locations was not available [100]. These sewage complaints are the number of reported incidents of surfacing or overflowing sewage from a septic system. It may be that there are more unreported incidents. Due to the proximity of the Colorado River, and because groundwater has a direct impact on the Colorado River in these areas, the Colorado River may have been affected. Resolution consists of one of the following actions: 1) repair of the septic system, 2) connection to sewer, or 3) disconnection of water service, at the request of the Mohave County, to abate the nuisance.

California

It is difficult to obtain exact numbers of septic systems in this area, as the jurisdiction for permitting and inspecting septic systems is spread between the RWQCB, San Bernardino County, and the city of Needles. Most communities in the lower Colorado River region utilize septic systems with the exception of the city of Needles, which has a sewer system serving part of the city. As of 2015, the city of Needles has approximately 210 septic systems in use [101]. The northern portion of Needles is not connected to the city's sewer system, so all new development relies on septic systems. To date, all development consists of single-family homes on minimum 2-acre lots. If a large subdivision were to be proposed in the future, the developer would likely be required to install a package plant for wastewater treatment and disposal.

The largest residential area near the Colorado River and under the jurisdiction of San Bernardino County is Havasu Landing, a 2-square mile area near the River. There are approximately 300 homes with accompanying septic systems in this area [102]. The San Bernardino County Code Land Use Services Department, Code Enforcement Division states that, although they respond to septic system failures, they do not track the incidents and have no way of confirming the number of failures over the reporting period. The San Bernardino County Department of Environmental Health has also reported that they do not keep track of septic system failures.

South of Needles to Parker Dam, there are several thousand individual septic systems for residential use and commercial facilities. The resorts and recreational vehicle (RV) parks along the Colorado River have group septic systems primarily designed for concentrated summer use. Winter visitation to these areas is increasing and these systems are now being utilized heavily year-round. Some of the larger systems use evaporation ponds, but most have underground leach fields. The exact extent of septic system usage cannot be estimated because of multiple jurisdictions – federal (BLM), tribal territory, or county jurisdiction.

Regulation and Management

Arizona

Effective March 1, 2014, the new Mohave County Environmental Quality/Waste Disposal Division of the Mohave County Health Department is responsible for conducting septic tank inspections, issuing permits for individual septic systems, and for issuing violations for failed septic systems. ADEQ reviews the design of community septic systems to make sure they meet required standards, but they do not conduct regular inspections. Septic systems over 24,000 gallons are required to have individual wastewater discharge permits from ADEQ and are inspected periodically.

As of July 1, 2006, ADEQ developed a new rule (Arizona Administrative Code R18-9-A316) requiring all onsite systems, whether conventional septic tank systems or alternative onsite systems, to be inspected when ownership of the property changes, regardless of the date of construction [103]. Previously, only new systems were inspected. The seller shall retain a qualified inspector to perform the transfer of ownership inspection within six months of property transfer. The inspector shall prepare a Report of

Inspection form, which is provided to the seller. Subsequently, the buyer shall complete a Notice of Transfer form to ADEQ.

California

San Bernardino County Department of Building and Safety issues permits for single-family residential septic systems in unincorporated areas of the county and conducts the initial inspections for new systems. The San Bernardino County Department of Environmental Health reviews the percolation reports to evaluate the capacity of the system based on soil conditions for all subdivisions and commercial facilities in unincorporated areas of the county. Once approved, the Department of Building and Safety issues a permit for the installation of these systems. The setback requirement for septic systems is 200 feet from the Colorado River. The County's Code Enforcement division in Land Use Services is responsible for following up on septic failures for single-family residences and restaurants.

All other public septic systems are the responsibility of the RWQCB-Colorado River Basin Region. Typically, the RWQCB regulates septic systems greater than 5,000 gallons. The RWQCB confirmed that there was one change to the number of septic systems regulated from the CRWSS 2010 Update due to the closure of a facility. Currently, there are 14 permitted facilities. **Table 4-6** provides a list of all septic systems with RWQCB-Colorado River Basin Region jurisdiction. There are additional septic systems on tribal lands, but they are not subject to RWQCB regulation.

Table 4-6. Summary of Septic Systems in California within RWQCB-Colorado River Basin Region Jurisdiction [47]

Facility ID	Permit No.	Facility Name	Address	Distance to Colorado River
7B361003001	97-50099	Sunshine Resort	Parker Dam Road Parker Dam, CA	500 feet
7B361011001	97-500159	Calizona RV Park	1902 Five Mile Road Needles, CA	5 miles
7B361007001	97-50082	Northshore RV Resort	RR4 Box 103 Needles, CA	5 miles
7B361281001	97-50006	River Lodge Resort	PO Box 908 Parker Dam, CA	5 miles
7B361345001	97-50070	Desert Riviera MH & RV	2515 Parker Dam Road Parker Dam, CA	500 feet
7B361006001	97-50073	Rio Del Colorado	PO Box 1088 Parker, AZ	1.5 miles
7B361005001	97-50072	Windmill Resort	7 miles NE Earp/Parker Dam Road Earp, CA	1 mile
7B361268001	97-50007	Echo Lodge Resort	10.5 miles N of Earp, CA	5 miles
7B361002001	97-50056	River Land Resort	HC 20, Box 105 Earp, CA	1 mile
7B360130002	97-50095	Gene Pumping Plant	PO Box 38 Parker Dam, CA	1.5 miles
7B361029011	97-50034	Rainbow Beach Resort	3520 Needles Highway Needles, CA	0.4 miles
7B131006011	97-500127	San Pasqual USD	676 Route 1 Baseline Road Winterhaven, CA	5 miles
7B131009011	97-500153	Walter's Camp, Inc.	Walter's Camp Road Palo Verde, CA	5 miles
7B131304001	97-50021	Pilot Knob RV Resort	3707 West Highway 80 Winterhaven, CA	5 miles

The city of Needles issues permits and conducts inspections for septic systems within its city limits. In addition, the RWQCB conducts yearly inspections to ensure that the systems are being maintained; they reported no major problems or spills during the reporting period.

The SWRCB adopted the Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems (OWTS) on June 19, 2012. The policy was adopted with the intent of providing consistent guidelines throughout California for the construction and maintenance of septic systems to protect surface water and groundwater from wastewater discharge. The OWTS Policy, effective on May 13, 2013, establishes a statewide, risk-based, tiered approach for the regulation and management of OWTS installations and replacements and sets the level of performance and protection expected from OWTS [104]. OWTS are classified into five tiers.

- Tier 0 OWTS are existing and functioning properly
- Tier 1 OWTS are low risk due to location and design
- Tier 2 OWTS comply with siting and design standards in an approved Local Agency Management Program
- Tier 3 OWTS are located near impaired water bodies and are subject to an Advanced Protection Management Program
- Tier 4 OWTS are failing and require corrective action.

The RWQCBs were required to incorporate the OWTS Policy, within a year of the effective date, into their Water Quality Control Plans (also referred to as Basin Plans). However, local agencies may continue to implement their existing OWTS permitting programs for 5 years after the effective date unless the OWTS is located near an impaired surface water body that is subject to a TMDL implementation plan or a special provision in the local agency management program [105].

Studies and Monitoring

As discussed in the CRWSS 2010 Update, there was a concerted effort by multiple entities and stakeholders including the Clean Colorado River Alliance, the Colorado Regional River Sewer Coalition (now Clean Colorado River Sustainability Coalition), ADEQ, and local agencies to support wastewater planning along the lower Colorado River during the last reporting period. During this reporting period, there were no new studies or significant efforts towards advancing wastewater infrastructure improvement projects along the lower Colorado River.

Agriculture

Occurrence in Watershed

There are multiple dairies within the Lake Mohave and Lake Havasu watersheds, but none discharging directly to the Colorado River. In addition, grazing occurs throughout various parts of the watersheds. Both activities are managed by jurisdictional agencies.

Lake Mead NRA

The Lake Mead NRA allows minimal grazing and agriculture on their lands. According to the BLM, there are four grazing allotments with shoreline access. These allotments are located on the Arizona side of

Lake Mohave and they are not permitted for current grazing use. However, trespass cattle are known to use the allotments in the summer. The four allotments are 300,000 acres (Big Ranch Unit B), 10,000 acres (Fort MacEwen Unit B), 30,000 acres (Portland Springs), and 5,000 acres (Thumb Butte). During the reporting period, the Big Ranch was required to obtain an ephemeral grazing permit twice, when cattle drifted from Big Ranch Unit A to Unit B located along the Colorado River [106].

BLM manages livestock grazing on public lands, but does not manage any dairies or AFOs. The Kingman Field Office is responsible for grazing on Arizona lands near Lake Mead, Lake Mohave, and Lake Havasu. The Kingman Office manages 46 ranch operations with over 5,000 cattle that utilize BLM lands within the Lake Havasu watershed. According to BLM, the grazing allotments are miles away from the Colorado River, and are located on the east side of the Black Mountain Range (away from the Colorado River). The Black Mountain Range is located east of the Colorado River, running north-south for 75 miles from approximately the eastern shore of the Colorado River near Hoover Dam to Needles. If cattle were to graze on the west side of the Black Mountain Range, an ephemeral permit would need to be obtained. According to BLM, there have been no ephemeral permits processed for this area in the last ten years. It was also confirmed that there are no large dairies or AFOs in the Lake Havasu/Parker Dam area.

On the California side, the Needles Field Office manages grazing. The Needles Office manages three active allotments, totaling about 300 to 400 head of cattle [107]. The closest allotment to the Colorado River is about 30 to 35 miles, so there is no concern with grazing on BLM land on the California side for the Lake Mohave and Lake Havasu watersheds.

Arizona Department of Environmental Quality

ADEQ manages a CAFO Program and issues two types of water quality permits:

- Aquifer Protection Permit (APP) protects groundwater by minimizing discharges of nitrogen to groundwater from waste impoundments and other CAFO activities through best management practice (BMP) requirements.
- Arizona Pollutant Discharge Elimination System Permit controls the discharge of pollutants from the facility including land application of manure and wastewater.

ADEQ is not able to provide a count of CAFOs within their jurisdiction since CAFOs are not required to submit any paperwork to apply for the APP Nitrogen Management General Permit; they are covered by the general permit if the operator complies with BMP requirements [108]. From further inquiry, the Arizona Department of Agriculture Animal Services indicated that there are no CAFOs located in the watershed [109].

RWQCB-Colorado River Basin, Region 7

Per RWQCB-Colorado River Basin Region, there are no CAFOs within their jurisdiction in the Colorado River watershed above Parker Dam. The CAFOs that they regulate are exclusively in Imperial County [110].

Regulation and Management

NPS allows grazing on its land, but does not have a comprehensive program to regulate range management. One of the objectives listed in the 2000–2005 Strategic Plan for the Lake Mead NRA is to continue development of a comprehensive grazing management program and to complete administrative records and maps of range developments. Per NPS, this objective has not been completed.

In July 2006, BLM issued final grazing regulations, which update 43 CFR Part 4100, to improve the management of public lands grazing. The regulations recognize the economic and social benefits of public lands grazing while preserving open space and wildlife habitat. BLM utilizes the federal land health standards to develop grazing permits and BLM conducts a series of actions to authorize cattle and sheep grazing use. Livestock producers apply to graze livestock annually or as conditions permit. Grazing use is permitted with written authorization and terms and conditions for grazing use are listed as necessary. BLM conducts field visits throughout the grazing period to ensure grazing is occurring as authorized.

Both California and Arizona have regulations for discharges from CAFOs. The states already require NPDES permits for large facilities based on number of animals and occurrences of discharge. The CWA defines a CAFO as any AFO that either meets a certain animal population threshold, or, regardless of population, is determined to be a significant contributor of pollutants by the appropriate authority. The RWQCB-Colorado River Basin Region has determined that all feedlots, dairies, heifer ranches, calf nurseries, and other similar facilities in the region shall be designated as CAFOs. Effective on September 30, 2014, CAFOs in the Colorado River Basin Region must meet the requirements of RWQCB Order No. R7-2013-0800 (previously authorized under Order R7-2008-0800): *Permit for Concentrated Animal Feeding Operations within the Colorado River Basin Region,* NPDES No. CAG017001.

Arizona's CAFO General Permit expired on April 17, 2009 and no new Notices of Intent will be accepted until the new CAFO General Permit is issued [111].

Studies and Monitoring

ADEQ's non-point source program monitors the Colorado River for constituents related to livestock grazing and dairies, such as coliforms. Based on ADEQ's Nonpoint Source State Management Plan for 2010-2014 and 2015-2019, ADEQ funds grazing-related projects through TMDL development, watershed planning, and water quality improvement grants [112].

Fires

Occurrence in Watershed

Fires and prescribed burns within the Lake Mohave and Lake Havasu watersheds have not been discussed in previous CRWSS reports. **Figure 4-12** and **Table 4-7** include the significant fires within the watersheds between 2005 and current, as of this writing. The largest fire during this period was the SH Ranch Complex Fire in 2005, which was sparked by lightning and burned over 21,000 acres approximately 10 miles east of Bagdad, Arizona [113].

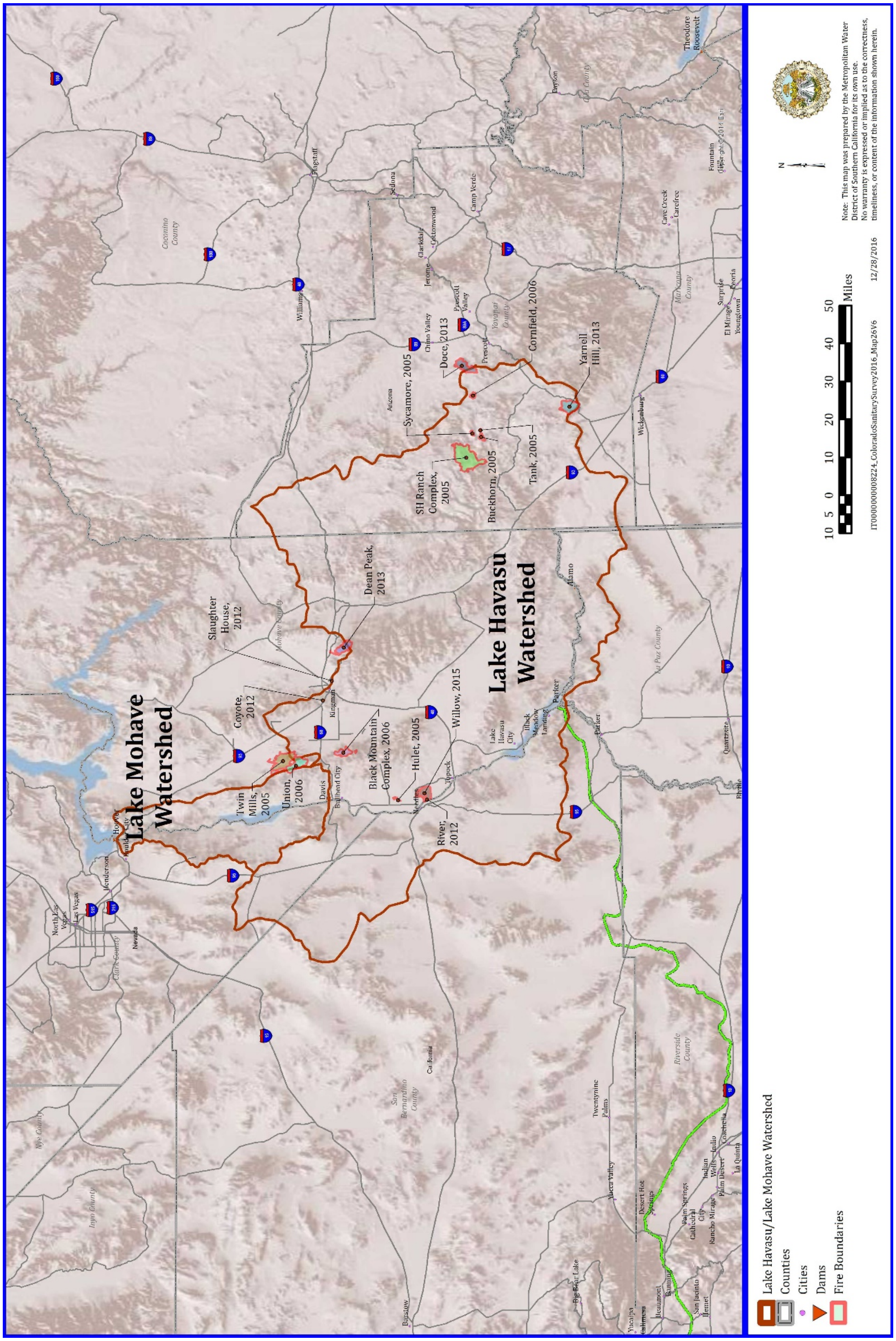


Figure 4-12. Fires in Lake Mohave and Lake Havasu Watershed since 2006

Table 4-7. Fires in Lake Mohave and Lake Havasu Watersheds, 2005–2015 [114]

Fire	Date	Acres Burned
Buckhorn	2005	1,105
Hulet	2005	422
SH Ranch Complex	2005	21,227
Sycamore	2005	555
Tank	2005	189
Twin Mills	2005	11,948
Black Mountain Complex	2006	4,249
Cornfield	2006	1,045
Union	2006	9,271
Wabayuma	2011	67
Coyote	2012	124
River	2012	267
Slaughter House	2012	89
Dean Peak	2013	5,418
Doce	2013	6,768
Yarnell Hill	2013	7,954
Willow	2015	6,072

Figure 4-13. Willow Fire Burned Area near Colorado River, August 10, 2015 [213]

Per BLM, fires have become a growing concern due to dry conditions along the Colorado River. However, the majority of fire incidents are manageable brush fires. There was one significant fire incident that affected areas adjacent to the Colorado River during the reporting period. The Willow Fire burned over 6,000 acres of federal, tribal, and private land near Topock, Arizona (**Figure 4-13**). The fire started on August 8, 2015 and was caused by a lightning strike on wildlife refuge marshlands and fueled by extensive tamarisk growth along the Colorado River and throughout the impacted area. There were no detectable impacts to Colorado River water quality; however, approximately 1,000 acres of adjacent refuge habitat burned, which may have long-lasting runoff and erosion impacts. A year after the fire, the Havasu National Wildlife Refuge has replanted 10 acres with native trees and will continue efforts to restore the affected areas [115].

Regulation and Management

In 2004, an inter-agency incident web information management system, InciWeb, was established to temporarily archive fire information. Oversight agencies in the Lake Mohave and Lake Havasu areas (i.e., BLM, NPS, USFWS, etc.) work cooperatively to respond to fire incidents and report both fire and other emergency related information to InciWeb [114].

BLM provides fire management of 12.2 million acres of public lands across Arizona including Lake Mohave and Lake Havasu areas managed by the Colorado River District. The BLM Colorado River District reports that approximately 36 fires occur per year on travel corridors or waterways in the lower Colorado River area [116]. To minimize fire threats, agencies are enforcing fire restrictions prohibiting open fires in undeveloped recreation areas. Arizona implemented fire restrictions, effective June 23, 2016, on state-owned and state-managed lands in the Mohave and La Paz counties, which include Lake Mohave and Lake Havasu areas [117]. BLM is enforcing this fire restriction on BLM-administered lands in these areas. Local agencies have also adopted fire restrictions including Mohave County, which banned fireworks and open flames in 2014 in all unincorporated county areas, and Lake Havasu City and city of Kingman, which also banned fireworks [118].

Summary for Lake Mohave and Lake Havasu Watersheds

The Colorado River through the Lake Mohave and Lake Havasu watersheds is susceptible to PCSs related to recreational activities, municipal and industrial discharges, and septic systems. In this desert reach, the Colorado River attracts both local and vacationing users to boating, camping, hiking, and other recreational activities. To ensure protection of Colorado River water quality, federal agencies such as NPS, USCG, and BLM provide oversight and regulations to manage recreational uses. Metropolitan reviews water quality data, published by multiple agencies, to monitor the impacts of the ongoing recreational activities.

Since 2005, Metropolitan has included its Colorado River monitoring data on Southern Nevada Water Authority's (SNWA's) Lower Colorado River Water Quality Database. This online regional database allows member-only access and contains data from multiple federal, state, and local agencies that monitor Colorado River water quality. The database also allows stakeholders, including Metropolitan, to track historic water quality changes at key locations along the lower Colorado River. The Lower Colorado River Water Quality Database is discussed in the CCRSCo section of **Chapter 6**. Several studies conducted by multiple agencies are also ongoing to assess water quality issues relevant to the lower Colorado River.

The general watershed area has minimal development and municipalities have populations less than 100,000. The existing development is concentrated in close proximity to the Colorado River and some of the communities rely on septic systems for wastewater treatment. The groundwater, which can contain high nitrate levels due to septic tanks, has the potential to degrade the river water quality. In recent years, Lake Havasu City and Bullhead City have constructed sewer collection systems and reduced the number of septic systems by more than 75 percent in their respective cities.

Metropolitan also stays informed and participates in ongoing monitoring and clean-up efforts for areas of concern. This includes reviewing groundwater monitoring data for the Needles Sanitary Landfill, tracking progress on initial efforts to clean up the McCulloch contaminated groundwater site, and actively participating in the PG&E Topock Gas Compressor Station chromium-6 remediation process. A long-term remedial alternative has been selected for the Topock site and PG&E completed design in 2015. Construction is expected to start in 2017 after completion of a subsequent environmental review, and would be completed in 2022.

Recommendations for Lake Mohave and Lake Havasu Watersheds

Continue to review groundwater monitoring data for the Needles Sanitary Landfill
Metropolitan will continue to review the monitoring data for the Needles Sanitary Landfill. Although current groundwater monitoring indicates that contaminants are below MCLs for drinking water, there has been an increase in tetrachloroethene (PCE) at one of the site's monitoring wells (N-4).

Continue to support the efforts of CCRSCo
Metropolitan will continue to participate in and support CCRSCo's efforts to protect the water quality of the Colorado River, including working with USBR on the spill notification process and supporting CCRSCo's development of a watershed plan with funding from a USBR WaterSMART grant to enhance watershed planning efforts for the lower Colorado River. Further discussion regarding CCRSCo efforts is provided in **Chapter 6**.

Continue to participate in advisory groups for chromium-6 remediation at the Topock Gas Compressor Station
Metropolitan will continue to coordinate with the lead regulatory agencies and PG&E and actively participate in various workgroups to support efforts to remediate the chromium-6 groundwater plume adjacent to the Colorado River near Needles, California. In addition, Metropolitan will review the Subsequent EIR, groundwater model improvements, and decommissioning of IM-3 facilities during construction, anticipated in 2019, to ensure protection of Colorado River water quality. Further discussion regarding the cleanup efforts at the Topock Gas Compressor Station is provided in **Chapter 6**.

Track ADEQ's progress on remediating the chromium-6 contamination at the former McCulloch corporation facilities
Metropolitan will track and support ADEQ's efforts to clean up the McCulloch contaminated groundwater site near Lake Havasu. ADEQ is in the preliminary phase of developing a remedial action plan for the project and will be engaging stakeholders in future project reviews.

Continue to track ongoing water quality studies in the Lake Mohave and Lake Havasu watersheds
Metropolitan will track a number of lower Colorado River-related water quality studies over the next five years. Notably, USBR's ongoing Lower Colorado River Contaminant Monitoring Program and ADEQ's proposed increase in beach monitoring.

Colorado River Aqueduct

The CRA begins at the Whitsett Intake Pumping Plant adjacent to Lake Havasu. The 242-mile CRA consists of five pumping plants, four flow-regulating reservoirs, and a series of canals, conduits, siphons, and tunnels. Of the 242 miles of the CRA, a total of 63 miles are trapezoidal open canal.

Approximately 25 miles east of Lake Mathews is a junction structure that connects the San Diego Canal to the CRA. From the CRA, the San Diego Canal conveys raw water approximately 20 miles south to Diamond Valley Lake, Lake Skinner, and the Skinner plant. Consistent with the previous sanitary surveys, the San Diego Canal watershed area is included in this analysis of PCSs along the CRA since there are potential impacts to water quality for both the San Diego Canal and CRA. The PCSs discussed for this region include *Erosion, Urban and Stormwater Runoff; Municipal and Industrial Discharge*; *Spills; Landfills; Leaking Underground Storage Tanks;* and *Agriculture*.

Erosion, Urban and Stormwater Runoff

Occurrence in Watershed

The CRA was designed to eliminate stormwater runoff, which may contain debris and contaminants, from entering the canal by constructing siphons in the areas where natural washes occur. The aqueduct is completely concrete-lined, which minimizes the possibility of contaminants that may be present in groundwater from entering the canal. However, the aqueduct is not sealed with an impermeable liner and therefore, groundwater can potentially migrate into the canal.

In previous CRWSS reports, the multiple drains located along the San Diego Canal were identified as potential sources for erosion runoff impacts. The CRWSS 2010 Update discusses Metropolitan's investigation into potentially removing the drains. It was determined that further action was not necessary to remove or relocate the drains.

Municipal and Industrial Discharges

Occurrence in Watershed

There are no municipal and industrial discharges along the CRA. The following energy development project is included as Metropolitan has been engaged to ensure protection of its adjacent facilities from potential indirect effects on water quality. Although not a municipal or industrial discharge, a discussion of Perris Dam seepage recovery is included in this section since there is potential for this seepage water to be discharged into the CRA. Also, the Cadiz Water Project is introduced as it proposes to deliver water supplies from California's high desert to southern California via the Colorado River Aqueduct.

Eagle Mountain Pumped Storage Project

Eagle Crest Energy Company (ECE) is proposing a 1,300-megawatt Eagle Mountain Pumped Storage Project on the site of the inactive Eagle Mountain mine in Riverside County. The project, which would be located on approximately 700 acres of federal BLM land and 1,828 acres of private land owned by Kaiser Eagle Mountain (Kaiser), would create an upper and lower reservoir from two inactive mining pits and would operate as a pumped storage facility. Water would be pumped from the lower reservoir to the upper reservoir during periods of low energy demand and then released to the lower reservoir to generate electricity during periods of high demand [119].

The project is included in the CRWSS 2015 Update due to potential impacts to the CRA. The project could potentially alter groundwater conditions through groundwater pumping of the proposed supply wells and seepage from the reservoirs. Subsidence is possible beneath the CRA at segments located downgradient of the proposed reservoirs. ECE will be undertaking several measures to protect environmental and water resources including 1) implementing an Erosion and Sediment Control Plan, 2) installing groundwater monitoring wells, 3) developing and implementing a water management plan, and 4) developing measures to prevent impacts to the CRA and its operations.

In June 2009, ECE filed a Final License Application with the Federal Energy Regulatory Commission (FERC) for the project. As lead agency, FERC issued a Final Environmental Impact Statement (EIS) for the project in January 2012 [119]. During the respective comment periods, Metropolitan submitted comments for the FERC License Application process, the Draft EIS, and the Final EIS. In Metropolitan's final comment letter on the Final EIS, dated March 19, 2012, Metropolitan noted concerns that had not been adequately addressed in prior licensing proceedings including subsidence issues, water quality and water quantity issues, consultation and coordination, energy issues, power and developmental benefits, and land use issues (**Appendix I**).

On June 19, 2014, FERC issued a license to ECE to construct, operate, and maintain the proposed Eagle Mountain Pumped Storage project. In October 2014, ECE consulted with Metropolitan to review the draft Aquifer Testing and Site Investigation Plans. Metropolitan provided input and requested ongoing consultation on future project developments including the forthcoming Groundwater Quality Monitoring Work Plan and other plans that detail crossing Metropolitan's facilities such as the CRA and transmission line right of ways. In July 2015, ECE purchased the Kaiser property for the project [120]. Metropolitan will continue to track progress on this project and provide input as required.

Perris Dam Seepage Recovery

In 2005, the California Department of Water Resources (DWR) identified seismic issues with parts of the Perris Dam foundation and proposed lowering the lake elevation to complete repairs. DWR also proposed dewatering the groundwater to allow for safe and stable excavation work. In 2007, per Metropolitan's request, DWR completed an assessment of groundwater quality at Perris Dam since the proposed dewatering activities would involve collecting groundwater and discharging it to the CRA via the existing seepage collection system. DWR's 2007 water quality assessment concluded that the quality of the groundwater is identical to SWP water stored in Lake Perris. The seepage water is less than 1 percent of the total CRA flow and would not have any effect on CRA water quality.

On March 2, 2015, Metropolitan notified DDW of the proposed Perris Dam Remediation project and dewatering activities scheduled to occur between March 2015 and November 2016. In a response letter dated March 18, 2015 (**Appendix J**), DDW requested that all discharges of groundwater collected by the seepage system be documented in this CRWSS 2015 Update. Per DDW's request, information is provided as current as of the writing of this report for this project.

Metropolitan completed a Title 22 water quality analysis of a groundwater sample representative of water that would be discharged to the CRA. The sample was collected during the Perris Dam repairs in April 2016 (**Appendix J**). The water quality results indicate that the groundwater would not impact CRA water quality. However, the groundwater that was collected by the seepage system was ultimately used for the onsite concrete batch plant and was not discharged into the CRA as originally planned. The Perris Dam Remediation project is expected to be complete by the end of 2017 and no further dewatering activities associated with this construction work are anticipated.

In a related effort, DWR is currently investigating the feasibility of an active seepage recovery system. Metropolitan is considering working with DWR to potentially recover up to 8,000 acre-feet of seepage water, which would be discharged into the CRA. If this effort moves forward, Metropolitan would provide further information in future CRWSS updates.

Cadiz Water Project

In 2008, Cadiz, Inc. (Cadiz), a Los Angeles-based land and water resource management company, began efforts to secure agreements and permits for constructing the Cadiz Valley Water Conservation, Recovery, and Storage Project (Cadiz Water Project). Cadiz owns approximately 34,000 acres in the Cadiz and Fenner Valleys located in the Mohave Desert. The Cadiz Water Project proposes to extract over 2 million acre-feet of groundwater (50,000 acre-feet over a 50-year period) from these valleys and create an alternative local water supply delivered via the CRA for southern California water providers [121]. The project's environmental review process began in February 2011 with the issuance of a Notice of Preparation of a Draft EIR. Metropolitan provided comments during the environmental review process noting various concerns including potential impacts to CRA water quality, operations, and capacity.

The Santa Margarita Water District certified the Final EIR and approved the project in July 2012, which resulted in numerous CEQA lawsuits challenging the project approval. The Final EIR and approval of the Cadiz Water Project was upheld by the California Appellate Court in May 2016 ending all pending CEQA litigation since no petitions were filed with the California State Supreme Court during the available time period [122]. Cadiz is currently pursuing approvals, permits, and purchase agreements to proceed with the project.

Spills

Occurrence in Watershed

CRA crossings, including Highway 95 near mile marker 29 and the California-Arizona railroad near the Freda siphon, can be susceptible to accidental spills. There were no reported spills on CRA crossings during this reporting period.

Landfills

Occurrence in Watershed

Eagle Mountain Landfill

The CRWSS 2010 Update discussed a proposed municipal landfill to be built by the Los Angeles County Sanitation Districts (LACSD) adjacent to the CRA near Eagle Mountain. Between 2000 and 2013, LACSD had been in escrow to buy Eagle Mountain from the Mine Reclamation Corporation. Based on LACSD's recycling efforts reducing the need for new landfills, the LACSD Board decided in May 2013 to cease negotiations with the Mine Reclamation Corporation and directed LACSD staff to expand an evaluation of long-term waste management strategies [123]. Metropolitan will no longer track this project activity.

Iron Mountain Landfill

The Iron Mountain Landfill was owned and operated by Metropolitan and received domestic waste from the Iron Mountain pumping plant. Metropolitan decided to close the landfill in 1995, as it was determined to be too difficult and costly to maintain. The landfill was properly closed by covering the waste with a multi-layered system of compacted soils, flexible membrane cover, geotextile fabric, and rock.

Regulation and Management

RWQCB-Colorado River Basin Region's responsibilities include permitting, monitoring, and enforcement of waste discharge requirements mandated by state (Title 27) and federal (Subtitle D) regulations for the disposal of waste to land. The RWQCB's goal is to protect the ground and surface water quality via these regulations.

In addition, the County of San Bernardino, Department of Public Health Division of Environmental Health Services inspects the Iron Mountain landfill quarterly. Their objective is to protect public health and safety from migration of landfill gases off-site.

Studies and Monitoring

Since the Iron Mountain Landfill is unlined, three groundwater monitoring wells were installed in 1995 to detect any groundwater contamination. Metropolitan performed groundwater sampling twice a year between 1998 and 2009 per the Waste Discharge Requirements (WDR) No. 98-007 (issued by the RWQCB-Colorado River Basin Region). Groundwater monitoring results did not show water quality concerns with this landfill. On September 16, 2010, the RWQCB-Colorado River Basin Region issued Board Order No. R7-2010-0045, which rescinded WDR No. 98-007. Therefore, Metropolitan is no longer required to conduct any groundwater quality monitoring for this landfill. As such, the monitoring wells were destroyed and filled with pressurized grout and concrete in early 2011.

Leaking Underground Storage Tanks

Occurrence in Watershed

No LUSTs were found along the CRA. Additionally, the design of the aqueduct prevents surface water flows from entering the aqueduct. With runoff being the primary transport method for petroleum products to enter the CRA, if a LUST existed along the CRA, the possibility for this type of contamination is extremely low.

Agriculture

Occurrence in Watershed

There are multiple CAFOs concentrated along the CRA and San Diego Canal junction located within the San Jacinto watershed as shown in **Figure 4-14**. While there are several CAFOs in the area, only a few are in close proximity to the CRA or San Diego Canal, which could potentially affect water quality. The CRA and San Diego Canal are primarily protected from discharges from dairies since they are located below ground. However, contamination from dairy discharges has the potential to affect Metropolitan's underground pipelines if contaminated groundwater enters a pipeline, such as when a pipeline is shut down or not under pressure.

One of the dairies in closest proximity to the CRA is the R&J Haringa Dairy, formerly the Tuls Dairy, which is located above the CRA at approximately mile marker 218, where the CRA is a concrete barrel, roughly seven to eight feet below the ground surface. Although the cattle are not located directly over the CRA, water from washing the cows before milking can pond and seep through to the groundwater. Metropolitan regularly patrols this area and informs the dairy owners informally if wastewater ponding occurs.

Concentrated Animal Feeding Operations along the San Diego Canal

The RWQCB-Santa Ana Region has identified 23 CAFOs with approximately 49,100 animals along the San Diego Canal. These CAFOs are located in the San Jacinto watershed, which eventually drains to Canyon Lake and Lake Elsinore. **Table 4-8** provides a summary of the facilities and approximate locations can be found in **Figure 4-14**.

Table 4-8. CAFOs along CRA and San Diego Canal, 2015 [124]

			Quantity of CAFO Types						
Map #	**Place ID**	**Facility Name**	Milking Cows	Dry Cows	Heifers	Calves	Horses	Pigs	Other
1	201050	O & S Holsteins	1100	180	750	300	0	0	0
2	205887	Dick Van Dam Dairy	1350	135	850	70	0	0	0
3	209966	Boersma Dairy	1100	200	900	200	0	0	0
4	222210	Ed Vander Woude Dairy	330	60	200	45	0	0	12
5	224360	Albert Goyenetche Dairy #2	999	200	0	0	0	0	0
6	230143	Herman De Jong Dairy	75	8	17	8	0	0	0
7	230193	Hettinga Dairy - San Jacinto	1030	155	73	2297	0	0	0
8	233675	Jim Bootsma Jr. Dairy	1300	150	700	0	0	0	0
9	233848	John Bootsma Dairy	1670	280	0	95	0	0	0
10	239719	Marvo Holsteins Dairy	1500	300	800	0	0	0	0
11	239820	Ramona Dairy #2	2400	250	0	0	0	0	0
12	245823	Offinga Dairy	750	100	500	200	0	0	0
13	247758	Pastime Lakes Dairy	1816	398	640	698	0	0	0
14	248091	Goyenetche Dairy #2	900	0	0	0	0	0	0
15	251581	Ramona Dairy	4350	650	0	0	0	0	0
16	256862	Marvo Holsteins #2	500	0	700	0	0	0	50
17	259493	Cottonwood Dairy	1650	200	200	0	0	0	2
18	630490	R & J Haringa Dairy	2600	350	150	0	0	0	20
19	630500	Expressway Dairy	862	119	743	0	0	0	0
20	630505	Hollandia Farms North	2400	200	0	0	0	0	0
21	630602	Scott Bros. Dairy	1066	200	685	370	0	0	0
22	630617	Oostdam Dairy 1710	1550	300	0	350	0	0	0
23	803515	Bootsma-Silva Farms	0	0	0	813	0	0	0

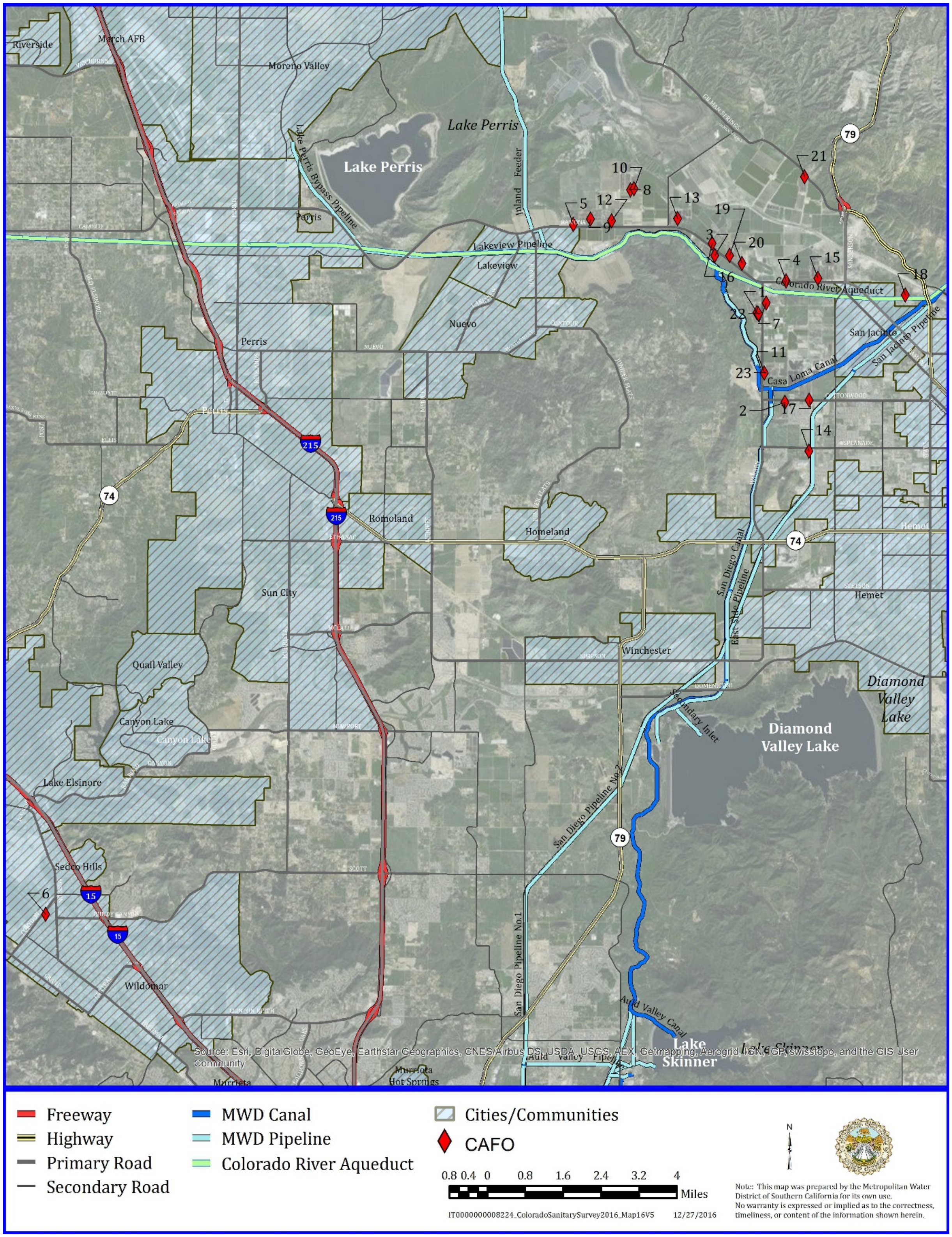


Figure 4-14. CAFOs along CRA and San Diego Canal

Regulation and Management

Concentrated Animal Feeding Operation Regulations

In California, runoff from rangeland is considered a non-point source of pollution. The CWA defines a CAFO as any AFO that either meets a certain animal population threshold or, regardless of population, is determined to be a significant contributor of pollutants by the appropriate authority. The RWQCB-Santa Ana Region is the regulatory agency for the CAFOs located near the San Diego Canal. The RWQCB-Santa Ana Region considers all AFOs with herd sizes of more than 20 cows or 50 heifers and/or calves to be a significant contributor of pollutants and classified as a CAFO. The CWA states that all CAFOs are point sources and are subject to NPDES permitting requirements.

These dairies had been previously regulated under general waste discharge requirement Order No. 99-11, Order No. R8-2007-0001, and are now covered under Order No. R8-2013-0001 (adopted June 7, 2013): *General Waste Discharge Requirements for CAFOs (Dairies and Related Facilities) within the Santa Ana Region*. The order prohibits the application of manure, process wastewater, or stormwater from manured areas on land associated with dairies that overlie groundwater management zones lacking assimilative capacity for TDS or nitrate unless a plan, acceptable to the Executive Officer, is implemented that offsets the effects to the underlying groundwater management zone.

Some of the other key issues that the CAFOs must comply with under Order No. R8-2013-0001 include the following:

- The discharger shall design, construct, and maintain containment structures to retain all manure, litter, and process wastewater within their facilities including all runoff and direct precipitation from a 25-year, 24-hour rainfall event.
- The discharger shall develop and fully implement an Engineered Waste Management Plan (EWMP).
- Dischargers who apply manure, litter, or process wastewater to croplands under their ownership shall develop and fully implement an approved site-specific Nutrient Management Plan, in addition to the EWMP.
- Retention ponds and manured areas at CAFOs in operation on or prior to November 27, 1984, shall be protected from inundation or washout from any stream channel during 20-year peak stream flows. New facilities (built after November 27, 1984) shall be protected from 100-year peak stream flows.
- Manure, litter, and process wastewater shall not be applied closer than 100 feet to any downgradient surface waters or other conduits to surface or ground waters.
- Manure removed from the corrals shall be removed from the facility within 180 days.

Herbicide Application Guidelines

Though not directly related to typical agriculture activities, herbicides are used along the CRA to treat vegetation that grows adjacent to the open canal sections of the aqueduct. Left untreated, vegetative growth can cause damage to the concrete panels that line the aqueduct.

AquaMaster® has been approved for use by DDW at Metropolitan facilities. Glyphosate is the active ingredient in AquaMaster® herbicide and it has favorable environmental characteristics, such as degradation over time in soil, sediment, and natural waters, and tight binding to most soils and sediment, which reduces bioavailability soon after application. Specific requirements exist for herbicide application to control non-native vegetation and prevent contamination of Lake Mathews with chemicals or sediment.

During the CRWSS 2015 Update reporting period (2010–2015), herbicide was applied along the CRA in 2011 (February and October/November), 2014 (February) and 2015 (February/March). Application of herbicide typically occurs during CRA shutdown periods.

Studies and Monitoring

In 2015, the 23 San Jacinto dairies generated an estimated 193,648 tons of manure [124]. Approximately 110,000 tons of manure was spread on land as fertilizer for crops within the San Jacinto River watershed. The General Dairy permit allows the dairies to apply manure on croplands at a rate of 12 dry tons per year or 17.5 tons per acre per year at 33 percent moisture [125]. An exceedance of the manure application rate requires documentation in the operator's annual report to the RWQCB. According to the RWQCB-Santa Ana Region, there are instances of excessive manure spreading and illegal dumping due to limited staff resources to monitor each manure-hauling event to cropland. There is no processing of the manure before it is spread on cropland. Manure is scraped from the corrals, put on a spreader truck, and taken directly to croplands for application.

A coalition of local AFO and farming representatives formed the Western Riverside County Agriculture Coalition (WRCAC) to study and formulate opportunities for nutrient and salt offsets. In addition, the San Jacinto Basin Resource Conservation District secured grant funding to develop an Integrated Regional Dairy Management Plan (IRDMP). The purpose of the IRDMP, completed in December 2009, is to provide an integrated regional plan for the dairy industry in the San Jacinto River watershed in their efforts to implement management practices necessary to meet regulatory requirements and maintain long-term sustainability for their dairy industry. To support the San Jacinto basin dairies' compliance with Order No. R8-2013-0001, WRCAC completed the San Jacinto Salt Offset and Dairy Impacts Report in 2014 and updated it in April 2016 [126]. Overall, WRCAC's 2014 and 2016 Salt Offset and Dairy Impacts Reports conclude that dairies are not impacting groundwater quality.

On behalf of the CAFOs, WRCAC is meeting the requirements of Order No. R8-2013-0001 as follows:

- Order No. R8-2013-0001 requires submittal of groundwater monitoring data within a five-mile radius of a CAFO. WRCAC's 2014 San Jacinto Salt Offset and Dairy Impacts Report met this permit requirement.
- Order No. R8-2013-0001 requires completion of an action plan for individual dairies with impacts to be submitted six months after the acceptance of the groundwater monitoring data. To meet this requirement, WRCAC submitted draft work plans to the RWQCB in April 2016 including the San Jacinto Dairy Salt Offset Groundwater Monitoring Annual Monitoring Work Plan for "No Impact" Dairies, the San Jacinto Dairy Salt Offset Groundwater Monitoring Additional Investigations Work Plan for Dairies with Inconclusive Impacts, and the San Jacinto Dairy Salt Offset Groundwater Monitoring Additional Control Measures Work Plan for Dairies with Potential Groundwater Impacts.

Due to the General Waste Discharge Requirements for CAFOs, dairies located along the San Diego Canal have changed the way they handle wastewater and manure quantity, quality, storage, treatment, and disposal. According to the RWQCB-Santa Ana Region, many of the dairies have started composting and some have developed nutrient management plans.

The 2014 San Jacinto Salt Offset and Dairy Impacts Report identified 9 dairies with potential for TDS impacts. As required by the RWQCB, WRCAC prepared the Draft San Jacinto Dairy Salt Offset Groundwater Monitoring Additional Control Measures Work Plan for Dairies with Potential Groundwater Impacts. The report identifies additional control measures to mitigate the potential impacts to groundwater quality, including but not limited to the following [127]:

- Improve well conditions by diverting or relocating sources with inadequate separation from wells, repairing degraded wells, or closing/sealing abandoned wells
- Improve management of livestock waste storage by relocating waste storage to appropriate location, directing clean runoff away from manure storage piles, installing curbing to contain/direct yard runoff, repairing the waste storage structure, or relocating the stacking area
- Provide wastewater treatment for milking centers such as a waste separation facility or waste treatment of wastewater being discharged to soil. Also, improve existing facilities by repairing leaking waste storage facilities, sealing the evaporation ponds, or improving surface infiltration
- Improve livestock yard management by installing curbing to contain and redirect runoff or relocating wells located on permeable soils.
- Improve fertilizer storage and handling by reducing the amount of fertilizer stored and constructing an agricultural chemical handling facilities

These specific control measures would address and mitigate risks associated with the various CAFOs in the San Jacinto Watershed.

Summary for Colorado River Aqueduct

This region, which includes a long reach of the CRA and San Diego Canal, consists of open barren lands and is primarily susceptible to potential spills from transportation vessels or contaminated runoff from CAFOs. Spills on vehicle and railroad crossings over the CRA would directly flow into the aqueduct and impact water quality. Metropolitan stays informed on reported spill activity. In addition, the prevalence of dairies along the CRA and San Diego Canal could have a potential impact on water quality. Metropolitan will continue to stay informed on regulatory and planning efforts and recommend appropriate measures needed to protect water quality with regards to CAFOs.

Since LACSD is no longer pursuing the Eagle Mountain Landfill, the Eagle Mountain Pumped Storage project is the only project of interest that is proposed in the Eagle Mountain area of the CRA. Metropolitan will continue to track progress for this project to ensure protection of the CRA. Metropolitan also began preliminary work with DWR on a Perris Dam active seepage recovery project, which would recover dam seepage water and discharge it to the CRA. Future CRWSS updates would include discussion of this project if it moves forward.

Recommendations for Colorado River Aqueduct

Continue to track progress of the Eagle Mountain Pumped Storage Project

Metropolitan will continue to track the proposed Eagle Mountain Pumped Storage Project and participate in the design review process to ensure protection of the CRA.

Assess water quality effects of a potential Perris Dam seepage recovery project

Metropolitan is currently investigating a project with DWR to recover seepage water from Lake Perris while assuring protection of CRA water quality. If the project moves forward, Metropolitan will provide update information in future CRWSS updates.

Lake Mathews Watershed

The PCSs discussed for the Lake Mathews watershed include Erosion, Urban and Stormwater Runoff; Spills; Landfills; Leaking Underground Storage Tanks; Septic Systems; Agriculture; and Fires.

Erosion, Urban and Stormwater Runoff

Occurrence in Watershed

The Lake Mathews watershed is primarily drained by Cajalco Creek, which is the main natural tributary into Lake Mathews. The largest single land use category in the watershed is vacant land, which accounts for 38.8 percent of the watershed area. Agriculture accounts for 4.8 percent of the total watershed area, and residential areas represent 19.7 percent of the watershed. **Figure 4-15** shows the land use distribution in the Lake Mathews watershed. The varied land use in the watershed directly influences the quantity of stormwater runoff and the type of contaminants in the runoff.

As a result of the Lake Mathews Drainage Water Quality Management Plan (DWQMP), Metropolitan constructed several sediment/water quality basins in the watershed to trap sediment before it enters Lake Mathews [128]. The Cajalco Creek Sedimentation Basin, located on the largest tributary to Lake Mathews, has a footprint of 31 acres and is located immediately upstream of the 70-acre Cajalco Creek Dam and Detention Basin (CCDDB). Four additional basins, with a total footprint of 15 acres, were constructed in 2001 south of Lake Mathews to control runoff from smaller sub-watersheds that drain directly to Lake Mathews, downstream of the CCDDB. In 2005, the Riverside County Flood Control and Water Conservation District (RCFCWCD) constructed the Gavilan Hills-Smith Road Debris Basin, which covers approximately 3.2 acres and intercepts sediment upstream of Metropolitan's Cajalco Creek Sedimentation Basin. Upstream of the CCDDB are two basins, with a combined area of 1.5 acres, which were built in series to mitigate runoff from the Boulder Springs development. The relative size and location of the sedimentation basins are shown in **Figure 4-16**.

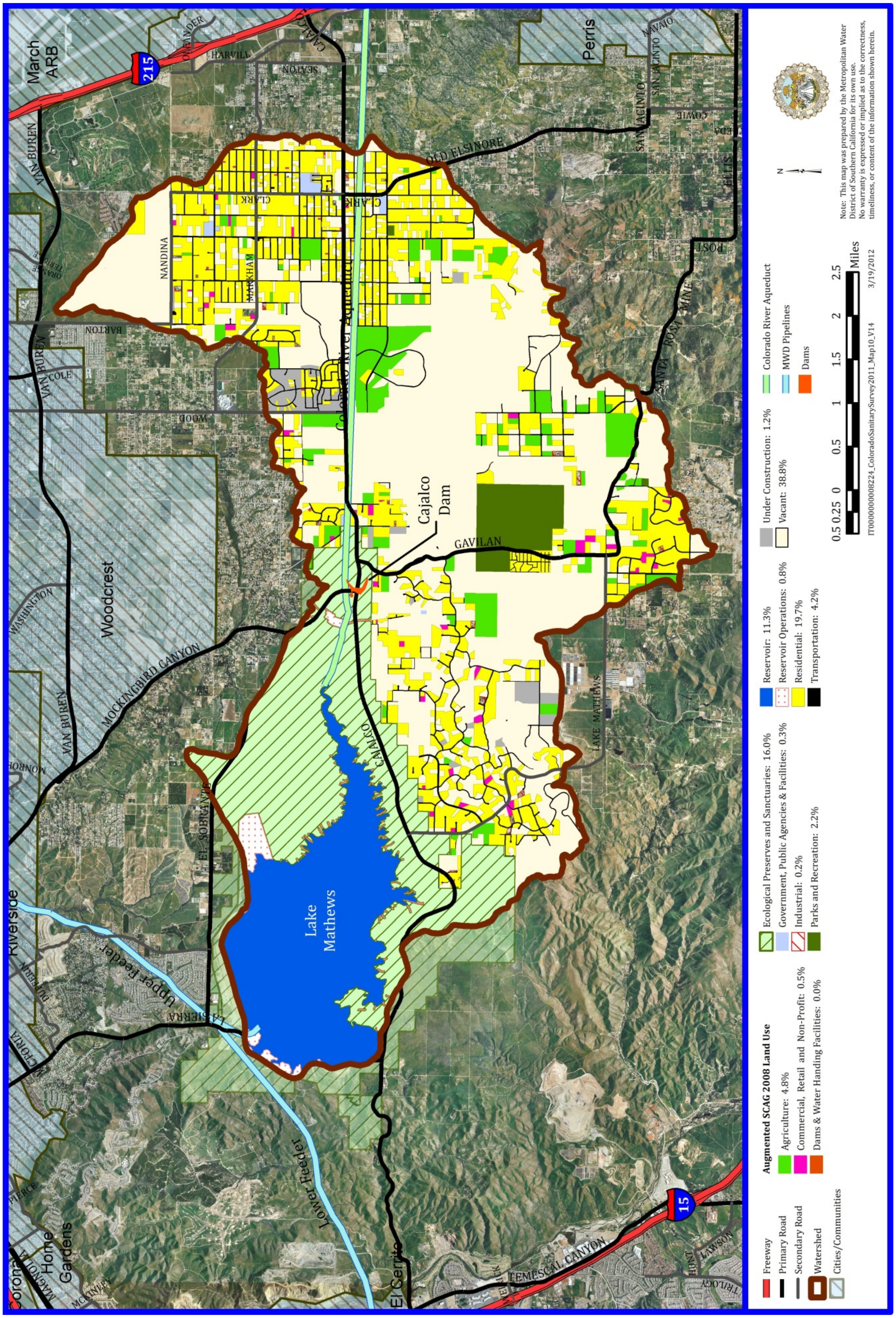


Figure 4-15. Lake Mathews Watershed Land Use

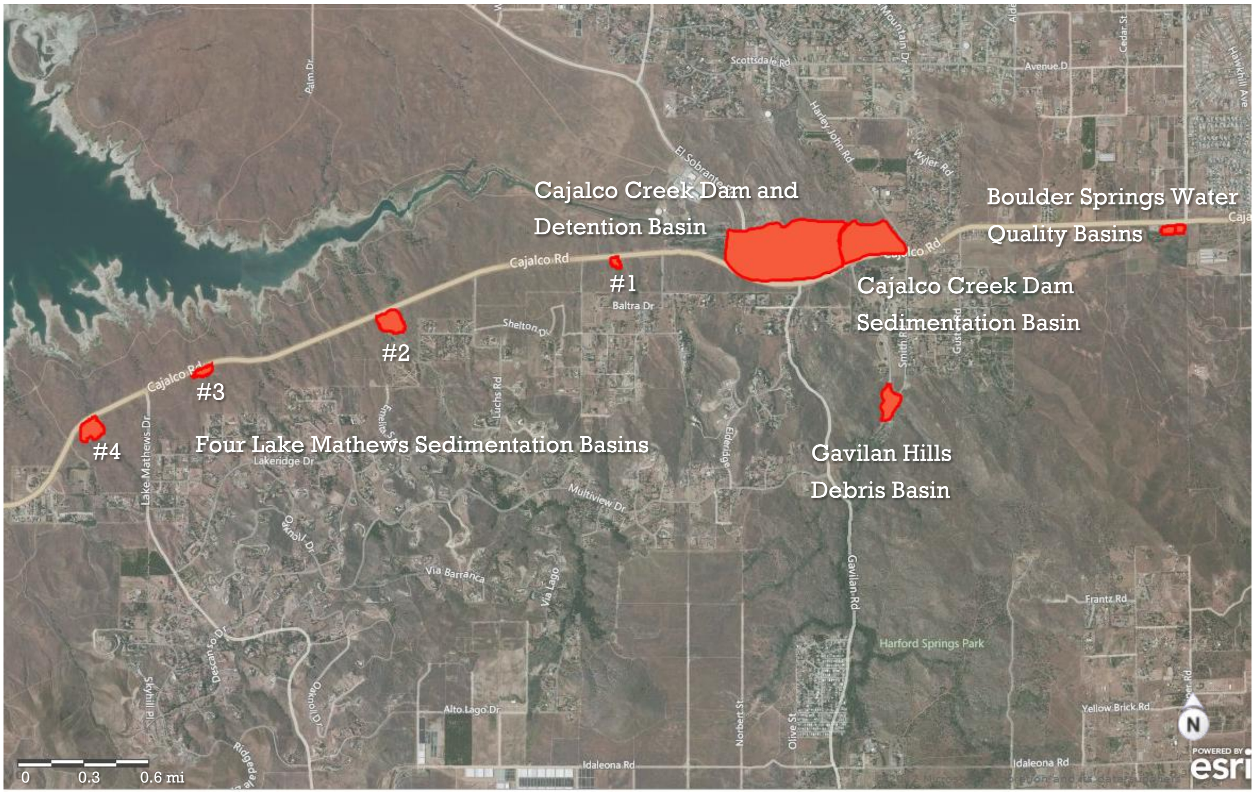


Figure 4-16. Detention and Sedimentation Basins within Lake Mathews Watershed

The CCDDB is operated by Metropolitan. Water can be released from the detention basin through three sluice gates. Storm events in the Lake Mathews watershed vary greatly in intensity and frequency. Generally, consecutive storm events are required to produce measurable runoff. When significant storms occur, runoff is captured in the CCDDB. The water level elevation in the detention basin is recorded daily and the water is held for 2 to 7 days to allow pollutants to settle. From the daily elevation reads, an estimate can be made of the amount of water captured by the CCDDB. Water is released when it appears sedimentation has occurred or to provide storage for additional runoff. During consecutive storm events, water may enter and exit the CCDDB at the same time. Downstream of the CCDDB is a flume meter that measures water entering Lake Mathews.

For comparison purposes, rainfall and volumes of runoff estimated from the CCDDB elevation and flume meter are shown in **Figure 4-17**. It should be noted these data may only be utilized for trending purposes because of the following limitations: flow data from the flume meter include runoff flows that enter Lake Mathews from tributaries downstream of the CCDDB; when the ground is not saturated, water released from the CCDDB percolates into the ground before it reaches the flume meter because the flow path from the CCDDB outlet tower to the flume meter is primarily unlined; occasionally, the flume meter gets jammed with debris, indicating flow without rainfall or no flow during major rain events.

Storm events in early 2011 produced significant rainfall and runoff. The discrepancy in the volumes measured from the CCDDB and the flume flow meter occurs from the limitations discussed previously. Since the early 2011 storm events, the area has received minimal rainfall resulting in minimal runoff captured at the CCDDB. Under these dry conditions, flow was measured at the flume flow meter only twice, in March 2011 (2.47 acre-feet) and December 2014 (0.7 acre-feet) as shown in **Figure 4-17.**

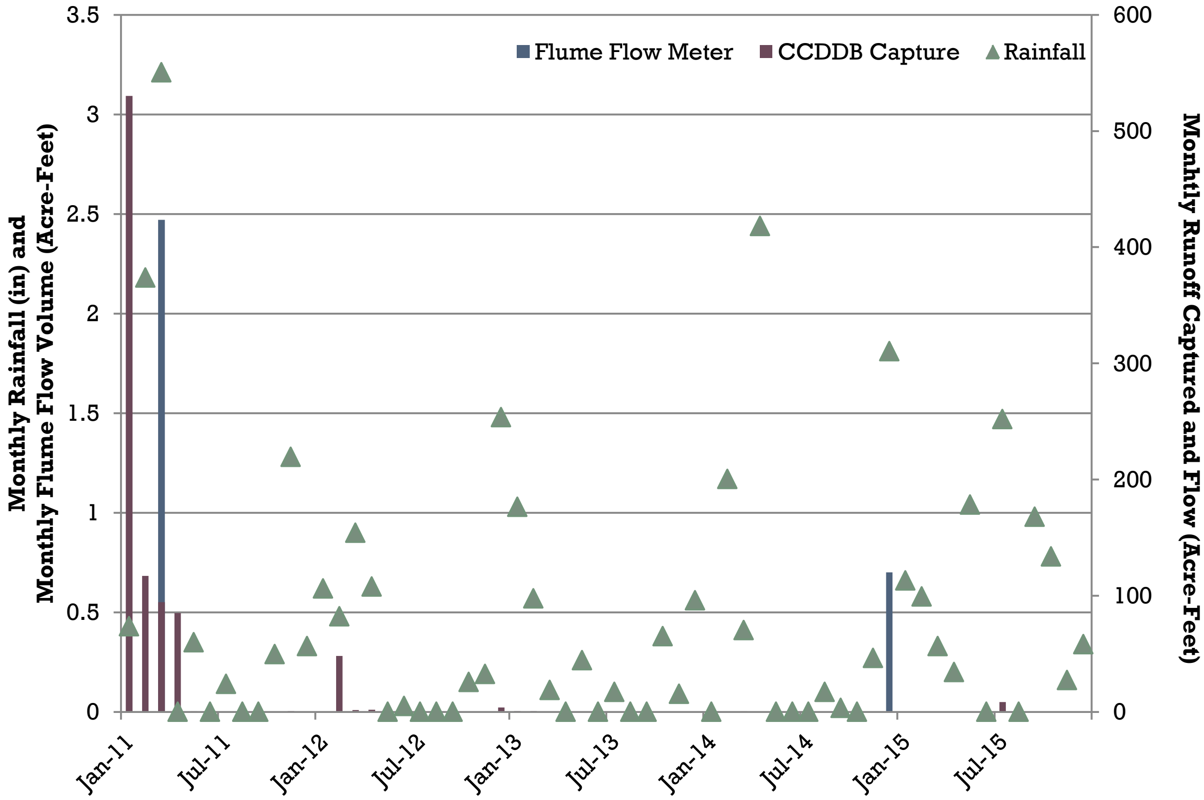


Figure 4-17. Rainfall and Runoff Captured at the CCDDB and Entering Lake Mathews

As indicated in **Chapter 3**, erosion of the exposed shorelines along the Lake Mathews inlet channel has been observed during low lake level conditions. In September 2014, Weymouth and Diemer plant influents received elevated levels of turbidity (above 3 NTU) and the issue was traced back to increased turbidity from the inlet channel and the suspension of fine sediment in the lake's water column. Lake operations were modified to minimize the turbidity leaving the outlet tower to the receiving treatment plants.

Regulation and Management

National Pollution Discharge Elimination System (NPDES) Stormwater Permit

Lake Mathews, Diamond Valley Lake, and Lake Skinner watersheds are located within Riverside County and consist mostly of unincorporated land. There are two separate MS4 permits to cover the watersheds in Riverside County. The RWQCB-Santa Ana Region governs the Lake Mathews watershed in the Santa Ana Region basin and the RWQCB-San Diego Region governs the Diamond Valley Lake and Lake Skinner watersheds in the Santa Margarita Region basin. For both permits, RCFCWCD is the principal permit holder. To streamline the regulatory process, the RCFCWCD is the general MS4 permit holder for these areas. Riverside County and the cities within each respective watershed are all co-permitees.

Stormwater discharges from the Lake Mathews area are permitted under the RWQCB-Santa Ana Region Order No. R8-2010-0033: Waste Discharge Requirements for the Riverside County Flood Control and

Water Conservation District, the County of Riverside, and the Incorporated Cities of Riverside County within the Santa Ana Region, NPDES No. CAS618033, also known as the Santa Ana Region (SAR) MS4 Permit. Order No. R8-2010-0033 was the fourth-term MS4 Permit issued to RCFCWCD and co-permittees and was adopted on January 29, 2010, and amended on June 7, 2013, as Order No. R8-2013-0024. On July 29, 2014, RCFCWCD submitted a Report of Waste Discharge (ROWD) for renewal of Order No. R8-2010-0033. The priorities for this fifth-term MS4 Permit include a continued emphasis on implementation of projects that address high priority water quality concerns; revision of the Receiving Waters Limitations permit language to make requirements more effective based on experience gained under the 2010 MS4 Permit; and enhancement of regional collaborations and support for innovative approaches to addressing water quality [129]. RWQCB-Santa Ana Region anticipates adopting the fifth-term MS4 Permit in 2017 [130].

DAMP

The Drainage Area Management Plan (DAMP) is a programmatic document that identifies major programs and policies to manage urban runoff in compliance with MS4 Permit requirements. The initial DAMP for the Santa Ana Region was developed in 1993 and most recently updated on August 29, 2015. The 2015 Riverside County DAMP-Santa Ana Region, applicable to the Lake Mathews watershed, addresses the requirements of the 2010 SAR MS4 Permit and incorporates programs developed since 1993 including a wide range of continuing and enhanced BMPs and control techniques. **Figure 4-18** provides a summary of the DAMP Program Elements [131].

WQMP

The Water Quality Management Plan (WQMP), A Guidance Document for Santa Ana Region of Riverside County was last updated on October 22, 2012*, and is applicable to the Lake Mathews watershed. The 2010 MS4 Permit requires that a WQMP be prepared for projects that meet Priority Development Project categories and thresholds for significant redevelopment and new development that reduce impervious surface areas. Specifically, the 2010 MS4 Permit mandates a low impact development (LID) approach to stormwater treatment and management of runoff discharges to minimize imperviousness, retain or detain stormwater, slow runoff rates, incorporate required source controls, treat stormwater prior to discharge, control runoff volumes, and provide for operation and maintenance of stormwater BMPs [132].

The WQMP Guidance Document supports compliance with the 2010 MS4 Permit requirements and provides guidelines for project-specific, post-construction BMPs and for regional and sub-regional source control BMPs and structural BMPs. The WQMP also identifies the BMPs, including design criteria for treatment control BMPs that may be applicable when considering any map or permit for which discretionary approval is sought. Examples may include tentative tract maps, parcel maps with land disturbing activity, discretionary grading permits where a project is not part of a master plan of development, and conditional use permits.

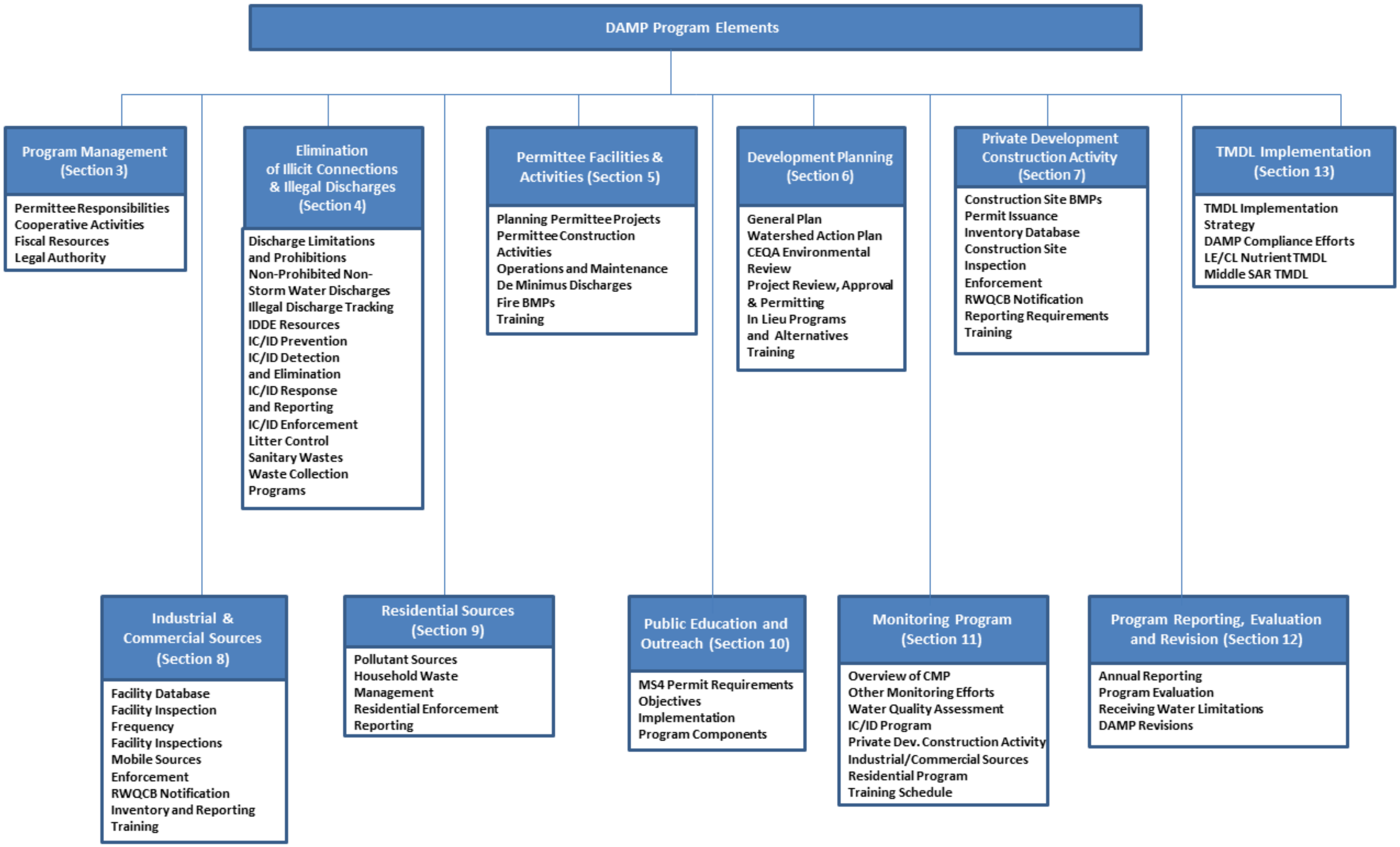


Figure 4-18. Riverside County Drainage Area Management Plan for the Santa Ana and Santa Margarita Regions (DAMP) Program Elements [215]

BMPs are to be incorporated into the project-specific WQMP to minimize the impact from the pollutants of concern and hydrologic conditions of concern identified for the project. Where pollutants of concern include pollutants that are listed as causing or contributing to impairments of receiving waters, BMPs must be selected so that the project does not cause or contribute to an exceedance of water quality objectives. Strategies to minimize the pollutants of concern in runoff from the project site and minimize hydrologic impacts include site design BMPs, source control BMPs, and treatment control BMPs. In preparing a project-specific WQMP, BMPs should be considered and incorporated into the project design plans in the following progression:

- LID Principles (site design BMPs)
- Source Control BMPs (non-structural and structural)
- LID BMPs (Treatment Control BMPs or participation in a regional or watershed program)

LID principles, or site design BMPs, aim to incorporate site features such as vegetation to reduce and control post development runoff rates. Because site design BMPs reduce runoff, incorporating them into project design plans minimizes the transport mechanism (runoff) for moving pollutants off-site, minimizes the difference between pre- and post-development hydrology thereby reducing changes in flow regime, and minimizes the size of necessary treatment control BMPs to treat pollutants of concern in urban runoff prior to discharge from the site or at regional facilities.

Source control BMPs reduce the potential for urban runoff and pollutants from coming into contact with one another. Source control BMPs are defined as any administrative action; design of a structural facility; usage of alternative materials; and operation, maintenance, and inspection procedures that eliminate or reduce urban runoff pollution. Each project is required to implement appropriate source control BMPs.

LID BMPs are defined as any engineered system designed and constructed to treat the adverse impacts of urban runoff pollution. These BMPs may remove pollutants of concern by filtration; media absorption; or other physical, biological, or chemical process. LID BMPs are an effective and natural form of treatment control BMPs. The 2011 Design Handbook for Low Impact Development Best Management Practices supplements the WQMP and provides guidance for the planning, design, and maintenance of LID BMPs used to mitigate water quality impacts of developments [133].

Site design BMPs, source control BMPs, and treatment control BMPs most effectively protect water quality when used in combination. Site design and source control BMPs may be implemented to a level that significantly reduces the size or extent to which treatment control BMPs need to be implemented. BMPs should be located as close to the pollutant source as appropriate and economically/technologically feasible, and before urban runoff is discharged into receiving waters.

Riverside County Plans

The Riverside County Integrated Project (RCIP), also applicable to the watersheds of all three Metropolitan reservoirs in Riverside County, was a planning effort between 1999 and 2002 that simultaneously prepared environmental, transportation, housing, and development guidelines. In anticipation of growth, the RCIP included the Western Riverside County Multiple Species Habitat Conservation Plan (WRC MSHCP) to conserve open space, nature preserves, and wildlife; the Community and Environmental Transportation Acceptability Process (CETAP) to identify improvements for highways and transit systems; and the General Plan for land use and housing.

The WRC MSHCP was permitted in 2004 and has a goal of creating a reserve system of 500,000 acres and providing habitat for approximately 146 species by 2029. The Western Riverside County Regional

Conservation Authority (RCA) is a joint powers authority responsible for implementing the WRC MSHCP. Due to the recession beginning in 2008, the RCA has been challenged with securing funding to meet the land conservation goals and approximately 99,600 acres remain to be acquired [134]. The CETAP is the transportation element of the RCIP and provides the blueprint for local transportation infrastructure and expenditures. CETAP is integrated with habitat conservation requirements, which will reflect future land use decisions. Lastly, the Riverside County General Plan (General Plan) with its transportation and environmental issues was adopted on October 7, 2003, as part of the RCIP. In 2008, General Plan documents were amended but not formally adopted. The current General Plan documents were adopted on December 15, 2015.

Under the General Plan, the county planning regulations and policies that affect source water protection for Lake Mathews include the Land Use Element and subsets of area plans, specific plans, and zoning ordinances. The General Plan contains the *Lake Mathews/Woodcrest Area Plan and the Mead Valley Area Plan*, which apply to the Lake Mathews watershed. **Figure 4-19** shows Lake Mathews within the *Lake Mathews/Woodcrest Area Plan.* The area plans provide additional policy guidance necessary to address local land use issues that are unique to the area or that require special policies that go above and beyond those identified in the General Plan. **Table 4-9** includes policies provided in the *Lake Mathews/Woodcrest Area Plan* to reduce impacts to Lake Mathews water quality [135]:

Table 4-9. Policies for Lake Mathews/Woodcrest Area [135]

Reference	Policy
LMWAP 6.1	Prior to any development approvals of less than 2 acres in size within areas designated for 1 acre or less development within the area addressed in the Drainage Water Quality Management Plan for the Lake Mathews Watershed, a master water and wastewater facility plan shall be developed and approved by the service providing agency.
LMWAP 6.2	A master drainage plan must be developed and approved prior to: 1) One acre or smaller development approvals within the following drainage areas: Cajalco Creek, Mockingbird Canyon, Lake Mathews, Dawson Canyon, Gavilan Hills; and 2) Development approvals less than 2 acres within Cajalco Creek and Lake Mathews. The approved Drainage Water Quality Management County of Riverside General Plan for the Lake Mathews Watershed shall be implemented to assist in the management of the water quality of Cajalco Creek and Lake Mathews and to mitigate water quality impacts resulting from development permitted under the Lake Mathews/Woodcrest Area Plan.
LMWAP 6.3	As Regional and Community Trails are acquired by the County of Riverside within the Lake Mathews Drainage Basin, appropriate specific mitigation measures shall be prepared and implemented prior to the construction or implementation of any of these trails so that the water quality of Lake Mathews will be fully preserved and protected.
LMWAP 6.4	Proposed projects within the Lake Mathews drainage basin, which may significantly increase run-off over natural levels shall be engineered to reduce potential pollutant loads that may affect water quality.

The General Plan and Area Plan policies would apply to all development, including the Cajalco Road Widening Project, which involves improvements to Cajalco Road between Interstate 215 and Temescal Canyon, south of Lake Mathews. In addition, Specific Plans establish requirements for individual residential developments. There are two development projects with Specific Plans proposed in the Lake Mathews watershed – the Boulder Springs and Gavilan Hills Estates Specific Plans. The Boulder Springs Specific Plan (Specific Plan No. 229, Amendment 1) was approved May 4, 2004, proposing development on the northeast side of the watershed north and south of Cajalco Creek between Wood Road and Alexander Street. During the reporting period, a developer resumed work on the Boulder Springs development and proposed the Dailey Ranch development located south of Cajalco Road at Wood Road and outside of the Specific Plan No. 229A1 area. Further discussion on these proposed developments and Lake Mathews watershed management efforts are included in **Chapter 6**.

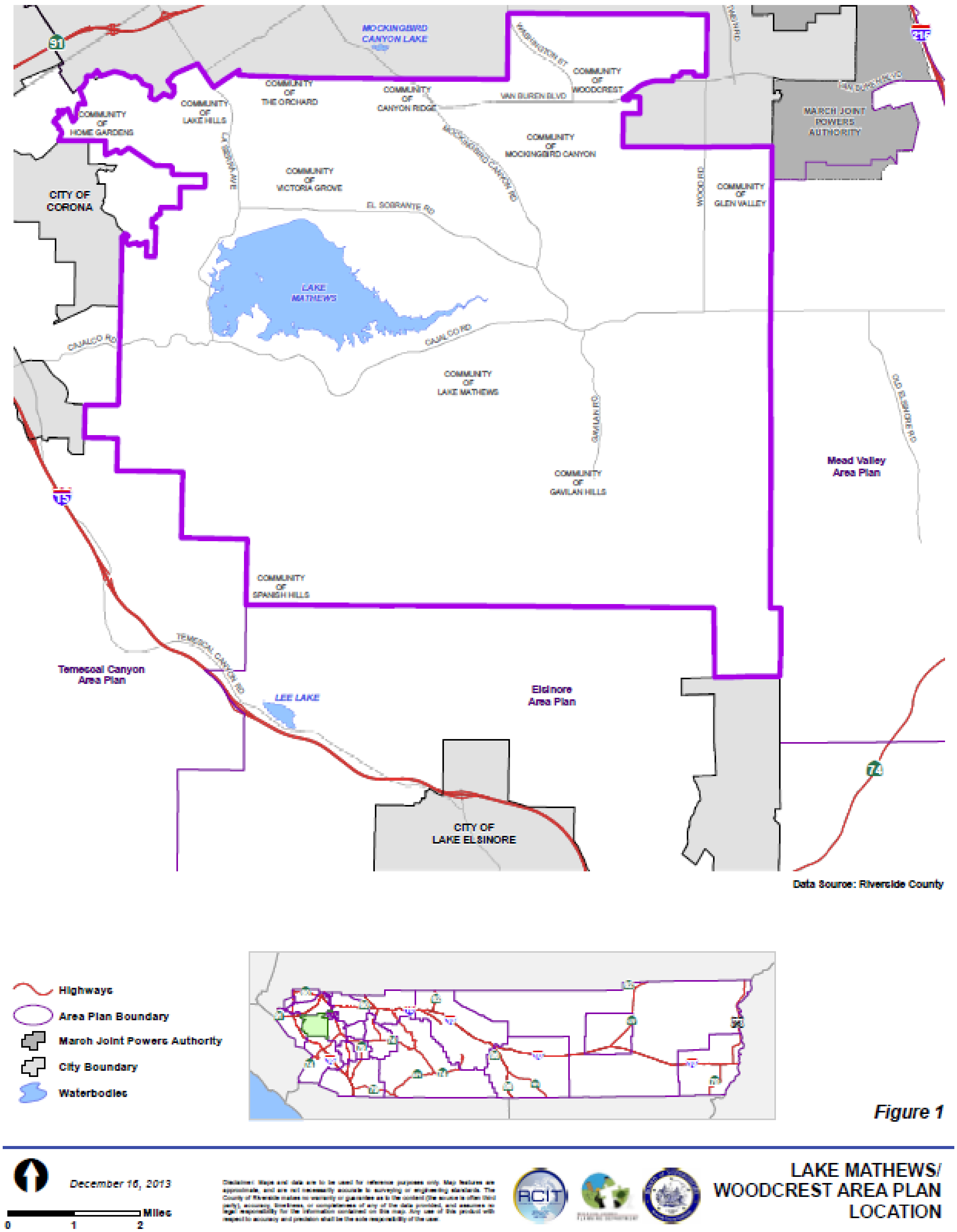


Figure 4-19. Lake Mathews Woodcrest Area Plan Location [135]

The Gavilan Hills Policy Area includes the Gavilan Hills Estates Specific Plan (Specific Plan No. 308, Amendment 1), which was approved May 25, 2010, and proposes development in the center of the watershed west of the Harford Springs County Park and north of Lake Mathews Drive. As stated earlier, these two developments have complied with the components of the DWQMP through the addition of water quality debris basins shown in **Figure 4-16**.

Riverside County Ordinances

Riverside County has a number of local stormwater, urban runoff, and erosion control ordinances. **Table 4-10** summarizes all Riverside County ordinances, which address specific activities that may contribute to urban runoff related issues. Several Riverside County departments and agencies have overlapping duties that provide enforcement for the many potential issues that could ultimately lead to urban runoff violations. These departments and agencies include Code Enforcement, Building and Safety, Transportation, Transportation and Land Management, Environmental Health, and Fire.

Table 4-10. County of Riverside Ordinances Providing Legal Authority for Urban Runoff Related Issues [136]

Ordinance No.	Ordinance Short Title
427	Land Application of Manure
457	Building Codes
520	Abandoned Vehicles
541	Removal of Rubbish
555	Surface Mining
559	Removal of Trees
615	Hazardous Waste: Storing, Treating, Recycling
651	Disclosure of Hazardous Materials & Emergency Response
657	Collection and Removal of Solid Waste
689	Unlawful Dumping of Trash
712	Collection, Transportation and Removal of Liquid Wastes
745	Comprehensive Collection and Disposal of Solid Waste
754	Stormwater/Urban Runoff Management Discharge Controls
857	Business Registration and Licensing Program

The main ordinance pertaining to urban runoff is Ordinance 754: *Establishing Stormwater/Urban Runoff Management and Discharge Controls*. The purpose of this ordinance is to ensure the future health, safety, and general welfare of county citizens through the following [136]:

- Reducing pollutants in stormwater discharges to the maximum extent practicable,
- Regulating illicit connections and discharges to the storm drain system, and
- Regulating non-stormwater discharges to the storm drain system.

Lake Mathews Drainage Water Quality Management Plan

To protect water quality in Lake Mathews from runoff contamination, the DWQMP was completed in the early 1990s as part of the Lake Mathews/Woodcrest Specific Area Plan, through a partnership between Metropolitan, County of Riverside, and RCFCWCD. The DWQMP was developed to protect the quality of water in Lake Mathews by taking a regional approach to managing runoff in the watershed. The plan investigated the effects that existing and future development might have on Lake Mathews' water quality, and recommended steps that could be taken to mitigate or reduce the contaminants that enter the lake associated with stormwater or accidental spills in the watershed.

Under the DWQMP, runoff pollution would be managed and mitigated through the implementation of 1) onsite BMPs applied throughout the watershed, 2) regional BMP facilities, and 3) ongoing program management activities [128]. Implementation of regional BMP facilities resulted in the construction of several detention/sedimentation basins along Cajalco Creek, as shown in **Figure 4-16**. Riverside County continues to require implementation of the DWQMP as part of the Lake Mathews/Woodcrest Area Plan policies listed in **Table 4-9**.

Lake Mathews Multiple Species Habitat Conservation Plan

A similar planning effort to the WRC MSHCP was completed for the Lake Mathews and Estelle Mountain areas. The *Lake Mathews Multiple Species Habitat Conservation Plan* (LM MSHCP), approved by Wildlife Agencies in 1995, includes the creation of a Multiple Species Reserve at Lake Mathews, and contains a detailed resource inventory of the area, habitat evaluation, habitat conservation, and impact mitigation measures for area development [137]. The Multiple Species Reserve constitutes the majority of the existing conservation land surrounding Lake Mathews. In 1998, the Riverside County Board of Supervisors moved to create a new General Plan that included integrating the WRC and LM MSHCPs and watershed protection with the goal of enhancing and maintaining biological diversity and ecosystem processes while allowing future economic growth [138].

Studies and Monitoring

Review of Lake Mathews Drainage Water Quality Management Plan

With the DWQMP being completed nearly two decades ago, many of the stormwater treatment facilities recommended in the plan are no longer feasible or appropriate based on current water quality and environmental regulations, advances in stormwater management technologies, and available land in the watershed. To review the DWQMP, Metropolitan, in cooperation with RCFCWCD and the County of Riverside, initiated the *Lake Mathews Watershed Water Quality Improvement Study*, which evaluated recommendations in the DWQMP. Through development of a watershed model, this study provided an updated assessment of the current and future threat of runoff pollution into Lake Mathews and developed solutions for protecting the lake based on the current regulatory, planning, and management environment. Further discussion on this Lake Mathews watershed management effort can be found in **Chapter 6.**

Stormwater Monitoring

After construction of the CCDDB, several sampling events were conducted during and after storms to investigate its pollutant removal capabilities. The CRWSS 2010 Update presents results from these sampling events dating back to 2004, including a rainfall event that extended into the current reporting period in 2011. Overall, nutrient levels are much lower and sulfate levels, naturally found in the Colorado River watershed, are higher in Lake Mathews compared to levels observed in stormwater. During this CRWSS 2015 Update reporting period, no additional samples were collected from the CCDDB due to dry conditions as shown in **Figure 4-17**.

Recreation

Lake Mathews is closed to the public except for an overlook area; there are no recreation facilities proposed at this time.

Riverside County Regional Park and Open Space District (RCRPOSD) has proposed to establish a multi-purpose recreation trail between RCRPOSD's Mockingbird Canyon Archaeological site and the Harford

Springs Reserve in Gavilan Hills. RCRPOSD has investigated various trail alternatives and established a preferred route. In September 2011, RCRPOSD amended the contract with their consultant to proceed with the environmental compliance documentation [139]. In 2014, development of the Mockingbird-Harford Springs Trail development was put on hold due to limited resources [140]. Metropolitan will continue to monitor the status of this development.

Spills

Occurrence in Watershed

Spills in the Lake Mathews watershed occur infrequently. A search was completed of the NRC chemical spill incidents database. No spills were reported in the NRC database within the Lake Mathews watershed [141].

Metropolitan documents hazardous substance releases on and near its property. While conducting routine patrols of and near Metropolitan facilities in the Lake Mathews area from 2011–2015, several occurrences of illegal dumping were reported. Dumped waste has typically consisted of paint, oil, and drug lab paraphernalia in various quantities and types of containers. Materials have leaked onto the ground, but none of the illegal dumping or accidental spills have resulted in contamination of Metropolitan's source waters. Incidents since the CRWSS 2010 Update are summarized in **Table 4-11**.

Table 4-11. Hazardous Substance Releases in the Lake Mathews Watershed [142]

Report Date	Occurrence	Action/Response
August 30, 2011	Unknown person(s) dumped 20 to 50 gallons of an oily substance onto the north fence line patrol road.	Metropolitan deployed contracted hazardous waste vendor to perform cleanup.
November 11, 2011	Auto accident on La Sierra Ave on Lake Mathews Dam, South of Monument.	Initial clean up conducted by Riverside County Fire Department. Metropolitan conducted additional cleanup of oil, melted metal and plastic auto parts.
November 30, 2011	Old bags of cement dumped on Lake Mathews access road to Gate 8.	Metropolitan deployed contracted hazardous waste vendor to perform cleanup.
January 1, 2012	A car hit the retaining curb on La Sierra Ave. on the lake side of the dam. The radiator was damaged and the coolant, as well as possible oil, drained onto the ground.	Absorbent material was spread over the spill, swept up and placed in a bucket, which was labeled and transported to the Lake Mathews hazardous waste storage area.
August 23, 2012	Five one-gallon plastic containers of used oil were dumped along the hillside of Tin Mine Rd. One container had a loose lid, which allowed approximately one cup of oil to spill onto the dirt.	The containers were picked up and the contaminated dirt was shoveled into a 5-gallon bucket. The waste was transported to the Lake Mathews hazardous waste storage area.

Report Date	Occurrence	Action/Response
September 12, 2012	Multiple incidents (> 10) of dumping of hazardous waste and non-hazardous waste (furniture, concrete, roofing material, and household trash) on Metropolitan right-of-ways. Waste includes 6 gallons of used oil, 1 gallon of antifreeze, and 1 car battery. Some of the liquid hazardous waste had leaked onto the ground.	Metropolitan deployed contracted hazardous waste vendor to perform cleanup of hazardous waste. A trash hauler was deployed to pick up non-hazardous trash.
September 9, 2013	Non-Metropolitan collision involving a commercial tractor and a 1-ton service truck. Approximately 0.25 gallons of antifreeze, transmission fluid, and oil leaked onto Metropolitan property on lake side of El Sobrante.	Metropolitan deployed contracted hazardous waste vendor to clean up and dispose of contaminated dirt. Approximately 300 lbs of contaminated dirt was removed and moved to the Lake Mathews hazardous waste storage area.
June 4, 2014	Hydraulic fluid leak on a Lake Mathews Loader. The loader was being operated in the Lake Mathews Rock Quarry near Gate 24. Approximately 3 gallons of hydraulic fluid spilled onto the dirt in the Lake Mathews Rock Quarry.	Contaminated dirt was shoveled into 4 drums and moved to Lake Mathews hazardous waste storage area.
December 8, 2014	Thirty-six five-gallon buckets and approximately 20 to 25 one-gallon buckets of old water-based paint were dumped on Tin Mine Road to the west of Lake Mathews. There were multiple dumping locations from the start of Tin Mine Rd. near La Sierra up to the top of the hill on Tin Mine Rd.	Metropolitan deployed contracted hazardous waste vendor to clean up and dispose of containers.
January 14, 2015	Four gallons of used oil in plastic containers were left on the south shoulder of Tin Mine Road.	Metropolitan moved containers and contaminated dirt to Lake Mathews hazardous waste storage area.
August 25, 2015	Unknown driver struck and damaged concrete wall along Lake Mathews West Dam northbound on La Sierra Drive causing oil to spill onto asphalt.	Metropolitan staff used absorbent to clean up oil and transferred the waste to Lake Mathews hazardous waste area.

Metropolitan also works proactively with other agencies during the planning phases of projects to ensure source water protection. For example, Metropolitan has worked with Western Municipal Water District (WMWD) to evaluate potential expansion of their non-potable water system expansion, which would be located north of the Lake Mathews inlet channel and downstream of the CCDDB. WMWD's proposed distribution pipeline, conveying non-potable water sources north of Lake Mathews to customers south of Lake Mathews, would cross above the inlet channel to Lake Mathews. Historically, WMWD has utilized raw Colorado River water to supply irrigation customers south of the CRA. To reduce reliance on imported water and supply nonpotable water to customers south of Lake Mathews, WMWD had proposed to replace the pipeline over the inlet channel with a doubled-contained pipeline with cathodic protection and leak detection. In 2011, WMWD completed an expansion of the Western Water Recycling Facility including installation of a new pump station. The facility has a treatment capacity of 3 MGD at a tertiary level but is currently only treating 0.7 MGD. WMWD is distributing all of the available recycled water to customers north of Lake Mathews. In the future, WMWD will reconsider upgrading the Lake Mathews inlet pipe crossing when sufficient nonpotable water supplies are available to meet demands from customers south of Lake Mathews [143].

Regulation and Management

Because of the rural nature of the unincorporated county areas and the transformation from rural farming to urban and suburban residential, illegal dumping has become a significant issue for the county. The Riverside County Building and Safety Department's Code Enforcement Division maintains a Special Enforcement Taskforce in order to more effectively respond to environmental violations throughout the unincorporated areas of the county. Code Enforcement conducts surveillance and investigations of illegally dumped materials. In addition, the county has developed the Riverside County Trash Taskforce consisting of stakeholders from both government agencies and community leaders to gain input and develop plans to deal with illegal dumping.

Metropolitan has a Hazardous Materials and Waste Emergency Contingency Plan to deal with handling chemical spills or other hazardous materials. When hazardous materials are found within the watersheds, the spill is reported immediately to the Riverside County Hazardous Materials Emergency Response (HAZMAT) Team. The direction of the clean-up effort is handled by Metropolitan and Riverside County. Metropolitan has a contractor available 24 hours a day for cleanup and hauling of hazardous materials. If criminal activity is suspected, the investigation is handled by Riverside County.

The HAZMAT Team is a joint agency effort with personnel from Riverside County Department of Environmental Health (RCDEH), Hazardous Materials Management Division, and Riverside County Fire/California Department of Forestry. This team responds to incidents involving hazardous materials throughout the county 24 hours per day, 7 days per week.

Studies and Monitoring

Monitoring is conducted on an as-needed basis after spills have occurred; monitoring was not required for the incidents that occurred during the reporting period.

Landfills

Occurrence in Watershed

There are no active landfills in the Lake Mathews watershed, as confirmed by data contained on the California Department of Resources Recycling and Recovery (Cal Recycle) website [144] . However, there are a few closed landfill sites within, and active and closed landfills adjacent to, the Lake Mathews watershed (**Figure 4-20**).

Approximately 2 miles southwest of Lake Mathews is the El Sobrante Landfill, which is active. Metropolitan noted an influx of gulls at Lake Mathews in January 2014 and February 2015. Metropolitan suspected that the prevalence of gulls was associated with migratory patterns and possible operational changes at El Sobrante Landfill. Metropolitan contacted El Sobrante Landfill and was informed that the landfill implements a full-time abatement program involving a falconer, between October and April, but they did not undergo any operational changes or note a heavier than usual presence of gulls at the landfill in early 2014 or 2015 [145]. While it is not known if a direct correlation exists between the increased gull population and the landfill, staff will continue to monitor this issue. Although not related to Colorado River watershed areas, the CRWSS 2010 Update discussed that Metropolitan has experienced similar concerns at Castaic Lake and Metropolitan's Joseph Jensen Water Treatment Plant. The presence of gull roosting at Castaic Lake is a potentially contaminating activity as gulls can contribute elevated *E. coli* levels to the Jensen plant [146].

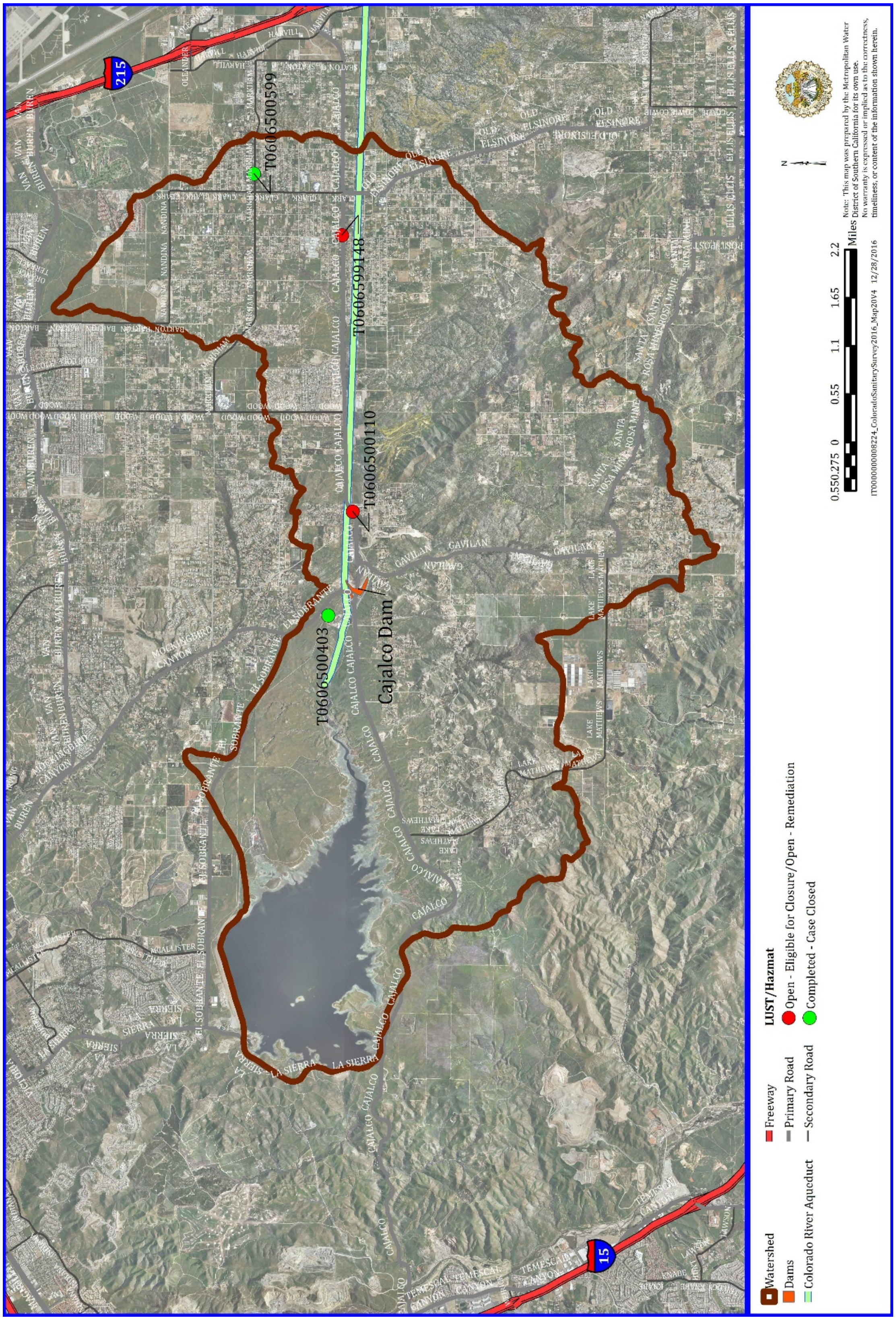


Figure 4-20. Active and Closed Landfill Facilities Adjacent to Lake Mathews Watershed [144]

Leaking Underground Storage Tanks

Occurrence in Watershed

A data review was completed for LUST sites for the reporting period. The area reviewed was within the Lake Mathews watershed boundary or a distance of one mile from the reservoir, whichever was greater, for the areas where the watershed boundary and the shoreline coincide. Two open LUST sites are undergoing remediation and two were closed during the reporting period. **Table 4-12** and **Figure 4-21** summarize the active and closed LUST sites during this reporting period.

The WMWD LUST site was of greatest concern to Metropolitan because of its proximity to Lake Mathews. WMWD has had a land lease from Metropolitan for their Operations Center since the late 1950s. The Operations Center is situated approximately 1,200 feet from the location where the unlined section of the CRA enters Lake Mathews, referred to as the Lake Mathews inlet channel. The LUST was discovered in July 1994 and WMWD completed soil and groundwater remediation activities in 2008 and, as requested by RCDEH, completed one year of monitoring in 2009. In May 2010, RCDEH and RWQCB-Santa Ana Region approved the closure of the site and requested documentation of monitoring well destruction and waste disposal. RCDEH issued a site closure letter on February 24, 2011. Further information on the WMWD LUST is discussed in the CRWSS 2010 Update.

Regulation and Management

As indicated in the *Leaking Underground Storage* PCS section for the *Lake Mohave and Lake Havasu* watersheds, RWQCBs provide state oversight of local agency UST programs. In Riverside County, RCDEH manages the remediation of LUST sites and issues permits for tanks that will store hazardous materials. It is required that all unauthorized releases by USTs are reported to the county. RCDEH works closely with the RWQCB-Santa Ana Region and RWQCB-San Diego Region on many LUST sites, but RCDEH is typically the lead agency.

Septic Systems

Occurrence in Watershed

As discussed in the 2010 CRWSS, RCDEH reported 339 active septic systems in the Lake Mathews watershed [147]. Metropolitan contacted RCDEH in 2016 to obtain an update on the number of septic system; however, due to limited staff resources, updated information could not be obtained for the current reporting period. It is important to note that the total number of septic systems is unknown since RCDEH does not have a complete historical database prior to 2006.

As previously discussed, WMWD's Operations Center is located on Metropolitan property adjacent to Lake Mathews. In 2011, WMWD completed an expansion and upgrade of WMWD's Operations Center and construction of an adjacent 9,400-square foot fire station. The site expansion for the facilities required additional wastewater treatment. Due to the proximity to Lake Mathews, Metropolitan coordinated with WMWD to review several wastewater treatment options, from onsite treatment to installation of a pump station and force main to convey sewage offsite, to ensure water quality would not be impacted. WMWD proceeded with the option to collect sewage in an onsite holding tank and routinely haul the wastewater to one of WMWD's existing lift stations, where it would be conveyed to a wastewater treatment plant for treatment and disposal outside of the Lake Mathews watershed. Metropolitan will continue to coordinate with WMWD on any future changes to sewage handling methods at this site.

Table 4-12. Summary of Active and Closed LUST Sites in or near the Lake Mathews Watershed [208]

Site ID	Report Date	Facility Name	Address	Distance to Lake Mathews (miles)	Contaminant	Status
T0606500110	1/14/1992	Lake Mathews General Store	17679 Cajalco Road Perris, CA	2 miles	Gasoline	Open – Eligible for closure as of 1/29/2016. Two 10,000 gallons removed in 1992. Soil and groundwater treatment completed in 2013.
T0606500403	7/26/1994	Western Municipal Water District Operations Center	16451 El Sobrante Rd. Riverside, CA	0.66 miles	Gasoline	Closed - as of 2/24/2011. Four USTs removed in 1995. Soil and groundwater treatment completed in 2008.
T0606500599	3/10/1999	Midway Jr. Market (Former Corner Produce Site)	21720 Markham St. Perris, CA	5.5 miles	Gasoline	Closed - as of 6/28/2013. Two 10,000-gallon gasoline tanks and some soil removed in 1999. Site determined to pose a low threat to human health, safety and the environment in 2012.
T0606599148	7/19/2000	Mobile Baldwin	21020 Cajalco Rd. Perris, CA	4.5 miles	Gasoline	Open - Remediation as of 3/21/2014. Soil and groundwater treatment completed in 2008. Ongoing monitoring.

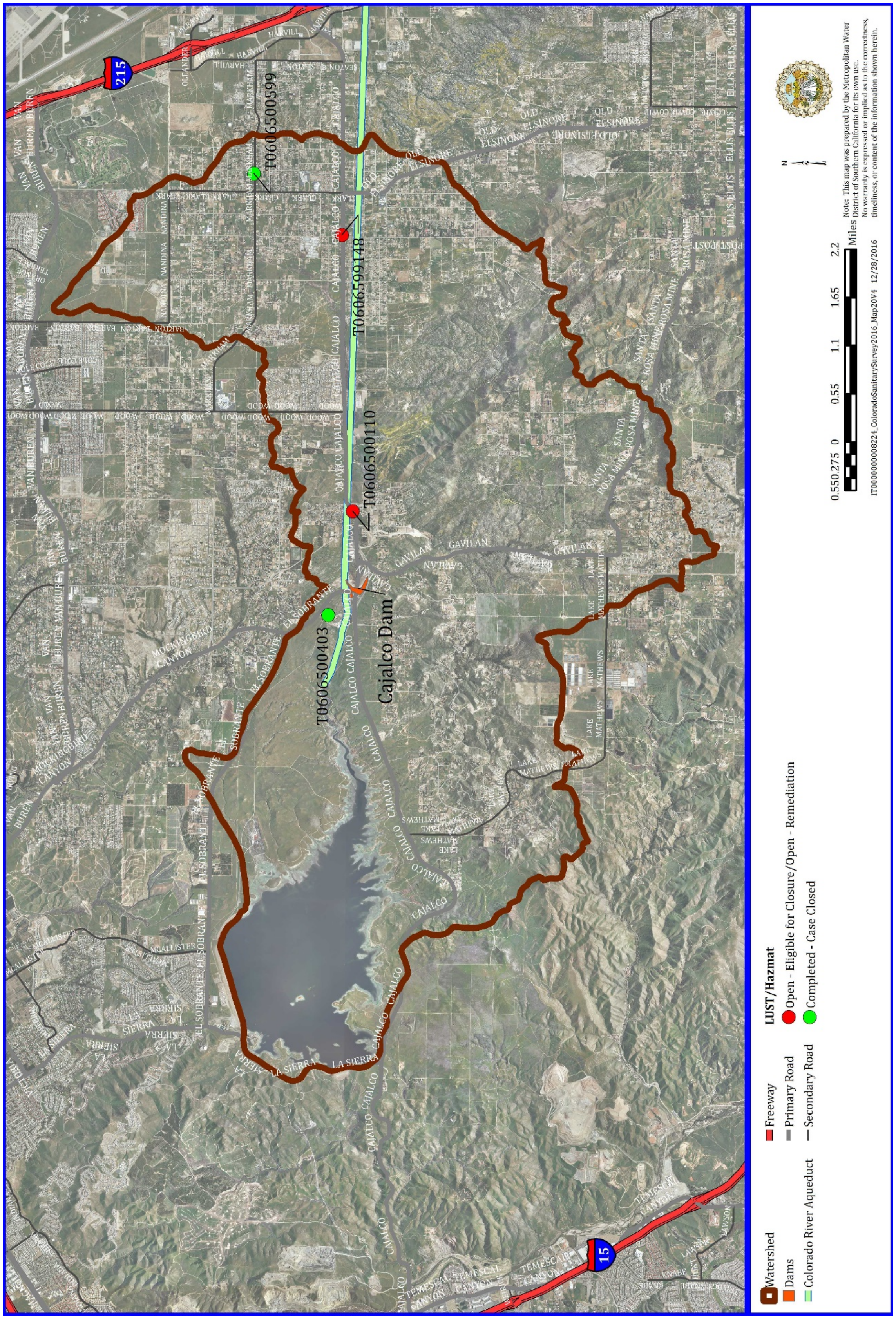


Figure 4-21. Active and Closed LUST Sites within Lake Mathews Watershed [208]

Regulation and Management

RCDEH permits and inspects installation of septic systems and issues violations for failed septic systems. Information on the number of violations during the reporting period was not available. Septic systems in the County of Riverside are regulated by Ordinances 592, 650, and 682 [136].

Ordinance 592: *Regulating Sewer Use, Sewer Construction and Industrial Wastewater Discharges in County Service Areas* ensures maximum beneficial public use of the Riverside County service area facilities through adequate regulation of sewer construction, sewer use, and industrial wastewater discharges. Examples of the prohibited sewage discharge include hazardous materials, low pH waste, nonbiodegradable oil products, and industrial process cooling water. Ordinance 592 also requires inspection of any facility that discharges directly or indirectly to the Riverside County's sewerage system.

Ordinance No. 650: *Regulating the Discharge of Sewage in the Unincorporated Areas of the County of Riverside* establishes construction requirements for septic systems, and in conjunction with the California Health and Safety Code Sections 5411 and 5461, establishes the authority and responsibility of RCDEH to investigate system failures. According to Ordinance 650, no person shall erect, construct, rebuild, convert, or alter any plumbing system designed for the discharge or disposal of sewage or sewage effluent unless they have first obtained a written approval for such purpose from RCDEH. Approval of a conventional septic system requires a detailed plan review, as well as pre-site and construction inspections.

Ordinance 682: *Regulating the Construction, Reconstruction, Abandonment and Destruction of Wells* specifies that the minimum setback distance for water supply wells from watertight septic tanks and subsurface sewage leach line or leach field is 100 feet.

Currently, due to lack of resources, RCDEH does not inspect septic systems routinely. They inspect systems on a complaint-basis only. If a system fails, RCDEH responds and requires the owner to fix the failed system.

As discussed in the *Septic Systems* PCS section of the *Lake Mohave and Lake Havasu* watersheds, SWRCB adopted the OWTS Policy on June 19, 2012. The OWTS Policy provides consistent guidelines throughout California for the construction and maintenance of septic systems to protect surface water and groundwater from wastewater discharge. In March 2015, RCDEH updated their OWTS Technical Guidance Manual to assist the contractor, designer, engineer, and installer in the design and installation of OWTS in compliance with the OWTS Policy [148]. In March 2016, the Riverside County Board of Supervisors approved RCDEH to initiate amendments of Ordinance 650 to incorporate the OWTS Policy requirements including the development of a Local Area Management Plan [149].

Agriculture

Occurrence in Watershed

Biosolids Application

As shown in **Figure 4-15**, agricultural activities comprise about 4.8 percent of the Lake Mathews watershed, and include croplands, minimal grazing, and previously, limited land manure applications. One issue that has been tracked in previous watershed sanitary surveys has been the application of biosolids. Biosolids are treated sludge that is a byproduct of wastewater treatment systems. They are categorized as either Class A or Class B, depending on the level of pathogenic organisms in the material. Since Class B biosolids were banned by Riverside County in November 2001 (Ordinance 812), land application of Class B biosolids has not been an issue in the Lake Mathews watershed. The ban on Class B biosolids is still in effect. In September 2004, Riverside County passed Ordinance 830 allowing the land application of Class A biosolids, beginning in November 2004. Per RCDEH, no applicants have filed for the legal application of Class A biosolids in Riverside County in the Lake Mathews watershed; however, Ordinance 830 exempts the application of Class A biosolids on active tree or vine farming operations [150].

It is legal to apply cow manure to land in Riverside County. Per RWQCB-Santa Ana, no land application of manure has occurred within the Lake Mathews watershed during the reporting period [124] . The majority of manure applied to land within the Santa Ana watershed has occurred in the Chino and San Jacinto sub-basins. When used, the application rates must be approved by the Riverside County Agriculture Commissioner's Office.

Herbicide Application

Though not directly related to typical agriculture activities, herbicides and controlled burns are used within the Lake Mathews watershed to control non-native vegetation that threaten habitat for native endangered species and lake operations. Also, to maintain the integrity of the dams, herbicides are applied to control weeds on the dry side of the dams. The application can be completed with a helicopter or with ground crews. Specific requirements exist for each of the management methods (herbicide application and controlled burns) to control non-native vegetation and prevent contamination of Lake Mathews with chemicals or sediment.

AquaMaster® has been approved for use by DDW at Metropolitan facilities. Glyphosate is the active ingredient in AquaMaster® herbicide and it has favorable environmental characteristics, such as degradation over time in soil, sediment, and natural waters, and tight binding to most soils and sediment, which reduces bioavailability soon after application.

In May 2015, Metropolitan observed unprecedented vegetation growth around Lake Mathews due to decreasing lake levels and exposed shoreline areas under drought conditions (**Figure 4-22**). On September 17, 2015, DDW approved temporary use of additional herbicide application (Habitat®) to treat vegetation at Lake Mathews, provided appropriate application, sampling and monitoring protocols, and contingency plan procedures are followed. Imazapyr is the active ingredient in Habitat®,, which is approved by U.S. EPA for aquatic use, and also has favorable environmental characteristics such as high solubility in water and rapid degradation through photolysis in water.

Figure 4-22. Willow Fire Burned Area near Colorado River, August 10, 2015 [213]

As indicated in **Table 4-13**, herbicide was applied along Lake Mathews to treat vegetation on numerous occasions during the 2015 CRWSS reporting period. The initial Habitat® application was by aircraft on October 27, 2015 and appropriate precautions were observed to protect Lake Mathews water quality. Control measures included a 10-foot buffer from Lake Mathews, monitored weather conditions, and designated offsite herbicide storage. As discussed in the following *Regulation and Management* section, DDW approved long-term use of Habitat® in September 2016 and the next CRWSS will document herbicide applications for the corresponding reporting period.

Table 4-13. Herbicide Application at Lake Mathews, 2011-2015

Aquamaster® Application Dates	Habitat® Application Dates
October 20–27, 2011	October 27, 2015
November 3, 2011	
March 14, 2012	
April 24, 2012	
June 4, 2012	
July 16, 2012	
August 30, 2012	
July 30, 2013	
September 17, 2013	
April 29, 2014	
May 28, 2014	
June 24, 2014	
April 29, 2015	
May 27, 2015	
June 29, 2015	

Regulation and Management

Biosolids Application Regulations

The federal biosolids rule is contained in 40 CFR Part 503. Biosolids applied to the land must meet risk-based pollutant limits specified in Part 503. All biosolids must meet the ceiling concentrations for 10 heavy metal pollutants in biosolids, specifically, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. If a limit for any one of the pollutants is exceeded, the biosolids cannot be applied to the land until the concentrations are within acceptable parameters.

Biosolids must also meet either Class A or Class B pathogen requirements; the two classes differ depending on the level of pathogen reduction that has been obtained. In order for biosolids to be classified as Class A, one of six treatment alternatives must be met. Additionally, the density of fecal coliform in the biosolids must be less than 1,000 MPN per gram total solids (dry-weight basis), or the density of *Salmonella* sp. bacteria in the biosolids must be less than 3 MPN per 4 grams of total solids (dry-weight basis).

The Class B requirements include site restrictions that prevent crop harvesting, animal grazing, and public access for a certain period of time until environmental conditions have further reduced pathogens. In order for biosolids to be classified as Class B, the biosolids must be treated by aerobic digestion, air-drying, anaerobic digestion, composting, lime stabilization, or equivalent process. Biosolids may also be classified as Class B if fecal coliform density is tested and the geometric mean of seven samples is less than 2 million MPN per gram of total solids or less than 2 million CFU per gram of total solids at the time of use or disposal.

RCDEH enforces Ordinance 830: *Regulating the Land Application of Class A Sewage Sludge for Agricultural Activities* and keeps track of all Class A applications in Riverside County. Similar to biosolids, RCDEH enforces the county ordinance on land application of manure (Ordinance 427.3: *Regulating the Land*

Application of Manure). The prohibition of land application of Class B sewage sludge is described in Riverside County Ordinance 812: *Prohibition of Land Application of Class B Sewage Sludge*.

The RWQCB-Santa Ana Region has their own restrictions on land application of manure, as outlined in the general waste discharge requirements for dairy operators under Order No. R8-2013-001 (adopted June 7, 2013, and revised from Order No. 99-11 and Order No. R8-2001-001): *General Waste Discharge Requirements for CAFOs (Dairies and Related Facilities)*. Manure must be applied to cultivated cropland, incorporated into the soil soon after application, and must not exceed the agronomic rate of 12 dry tons per year or 17.5 tons per acre per year at 33 percent moisture [125]. Dairy operators are also required to prepare and submit a manifest of the manure hauled away, which states where the manure is being applied and the quantity. According to RWCQB-Santa Ana Region, they carefully review the submitted manifests and ensure that the manure is being applied to cultivated croplands at the proper agronomic rate [124] .

Herbicide Application Guidelines

Vegetation control with herbicides at Metropolitan facilities is approved by DDW. On February 14, 2014, DDW approved revisions to Metropolitan's herbicide application along the Colorado River Aqueduct, Lake Mathews, and Lake Skinner. DDW granted approval to use AquaMaster® provided appropriate application, monitoring, and action plan procedures are followed. In general, any spray application must be directed away from the lake. Below is a list of Metropolitan's requirements, approved by DDW, that need to be followed when spraying AquaMaster® near source waters:

- Herbicide Application – application will not be completed in windy or rainy conditions; precautions will be taken to avoid drip, drift, and runoff; all stock solution will be stored in a secondary container off-site with limited product on-site at any time.
- Sampling and Monitoring Program – if there are detectable glyphosate levels, water samples will be collected along the nearest CRA pumping plant downstream of the application area and increased monitoring will be conducted at Lake Mathews and Lake Skinner.
- Contingency Plan – in the event of a spill, the product would be contained and absorbed and/or sampling and chlorine application would be increased; current chlorination for quagga mussel control provides protection against glyphosate.

On September 30, 2016, DDW approved long-term use of additional herbicide application (Habitat®), with active ingredient imazapyr, to treat vegetation at Lake Mathews (**Appendix K**). Metropolitan may apply Habitat®, using backpack and ATV sprayers, on an as-needed basis year-round but will focus on application between February and October. Metropolitan will follow all applicable manufacturer directives and Metropolitan's requirements, as approved by DDW, when spraying Habitat® around Lake Mathews including prohibiting application under inclement weather conditions, maintaining a 10-foot linear buffer from the lake water level, and limiting the amount of herbicide storage on-site. In addition, Metropolitan will adhere to sampling and monitoring protocols to monitor concentrations of imazapyr in Lake Mathews until Metropolitan determines sufficient data is collected under varying hydrologic and operational conditions. During monitoring, DDW will be notified if any samples have detectable levels of imazapyr. If sampling results reach monitoring trigger levels, Metropolitan will take appropriate action, per the approved contingency plan, including collecting additional samples.

Fires

Occurrence in Watershed

Data on historic fires from CAL FIRE is available through the CAL FIRE Incidents database [151]. The name, year, and size of fires that have occurred in the last 10 years are included in **Table 4-14** and shown in **Figure 4-23**. The Mockingbird Fire in March 2007 occurred in close proximity to the Lake Mathews inlet. However, there were no reports of water quality impacts resulting from the fire. No fire incidents occurred since the CRWSS 2010 Update in the Lake Mathews watershed.

Table 4-14. Wildfires in the Lake Mathews Watershed, 2005-2015

Fire Name	Year	Area (acres)
Mockingbird	2007	737.3
Dawson	2007	23.2
Straw	2007	42.6

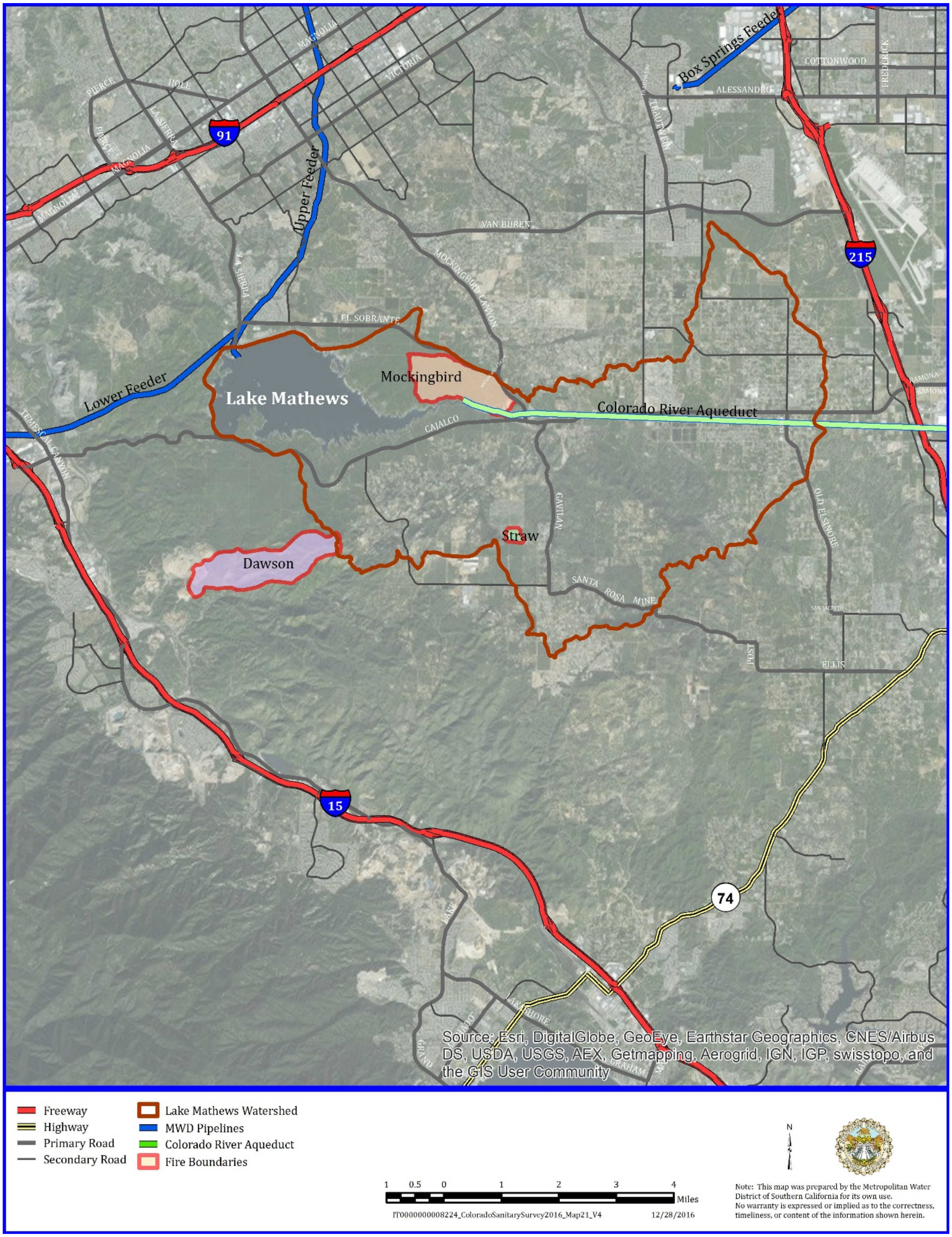


Figure 4-23. Lake Mathews Watershed Fires, 2005-2015

Regulation and Management

In 1994, the *Lake Mathews Fire Management Plan* was created by CAL FIRE with input from Metropolitan [152]. The 1994 Fire Management Plan covered the Lake Mathews Multiple Species Reserve and the surrounding Metropolitan-owned buffer lands. In 1998, the CAL FIRE Riverside Unit integrated its Vegetation Management and Pre-Fire Engineering Programs creating a Pre-Fire Management Plan. The Pre-Fire Management Plan combined the planning and assessment tools with the resources of the Vegetation Management Program in order to implement fire hazard/fuels reduction and ecological restoration projects in Riverside County. Subsequently, the 2005 *Riverside County Pre-Fire Management Plan* [153] specified the use of prescribed burns to reduce or eliminate the non-native annual grasses and return the landscape to native grass and sage scrub species for the Lake Mathews/Estelle Mountain Reserve. The Pre-Fire Management Plan, now called a Unit Strategic Fire Plan, was updated in 2009 and subsequently every year since 2011. The *2016 Unit Strategic Fire Plan* continues to identify Lake Mathews, Lake Skinner and Diamond Valley Lake as critical assets and discusses that potential water run-off and sediment could cause an issue for these reservoirs following a fire [154] . To protect these reservoirs, the 2016 Plan proposes to continue implementing prescribed burning and fuel reduction projects as needed.

Following a wildfire, and considering the severity and location of a wildfire within Metropolitan's watersheds, Metropolitan inspects the area and works with other local agencies as needed to determine if filtering or slope stability materials will need to be installed to control sediment and ash dispersion prior to rainfall events.

Summary for Lake Mathews Watershed

The terminus of the CRA is at Lake Mathews, which is surrounded by large community developments in the unincorporated areas of Corona, Woodcrest, Lake Elsinore, and Riverside. Lake Mathews does not offer recreational opportunities; hence, the primary potential impact to source water quality is related to the development growth in the watershed area. Over half of the watershed is developed with residential, commercial, or industrial improvements while the remaining watershed primarily encompasses open space and agricultural land uses.

Significant efforts have been undertaken to ensure the protection of Lake Mathews' water quality. Previous efforts include the development of the DWQMP, which provided recommendations for large scale BMPs located along Cajalco Creek and other watershed tributary drainages. Regional BMPs, such as flood control and sedimentation facilities, have been constructed with support from Metropolitan. In addition, Metropolitan provides ongoing services to support the Lake Mathews MSHCP in protecting the Multiple Species Reserve buffer that surrounds Lake Mathews.

Riverside County continued to implement their 2010 MS4 Permit, which mandates implementation of LID BMPs and requires significant development projects to complete WQMPs to identify applicable BMPs. Metropolitan, in cooperation with RCFCWCD and the County of Riverside, completed the Lake Mathews Watershed Study and developed a watershed model to evaluate the effects of development and various BMPs on runoff pollutant loading into the lake.

During the reporting period, Riverside County also adopted General Plan documents containing policies to protect Lake Mathews. Based on the Riverside County General Plan, development in the watershed will continue to increase. A proposed transportation project within the watershed is Riverside County's Cajalco Road Widening project, which will improve Cajalco Road between Interstate 215 and Temescal Canyon, south of Lake Mathews. Also, a proposed housing developments in the watershed is the Boulder

Springs-Dailey Ranch development project, located east of Lake Mathews and along Cajalco Road. However, Metropolitan will work with project stakeholders to ensure that water quality impacts are minimized through stormwater management practices and other development requirements.

Recommendations for Lake Mathews Watershed

Continue to coordinate with Riverside County Flood Control and Water Conservation District on development reviews

Metropolitan will coordinate closely with RCFCWCD on development proposals that could impact water quality within the Lake Mathews Watershed including the Boulder Springs-Dailey Ranch development project. As appropriate, Metropolitan would recommend the application of the Lake Mathews watershed model to evaluate the effectiveness of proposed stormwater treatment options in protecting Lake Mathews' water quality. Further discussion regarding Lake Mathews watershed planning and management efforts is provided in **Chapter 6**.

Continue to track progress of the Cajalco Road Widening project and evaluate potential impacts to Lake Mathews

Metropolitan will continue to track the status of the Cajalco Road Widening and Safety Enhancement project, evaluate potential impacts to Lake Mathews based on the proposed alignments and provide input into the environmental review process. Further discussion regarding the Cajalco Road Widening project is provided in **Chapter 6**.

Diamond Valley Lake Watershed

The PCSs discussed for Diamond Valley Lake Watershed include *Erosion, Urban and Stormwater Runoff*; *Recreation; Spills;* and *Fires*.

Erosion, Urban and Stormwater Runoff

Occurrence in Watershed

As shown in **Figure 4-24** the Diamond Valley Lake watershed is primarily undeveloped with approximately 60 percent of the watershed consisting of the lake itself and 28 percent designated as ecological preserves and sanctuaries land use. The remaining area land use consists of the reservoir operation footprints and the marina.

The impact of erosion, urban and stormwater runoff is minimal due to Diamond Valley Lake's small watershed, which is not urbanized. Most of the watershed has natural vegetative cover that minimizes sediment transport through runoff. Areas that are subject to erosion are limited to the high water road and bare slopes that become exposed to rain due to fluctuating water levels in the reservoir.

Regulation and Management

Stormwater regulations that apply to the Lake Skinner watershed would also apply to Diamond Valley Lake because both watersheds lie within the larger Santa Margarita River watershed. RCFCWCD is the principal permitee for the MS4 NPDES permit that covers the Diamond Valley Lake watershed, as regulated by the RWQCB-San Diego Region. The same DAMP and WQMP that govern the Lake Mathews watershed also covers the Diamond Valley Lake watershed. However, with the Diamond Valley Lake watershed being undeveloped, no further discussion is warranted.

Recreation

Occurrence in Watershed

Diamond Valley Lake was opened to the public in October 2003. Water quality protective measures were incorporated with the multiple recreational facilities that were included in Diamond Valley Lake.

The East Marina is located on the northeast end of the lake and consists of a two-lane paved access road, a paved parking area for 250 vehicles, an 11-lane boat launch ramp, restroom facilities, a small concessionaire area, dry storage area for boats, and a partial wave attenuator. The dry storage area for boats was constructed in 2005 and was expanded twice by 2007. The current dry storage area is approximately 2¾ acres.

Initial trails included 2 miles of pedestrian-only trails, 6 miles of hiking/equestrian trails, and a trail staging area for equestrians on the northwest end of the lake, which is outside of the watershed. The high water road, around the lake, was constructed to facilitate Metropolitan's lake operations; it was approved for pedestrian use and biking in June 2005 and renamed the Lake View Trail. Approximately 1½ miles of shoreline were opened for fishing in the East Marina area, which was well received by the public.

Since 2011, the lake elevation dropped 115 feet due to drought conditions and dipped below the existing boat ramp in April 2015, forcing boat launching to be closed. During the closure, Metropolitan extended the middle three launch lanes of the boat launch ramp. Metropolitan began refilling DVL in late March 2016 and was able to reopen the lake for boating in mid-May 2016. **Figure 4-25**, found on the www.dvlake.com website, provides a map of current recreational facilities.

Public motor boats and sail boats are allowed on Diamond Valley Lake provided they meet Metropolitan's requirements. Pontoon and bass fishing boats can also be rented from the East Marina concessionaire.

Three floating restrooms are provided on the lake for boater use. Each floating restroom dock system is held in place by two 4,000-pound anchors. The anchors for the floating restrooms are inspected every six months by Metropolitan's Maintenance Dive Team. Along the anchor line is a pulley system with a counter weight. The configuration allows the length of the anchor line to automatically adjust to changes in water surface elevation. Routine cleaning of the floating restrooms is completed by the concessionaire who also operates the marina store.

Metropolitan has engaged in various planning level discussions with commercial developers on expansion of the East Marina and recreational facilities outside of the watershed adjacent to the east dam. These efforts stalled due to recent economic downturns. Expanding recreation and other compatible uses at Diamond Valley Lake continues to be explored. As of early 2016, Metropolitan has begun designing an upgrade to the East Marina restroom facilities since the originally installed marina sanitation trailer has reached the end of its service life with potential for failure. Metropolitan proposes replacing the marina sanitation trailer with a modular restroom building that better supports visitor usage. Metropolitan is also planning electrical upgrades to the East Dam.

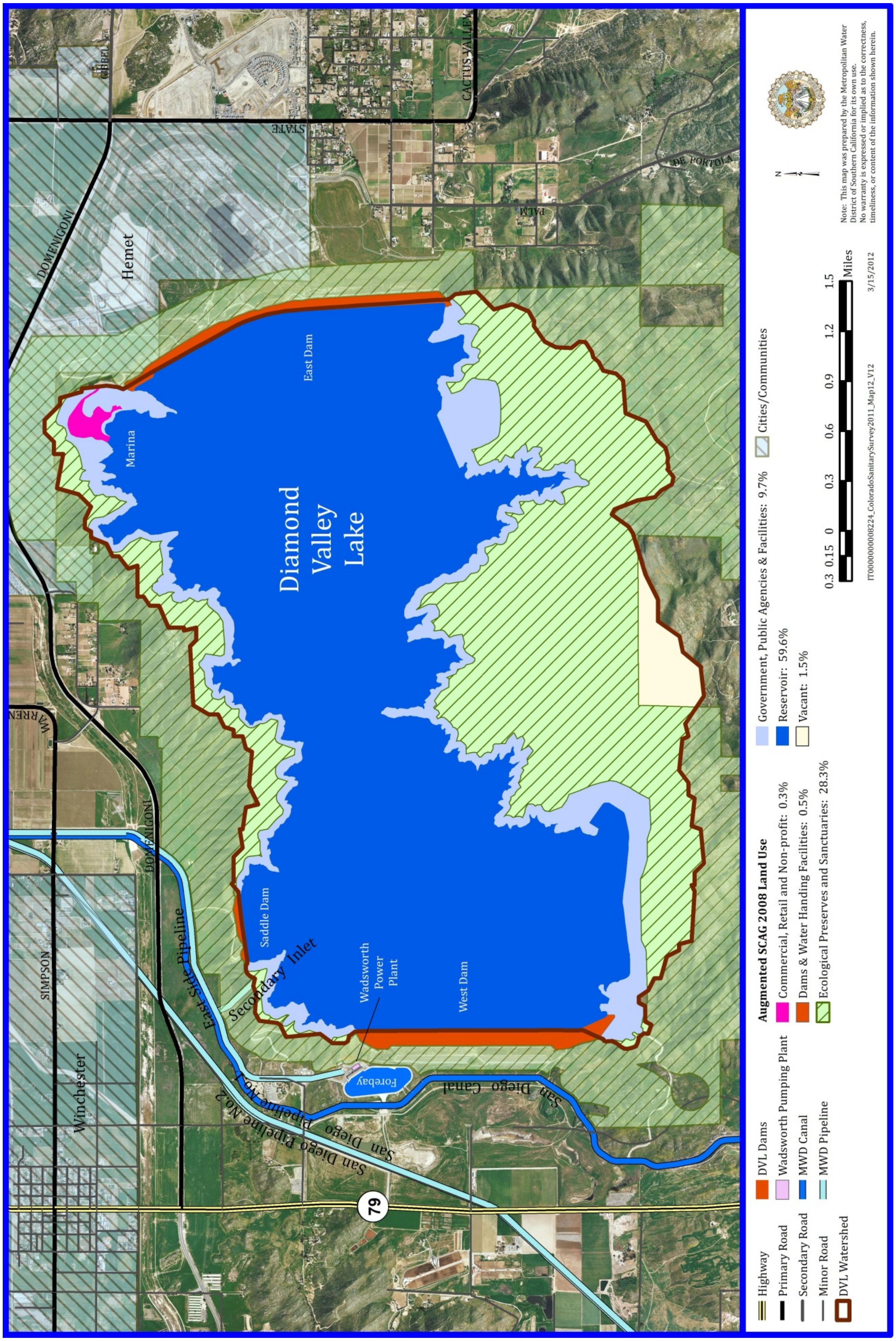


Figure 4-24. Diamond Valley Lake Watershed Land Use

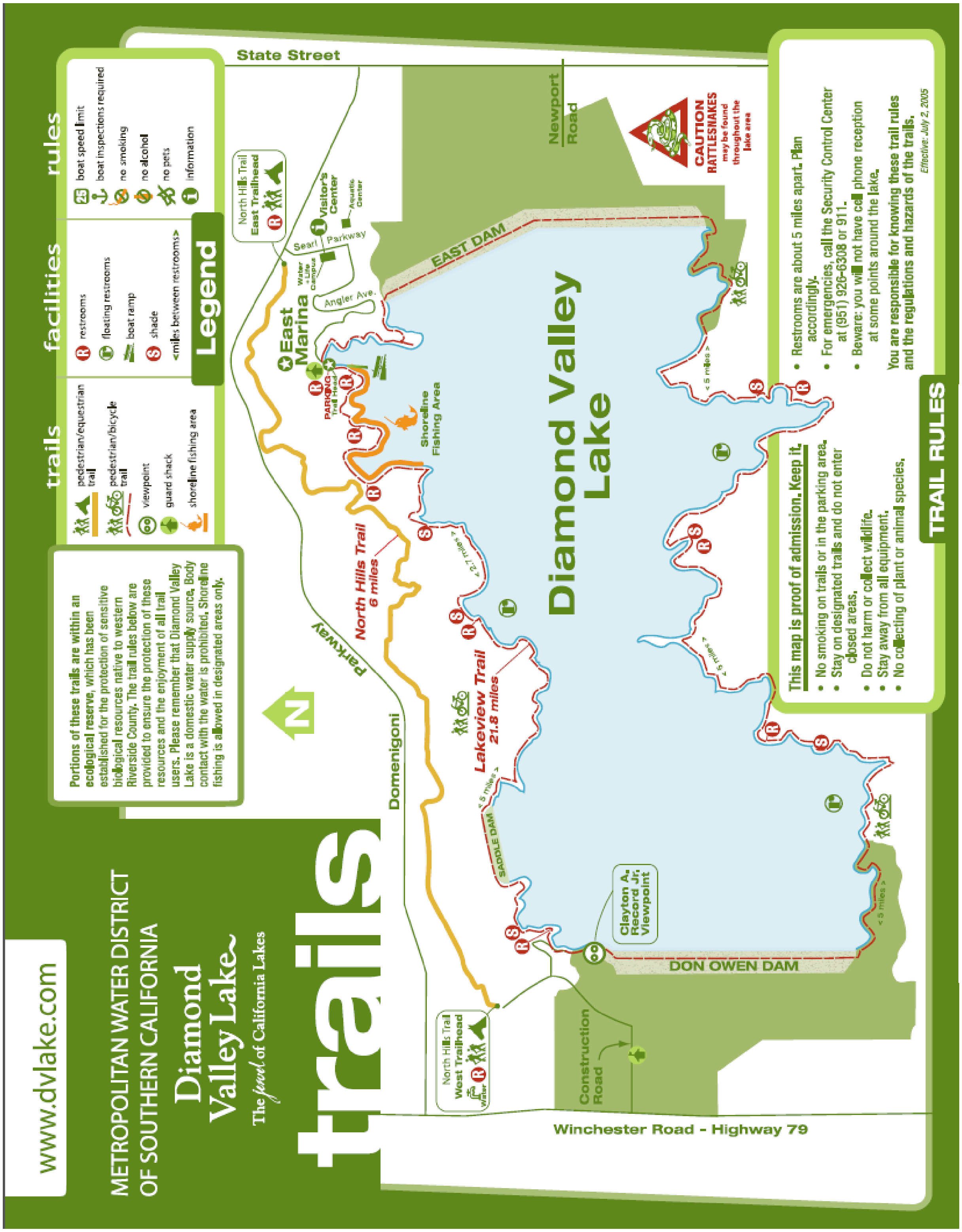


Figure 4-25. Diamond Valley Lake Recreation Facilities [210]

Regulation and Management

Metropolitan submitted the *Recreational Activity Plan for Phase I Diamond Valley Lake Recreation* (RAP) to DDW to operate recreational facilities on and near Diamond Valley Lake. The plan was approved in June 2003. New recreational facilities must be included in the RAP and a letter is sent to DDW with plans, including water quality protection measures. During the current CRWSS reporting period, only one addendum to the RAP was submitted to DDW (**Appendix L**):

- Replacement of Marina Sanitation Facilities (March 26, 2015)

The RAP requires that DVL provide sufficient sanitation facilities based on daily usage and criterion of 70 persons per toilet. Based on anticipated usage, DVL originally provided 13 toilets. Visitor usage has not reached the original anticipated levels and only receives an average of 250 visitors per day on normal weekends and 350 visitors per day on peak weekends (March through June). As approved per the RAP addendum, Metropolitan's permanent modular restroom facility will be equipped with 7 toilets to accommodate the current level of usage.

Metropolitan's Board of Directors approved boating rules for Diamond Valley Lake and Lake Skinner in 2002. Rules and regulations for the recreation area were passed in 2003. Copies of both rules are presented in **Appendix M.**

Combustion-engine watercraft must meet the following criteria, which became effective in October 2003:

- Engines shall use MTBE-free fuel; this has been a decreasing concern since the ban of MTBE in California in January 2004.
- Engines shall be either 4-stroke, 2-stroke equipped with direct fuel injection, or 2-stroke engines that comply with the California Air Resources Control Board 2001 or later model spark-ignition marine engine standard (or USEPA 2006 equivalent).

Compliance with these regulations is enforced, as all boats must undergo a vessel inspection. If the engine is found to be in compliance, a sticker is issued and placed on the boat. This sticker will allow the boat on the lake for subsequent visits without an inspection.

With the discovery of quagga mussels in Lake Mead in 2007, regulations for boat inspections to protect lakes and reservoirs throughout the state have been implemented. Since quagga mussels have not been discovered in Diamond Valley Lake, a specific policy for boat inspections has been implemented for the lake (**Appendix M**). General boating guidelines to reduce the spread of these invasive species include the following:

- Inspection of the boat, trailer, and boating equipment and removal of any visible plants and animals.
- Draining water from the motor, livewell, bilge, and transom wells while on land and before leaving any waterbody. The veligers (mussel larvae) are microscopic and cannot be seen without magnification; therefore, draining all standing water and drying those areas is essential.
- Emptying the bait bucket in disposal containers before leaving the waterbody. Never release live bait into a waterbody or release aquatic animals from one waterbody into another.
- Washing and drying the watercraft, tackle, downriggers, trailer, and other boating equipment to kill harmful species that were not visible at the boat launch.

There has been recent legislative interests on recreational issues at DVL. On January 27, 2015, Senator Jeff Stone introduced Senate Bill 143 proposing to allow body-contact recreation in DVL. SB 143 was opposed by multiple water agencies and did not receive any support on record. As of February 1, 2016, the bill had not moved past the Senate Committee on Environmental Quality. A similar bill (SB 1251) to allow body-contact recreation in DVL had been proposed in 2004 and also did not gain any traction.

County of Riverside General Plan Policies

Riverside County approved a revised General Plan, effective December 15, 2015, which identifies Diamond Valley Lake as a key recreational element to the surrounding areas. The General Plan anticipates that in support of the lake's recreational facilities, other tourist-oriented facilities such as hotels, restaurants, and commercial services will be developed in the future [155]. The San Jacinto Valley Area Plan and the Harvest Valley/Winchester Area Plan, of the General Plan, include policies for the development of the Diamond Valley Lake area as shown in **Table 4-15**.

Table 4-15. Policies for Diamond Valley Lake Policy Area [155]

Reference	Policy
SJVAP 2.1 HVWAP 5.1	Continue cooperating with the Metropolitan Water District and the City of Hemet to encourage the development of a comprehensive program for recreational and support commercial facilities at Diamond Valley Lake.
SJVAP 2.2 HVWAP 5.2	All development shall occur through specific plans. Any specific plans adopted in the Diamond Valley Lake Policy Area shall be classified as Community Development Specific Plans.
SJVAP 2.3 HVWAP 5.3	The Diamond Valley Lake Policy Area, in its entirety, is included in the Highway 79 Policy Area (Circulation Element Policy C 2.6).

Spills

Occurrence in Watershed

Spills and illegal dumping occur infrequently in the Diamond Valley Lake area and there were no incidents reported during the reporting period.

Regulation and Management

As Diamond Valley Lake is located within Riverside County, content from the Lake Mathews watershed *Spills* PCS section applies to the Diamond Valley Lake watershed. Metropolitan adheres to a Hazardous Materials and Waste Emergency Contingency Plan when responding to chemical or hazardous material spills. Metropolitan reports spills to Riverside County's HAZMAT Team and works with the county to direct the cleanup.

Fires

Occurrence in Watershed

The CRWSS 2010 Update discussed the Skinner Fire, which occurred in July 2010, as shown in **Figure 4-26.** Since the 2010 Skinner fire, the vegetation at the site is recovering naturally and no water quality impacts from the fire have been noted. There was one wildfire during this reporting period. The Vista Fire, shown in **Figure 4-26**, was a brush fire that started on August 20, 2012 and burned 500 acres. No prescribed burns have occurred in the Diamond Valley Lake watershed.

Regulation and Management

The *2016 Riverside Unit Pre-Fire Management Plan* described in the *Regulation and Management* discussion within the *Fires* PCS section for the Lake Mathews watershed also applies to Diamond Valley Lake.

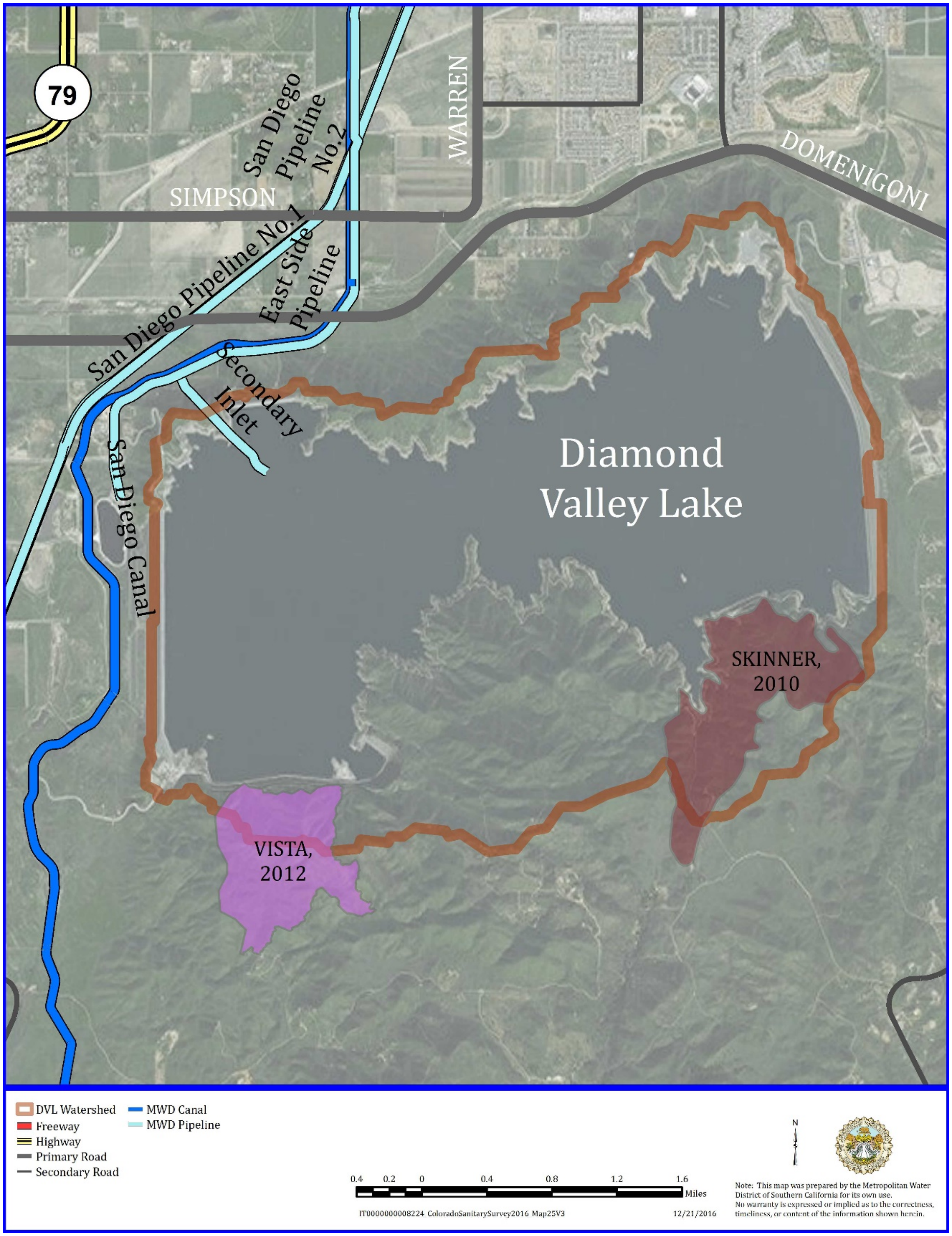


Figure 4-26. Fires within Diamond Valley Lake Watershed, 2005-2015

Summary for Diamond Valley Lake Watershed

The Diamond Valley Lake watershed is unique in that Metropolitan owns and manages the watershed area surrounding the lake. The surrounding property does not have urban development, but the lake is open to public use for fishing, boating, hiking, biking and other non-body contact recreational uses. Since the lake is primarily susceptible to PCSs from these recreational activities, Metropolitan has developed Boating Rules and Regulations for Diamond Valley Lake.

In addition, Metropolitan has adopted a RAP to promote and operate recreational facilities within the Diamond Valley Lake area. This includes the 6-mile long North Hills Trail, which is primarily outside the watershed, but connects two 5-acre trailheads at the northwest and northeast ends of the lake. The watershed's aesthetic and recreational opportunities have appealed to developers interested in expanding recreational uses.

During the reporting period, Metropolitan extended the boat launch ramp, which was exposed under low lake levels due to drought conditions. Metropolitan also began efforts to upgrade the marina restroom facilities. Metropolitan will continue to be involved with recreational planning efforts to minimize the potential for water quality impacts and will amend the RAP as necessary.

Recommendations for Diamond Valley Lake Watershed

Continue to be involved in long-term recreational plans for Diamond Valley Lake

Metropolitan will continue to assess recreational and other development proposals to ensure that any new facilities within the Diamond Valley Lake watershed are consistent with existing permitted activities and are protective of water quality. Metropolitan will update the Recreational Activity Plan, as needed, to reflect recreational improvements.

Lake Skinner Watershed

The PCSs discussed for the Lake Skinner watershed include Erosion, Urban and Stormwater Runoff; Recreation; Spills; Leaking Underground Storage Tanks; Septic Systems; Agriculture; and Fires.

Erosion, Urban and Stormwater Runoff

Occurrence in Watershed

The 51-square mile Lake Skinner watershed is a subwatershed of the Upper Santa Margarita watershed and is drained by three main tributaries. These tributaries are Rawson Creek, Middle Creek, and Tucalota Creek (**Figure 4-27**). Tucalota Creek is the main source of runoff from the watershed entering Lake Skinner. The largest single land use category in the watershed is vacant land, which accounts for 70.7 percent. Ecological Preserves and Sanctuaries accounts for 10.8 percent, agricultural land use 4.3 percent, and residential areas represent 5.6 percent of the watershed. **Figure 4-27** shows the land use distribution in the Lake Skinner watershed. The varied land use in the watershed directly influences the quantity of stormwater runoff and the type of contaminants in the runoff.

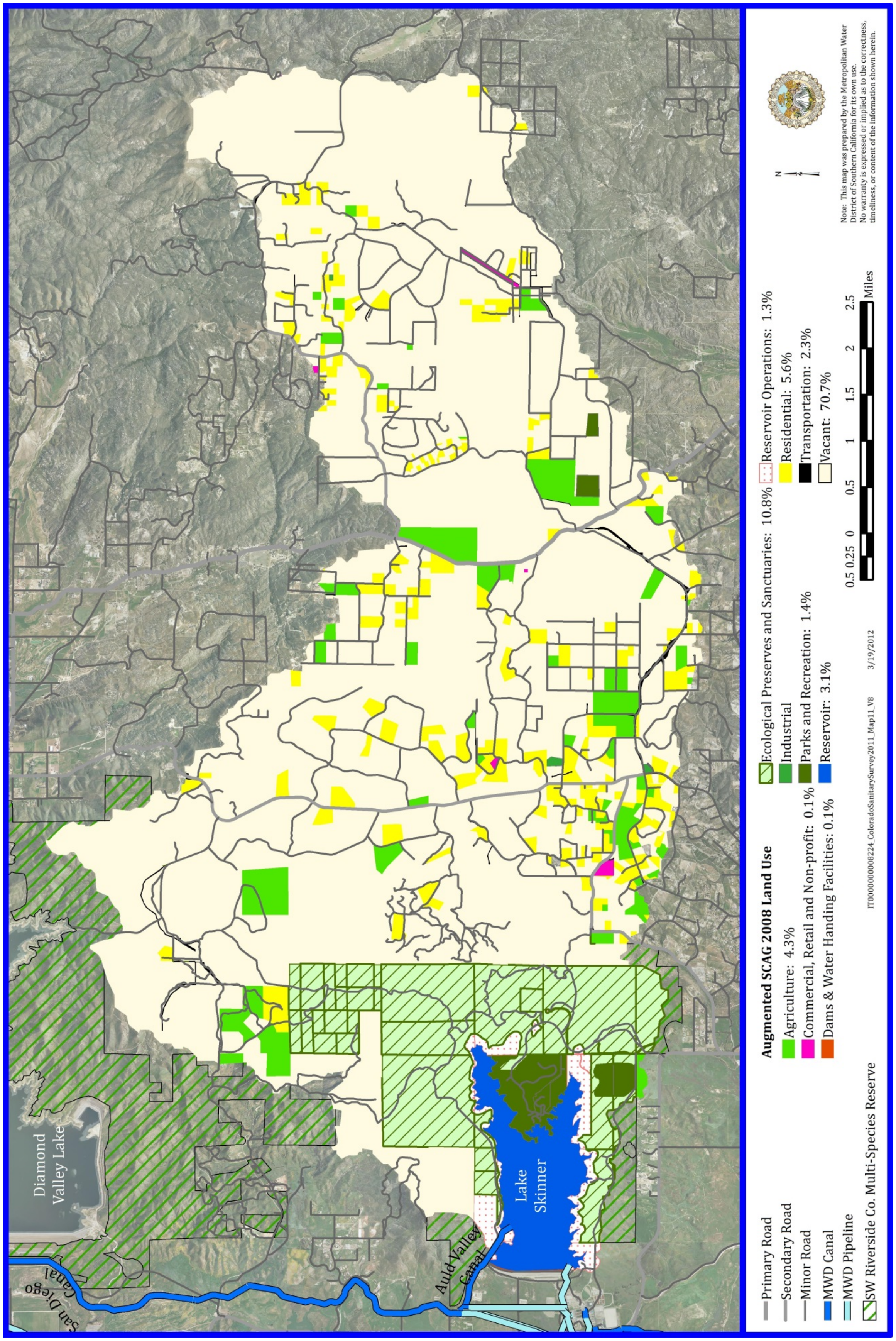


Figure 4-27. Lake Skinner Watershed Land Use

Rawson Creek and Tucalota Creek combine before entering Lake Skinner at the northeast end of the lake. **Figure 4-28** provides rainfall data for the Skinner area and runoff entering Lake Skinner from Tucalota Creek. As is typical of storm events in southern California, the amount of rainfall and the amount of runoff produced for each storm varies significantly from year to year.

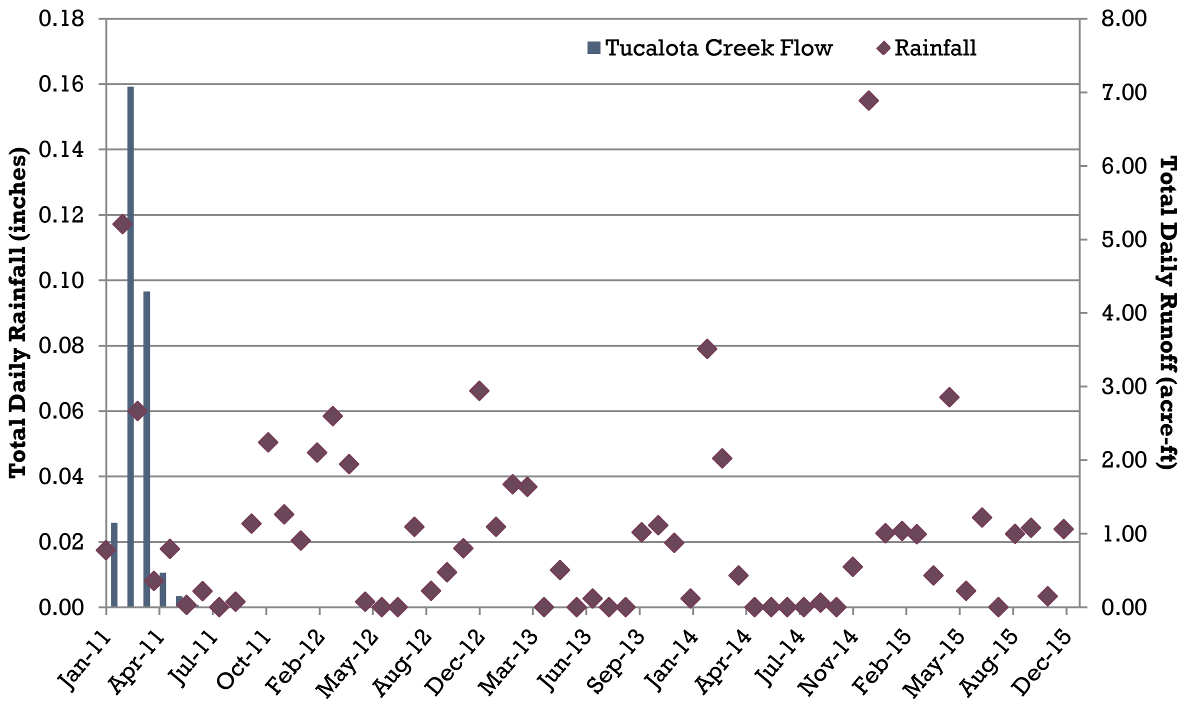


Figure 4-28. Lake Skinner Watershed Rainfall and Runoff from Tucalota Creek

Significant rainfall from large storms or consecutive storm events is required to produce measurable runoff. As shown in **Figure 4-28**, Tucalota Creek infrequently flows into Lake Skinner and the only measurable runoff occurred in early 2011. The area has been under extreme drought conditions over the past five years and has received minimal rainfall. Erosion induced by rain events is influenced by the watershed topography, soil types, and vegetation density. There are many vegetative, flat areas immediately upstream of the lake that provide natural filtration of sediments being carried in the tributaries entering Lake Skinner.

Urban runoff and development is a concern in the Lake Skinner watershed as the watershed is subject to increasing development over time. Metropolitan contacted the Riverside County Transportation and Land Management Agency (RCTLMA) in 2016; however, due to limited county staff resources no new information could be obtained on development for the current reporting period.

As the Lake Skinner watershed is generally rural, there are no MS4 facilities within the watershed. Due to the lack of MS4 facilities, all runoff within the Lake Skinner watershed will drain naturally into a Lake Skinner tributary or percolate into the ground.

Regulation and Management

National Pollution Discharge Elimination System (NPDES) Stormwater Permit

The majority of regulations that govern Lake Skinner watershed activities and land use are the same as those described for the Lake Mathews watershed, *Regulation and Management* discussion for the *Erosion, Urban and Stormwater Runoff* PCS section. Therefore, the regulations discussed below only pertain to the Lake Skinner watershed.

Stormwater discharges from the Diamond Valley Lake and Lake Skinner areas are permitted under the RWQCB-San Diego Region Order No. R9-2004-001: *Waste Discharge Requirements for Discharges of Urban Runoff From the Municipal Separate Storm Sewer Systems (MS4s) Draining the County of Riverside, The City of Murrieta, The City of Temecula and the Riverside County Flood Control and Water Conservation District,* NPDES No. CAS0108766, or the Third-term Santa Margarita Region MS4 Permit. On November 10, 2010, the Third-term permit was reissued as Order No. R9-2010-0016. RCFCWCD is the principal permitee for the General NPDES permit, which covers the Lake Skinner watershed.

On May 8, 2013, RWQCB-San Diego adopted Order No. R9-2013-0001: National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining Watersheds within the San Diego Region. Since the expiration of Order No. R9-2010-0016 on November 10, 2015, the co-permittees were subject to waste discharge requirements under Order No. R9-2013-0001. The co-permittees expressed concerns and legal objections to inclusion in Order No. R9-2013-0001 and on May 10, 2015, the co-permitees submitted a renewal application for Order No. R9-2010-0016, Report of Waste Discharge. The RWQCB-San Diego considered the Report of Waste Discharge, and on November 18, 2015, amended Order No. R9-2013-0001 as Order No. R9-2015-0100 and determined that the Riverside County co-permittees would need to comply with the revised order [156].

The Lake Skinner watershed is a sub-watershed within the Santa Margarita River watershed. In addition to the management plans referenced above, individual SWMPs have been established for the Santa Margarita River watershed. The two plans that are applicable to the Lake Skinner watershed are the *County of Riverside Santa Margarita Region SWMP* [157] and *RCFCWCD SWMP* [158]. Both of these plans describe the specific urban runoff management programs and activities that will be implemented to comply with the requirements of the MS4 permit, as described in the DAMP. The same DAMP and WQMP that governs the Lake Mathews watershed also covers the Lake Skinner watershed. On July 1, 2013, in accordance with Order No. R9-2010-0016, the Riverside County co-permittees also submitted a draft Santa Margarita Region Hydromodification Management Plan to manage increases in runoff discharge rates and durations from priority development projects.

Southwestern Riverside County Multi-Species Reserve

The Southwestern Riverside County Multi-Species Reserve (Reserve), shown in **Figure 4-29**, was established in October 1992 as mitigation for impacts to sensitive species resulting from the creation and operation of Diamond Valley Lake. To this end, Metropolitan developed an MSHCP, which included the establishment of the Reserve, provisions for research and management funding, and a Cooperative Management Agreement between the five agencies with interest in the Reserve: Metropolitan; Riverside County Habitat Conservation Agency; RCRPOSD; California Department of Fish and Wildlife; and USFWS. The Reserve was established by combining the Shipley Reserve and natural lands surrounding both Lake Skinner and Diamond Valley Lake between Hemet and Temecula to create a contiguous reserve. Initially, the Reserve consisted of approximately 9,000 acres; subsequent land acquisitions have increased the Reserve boundary to approximately 13,721 acres (21 square miles). The Reserve contains several different types of native California habitat, including coastal sage scrub, willow riparian and oak woodlands, and grassland. Many plant and animal species call the Reserve home, including more than 16 listed as sensitive, threatened, or endangered species [159].

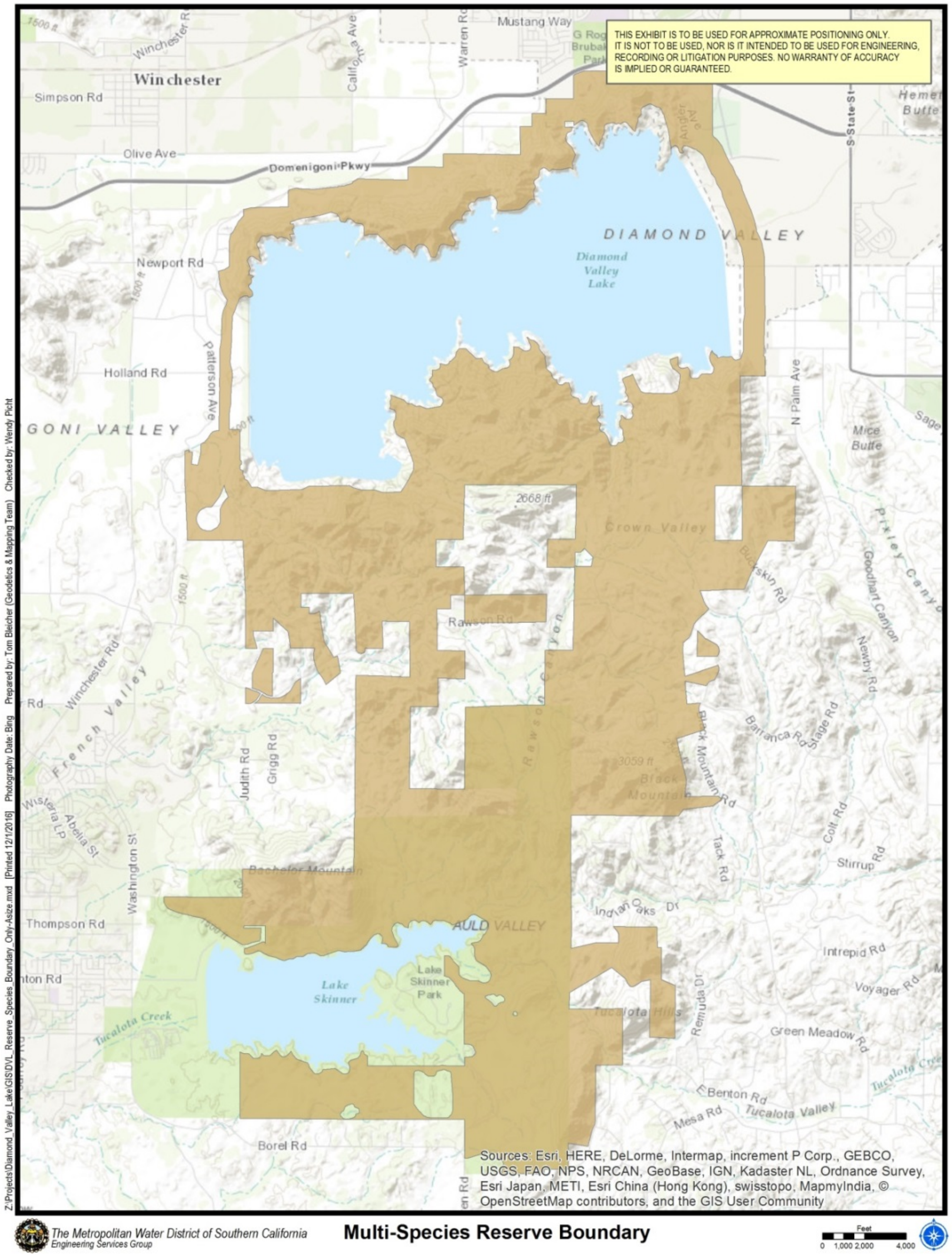


Figure 4-29. Southwest Riverside County Multi-Species Reserve [160]

Lake Skinner Water Quality Protection Plan

A successful proactive approach to managing activities within the Lake Skinner watershed has been to acquire property within the watershed. In 1998, Metropolitan adopted the *Lake Skinner Water Quality Protection Plan*, which provides for the acquisition of lands in the watershed that contribute to meeting the following water quality protection criteria:

1. Potential for the acquisition to result in reduction and/or control of pollution draining directly to Lake Skinner itself or to Lake Skinner via one of its main drainages,
2. Potential to enhance fire management, and
3. Potential to control illegal dumping [161].

There are approximately 1,500 privately owned parcels covering nearly 21,000 acres within the Lake Skinner watershed. The County of Riverside General Plan and zoning regulations allow for residential and equestrian development on these properties, which could cause water quality problems through the introduction of microbial pollutants and nutrients. It is more cost-effective to prevent pollutants from reaching the reservoir by controlling land use development through the acquisition of properties than to install BMP facilities for treating pollutants and preventing them from entering the reservoir.

In April 1999, Metropolitan's Board of Directors appropriated $3,000,000 for the acquisition of real property within the Lake Skinner watershed. As a result, 33 properties totaling 786 acres were purchased for source water protection. The properties are all located within 1½ miles east of the Reserve, and several parcels are adjacent to or include creeks that flow seasonally.

County of Riverside General Plan Policies

The County of Riverside General Plan recognizes that non-point source pollution due to urban stormwater system runoff can result in water quality issues and includes policies to provide local guidance for the protection and maintenance of water quality. The following policies in **Table 4-16** pertain to minimizing impacts from stormwater runoff.

Table 4-16. County of Riverside General Plan Water Quality Policies [162]

Reference	Policy
OS 3.3	Minimize pollutant discharge into storm drainage systems, natural drainages, and aquifers (AI 3)
OS 3.4	Review proposed projects to ensure compliance with the National Pollutant Discharge Elimination System (NPDES) Permits and require them to prepare the necessary Stormwater Pollution Prevention Program (SWPPP). (AI 3)
OS 3.5	Integrate water runoff management within planned infrastructure and facilities such as parks, street medians and public landscaped areas, parking lots, streets, etc. where feasible.
OS 3.6	Design the necessary stormwater detention basins, recharge basins, water quality basins, or similar water capture facilities to protect water-quality. Such facilities should capture and/or treat water before it enters a watercourse. In general, these facilities should not be placed in watercourses, unless no other feasible options are available.
OS 3.7	Where feasible, decrease stormwater runoff by reducing pavement in development areas, reducing dry weather urban runoff, and by incorporating "Low Impact Development," green infrastructure and other Best Management Practice design measures such as permeable parking bays and lots, use of less pavement, bio-filtration, and use of multi-functional open drainage systems, etc. (AI 57, 62)

Studies and Monitoring

Metropolitan staff patrols the Lake Skinner area daily and records Tucalota Creek runoff flow during storm events. Monthly reports are generated identifying the lake's characteristics, such as elevation, storage capacity, precipitation, evaporation, inlet flow, and outlet flow. In addition to flow measurements, water samples are collected during significant runoff events to represent quality of runoff flows into the lake. **Figure 4-28** demonstrates that Tucalota Creek flows into Lake Skinner occur infrequently.

Fallbrook Public Utility District (FPUD), in collaboration with Metropolitan, hired a consultant in November 2009 to perform a hydrologic analysis of the Lake Skinner watershed to estimate inflows to the lake and predict historic and future conditions. A draft report, *Estimating Inflow to Lake Skinner – A Watershed Modeling Study*, was prepared to study the physical characteristics of the Lake Skinner watershed and develop a hydrologic model. However, insufficient data are available to calibrate the model accurately. During the reporting period, FPUD and Metropolitan installed temporary flow gauging and recording stations at Tucalota Creek and Middle Creek, to provide additional data for model calibration. However, no data has been collected due to dry conditions.

Recreation

Occurrence in Watershed

The Lake Skinner Recreation Area includes Lake Skinner, owned by Metropolitan, and the Lake Skinner County Park, which is operated by RCRPOSD. The county park consists of 287 developed campsites for both tent and RV campers. There are 234 sites with full hook-ups (water, sewer, and electricity), 16 sites with water and electricity, and 41 sites with water only. Auxiliary recreational facilities include a dump station, restrooms, picnic areas, a boat launch, boat rentals, shoreline fishing, fish cleaning facilities, equestrian camping areas, a ranger's residence, a general store with café, and a fueling station. Body contact recreation is not allowed in Lake Skinner. The average number of visitors to the Lake Skinner County Park is over 300,000 annually, and the maximum number of visitors per day is 9,000. The general layout of the Lake Skinner Recreational area, as found on the Riverside County Parks www.rivcoparks.org website, is shown in **Figure 4-30**.

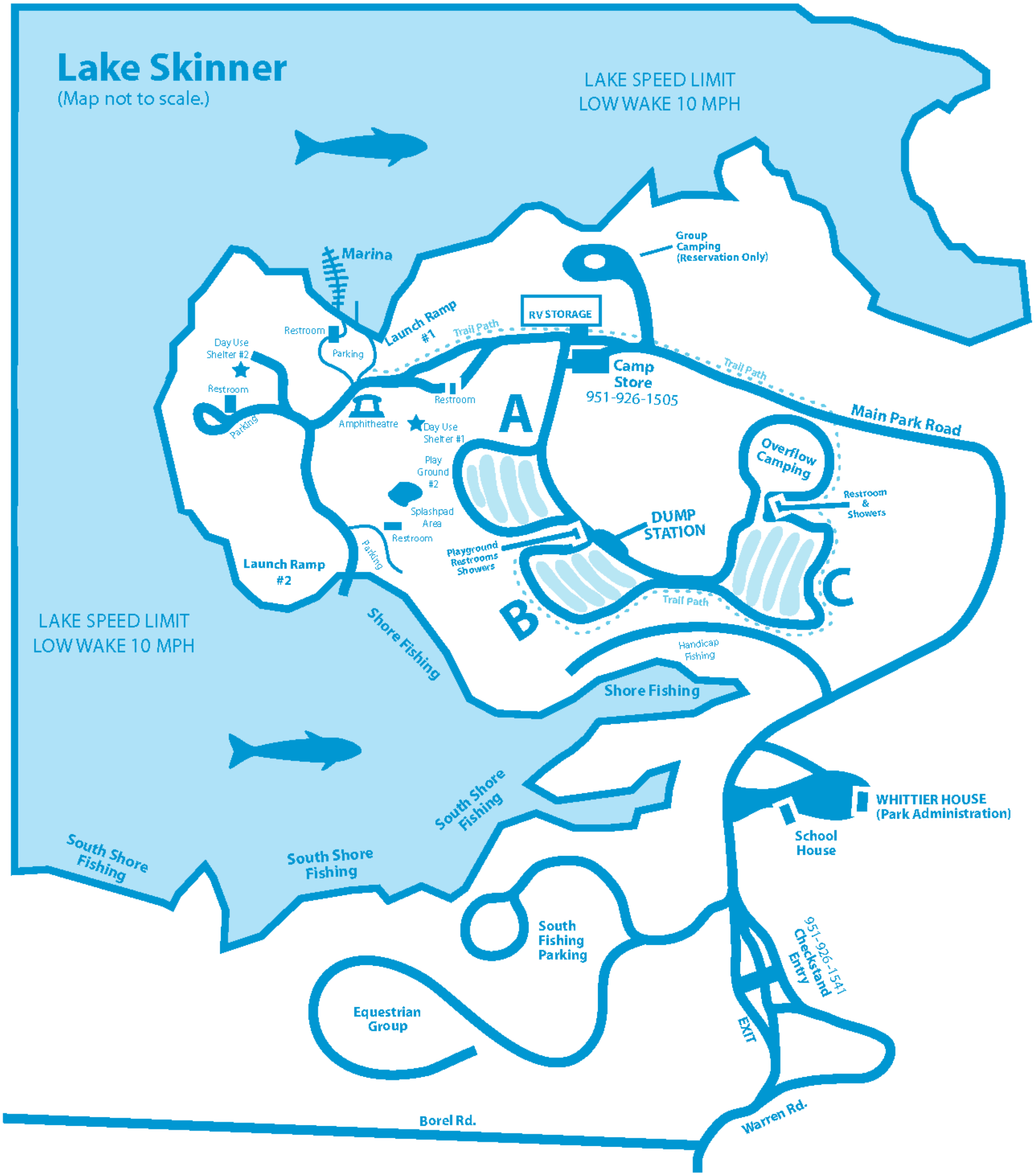


Figure 4-30. Lake Skinner Recreation Area [163]

Recreational facilities include an amphitheater, and a 6,000-square foot splash pad—a flat area with interactive water features for children. Approximately 1.5 miles of multi-purpose trails, designated for biking and pedestrian uses were added to existing trails in the developed areas of the park to create a loop. During the reporting period, RCRPOSD completed improvements to the Alamos School House, shown in **Figure 4-30**, which serves a wildlife education center. RCRPOSD also installed pole fencing around the special event parking lot, resurfaced the Campground C entrance road, and completed repairs and improvements to the Ramp 1 dock.

The Reserve has a 4½ mile (one-way) hiking and equestrian trail that passes through a portion of the watershed. The trail is open to equestrian riding from May 20 through November 30. Riders must first sign in and pay a day-use fee at the park kiosk. Minimal equestrian trail use occurred during the reporting period. As shown in **Figure 4-30**, the equestrian trail begins at a horse camp, proceeds east and then north. Rainwater that falls on the trail drains away from Lake Skinner. There is a portable restroom at the end of the trail, which is maintained by RCRPOSD.

Overnight equestrian camping for groups of up to 20 users are allowed at the horse camp with reservations made through the Reserve. Usually, there are less than two groups per year using the horse camp. The location of the horse camp is located outside of the Lake Skinner watershed [164]. Manure pickup from the corrals at the horse camp is the responsibility of the RCRPOSD staff.

A few private campgrounds are located within the Lake Skinner watershed. The Indian Oaks Trailer Ranch is located near East Benton Road in Temecula. The site is 21 acres and offers camping, swimming, fishing and hiking. The campground consists of 60 sewered sites for RVs, restrooms, laundry, propane, dump station, snack bar, and paddleboat rentals. The swim area is an impoundment of Tucalota Creek and is fed by natural springs.

The Tucalota Springs RV Park is located along East Benton Road in Sage. Recreational uses include camping, fishing, swimming, and hiking. The trails are for biking and pedestrian use only. The park has a total of 80 sewered RV spaces and 12 tent areas, public restrooms with showers, laundry facilities, a small catch and release pond, a swimming pool, and a dump station.

Special Events

Special events held regularly at the Lake Skinner County Park include the American Heart Association Heart Walk, the Solar Cup, the Temecula Balloon and Wine Festival, and a series of summer events, which occur annually. Summer events include a Concert in the Park series and a Movie in the Park series. There are also one-time events such as the Lightning in a Bottle music and arts festival, which was held July 11–15, 2013. The Lightning in a Bottle event drew 15,000 people to Lake Skinner each day and occupied 285 campsites with full hook-ups and 1,970 primitive campsites. Water quality impacts were minimized with extensive patrolling of the area to ensure that the event organizer complied with the event business plan requirements, including prevention of body-contact with the lake and requirements for appropriate waste management.

Figure 4-31. Solar Cup at Lake Skinner, 2015

The Solar Cup is an education program sponsored by Metropolitan and its member agencies in which high school teams, totaling over 700 students, build and race solar-powered boats at Lake Skinner as shown in **Figure 4-31**. The races occur over a two-day period. Students learn about conservation of natural resources, electrical and mechanical engineering, and problem solving. Solar Cup began in 2003 with eight high school teams and grew to 41 teams in 2015.

The Temecula Balloon and Wine Festival has been held at Lake Skinner since 1991. It is a three-day event consisting of live musical entertainment, food, wine tasting, children's fair, arts and crafts, and other commercial exhibits. Balloon rides for guests and a balloon launch, where up to 50 balloons get underway, are main attractions of the event. According to the 2005 entry permit between Metropolitan and the RCRPOSD, ticket sales are limited to a maximum of 75,000 general admission tickets over the three-day event.

Regulation and Management

RCRPOSD manages the Lake Skinner County Park and all park amenities through a lease with Metropolitan. A 25-year lease was signed between Metropolitan and RCRPOSD in 2005. Portable toilets located around the lake are checked daily and pumped weekly, the fish cleaning station is serviced once per day, and litter control occurs two to three times a week at a minimum. Higher levels of service for litter control are conducted during holidays and special events.

Riverside County Ordinance 328: *Prescribing Rules and Regulations for the Government of County or District Owned or Operated Parks and Open-Space Areas* specifies unlawful activities for any person to commit within the limits of any park or open space area belonging to or operated by Riverside County. The following water quality related excerpts are from Ordinance 328 [165]:

- It shall be unlawful to own, or have custody, possession, or control of any animal and to fail to collect, pick up, and remove all fecal matter or debris promptly after it has been deposited by the animal
- It shall be unlawful to dispose of dishwater or other waste liquids, or dispose of any garbage, empty container, or other solid waste material other than in receptacles or other facilities provided for such disposal
- It shall be unlawful to urinate or defecate in other than a permanent or temporary restroom

Regular patrols around the perimeter of Lake Skinner are conducted on a daily basis by Metropolitan staff.

For the recreation areas, control of mosquitoes with Permanone® or Scourge® 4+12 (resmethrin) has been approved by Metropolitan and DDW. The requirements are for the application to occur 100–200 feet from the water's edge. After application, Metropolitan must be notified of the amount of pesticide applied and the general area of application.

Boating Regulations

As indicated in the *Recreation* PCS section for the *Diamond Valley Lake* watershed, rules and regulations for the Diamond Valley Lake and Lake Skinner recreation areas were passed in 2003 (**Appendix M**).

Also described in the Diamond Valley Lake *Recreation* PCS, the Colorado River system has been infested with quagga mussels. Quagga mussels are in Lake Skinner, and efforts are being made to avoid their spread to uninfested water bodies in California. **Figure 4-32** is an example of the signs present at Lake Skinner to educate and remind the public of the potential to spread this invasive species.

Figure 4-32. Quagga Mussel Warning Sign at Lake Skinner

Special Event Agreements

The RCRPOSD and Metropolitan sign a concession agreement for the Solar Cup event every year, where Metropolitan is the concessionaire. The only requirement related to water quality is that Metropolitan should ensure that the location and surrounding areas are immediately cleared of all trash, debris, or other materials related to the activity upon conclusion of the activity.

To coordinate activities for the Temecula Balloon and Wine Festival, an entry permit between the RCRPOSD and Metropolitan was developed every year through 2005. The 2005 entry permit specifies a number of requirements to protect water quality. Since 2005, Metropolitan has not issued a separate entry permit for the annual event, rather, the overall lease signed in 2005 between RCRPOSD and Metropolitan addresses water quality and related controls as follows:

- No animals are allowed on the festival grounds without prior written authorization from Metropolitan
- RCRPOSD shall submit a plan to Metropolitan to protect the lake from potential contamination from parking lot or sewage spills
- RCRPOSD shall immediately notify Metropolitan if any potential water quality issues are noticed or reported by or to the RCRPOSD

- RCRPOSD shall place signs at the entrance gate and in the parking area stating Lake Skinner is a drinking water supply reservoir and the importance of not contaminating the lake

RCRPOSD is also responsible for shoreline and campground patrol. A vendor is contracted for trash receptacles and trash removal. Sufficient portable restroom facilities are installed by a local waste company, and they are allowed to dispose of sewage from the portable restrooms into evaporation ponds outside of the watershed. In order to prevent the release of hazardous or toxic chemicals, chemical compatible tarps will be placed under any holding vessel of gas or diesel fuel and berms will be placed around the perimeter. In addition, chemical and soil absorbents will be kept nearby.

Animals are not allowed within the festival area, and horses belonging to the Riverside Sheriff's Posse will stay a minimum of 300 feet from the water's edge. Any droppings from horses will be disposed of properly within 48 hours.

Spills

Occurrence in Watershed

Spills and illegal dumping occur infrequently in the Lake Skinner area and there were no incidents reported during the current CRWSS reporting period. Waste from illegal dumping can accumulate and potentially pollute stormwater runoff into Lake Skinner or its tributaries. As documented in previous watershed sanitary surveys for the Colorado River, illegal dumping of toxics associated with the manufacture of methamphetamines has occurred. According to Metropolitan staff conducting regular patrols around Lake Skinner, the problem of illegal dumping has decreased in recent years.

Regulation and Management

As Lake Skinner is located within Riverside County, content from the Lake Mathews watershed S*pills* PCS section applies to Lake Skinner watershed. Metropolitan adheres to a Hazardous Materials and Waste Emergency Contingency Plan when responding to chemical or hazardous material spills. Metropolitan reports spills to Riverside County's HAZMAT Team and works with the county to direct the cleanup.

Leaking Underground Storage Tanks

Occurrence in Watershed

Table 4-17 shows there is only one LUST in the area near Lake Skinner, per data available on the SWRCB's GeoTracker website. The site is located on Metropolitan's property near Lake Skinner and was closed on February 17, 2012.

Table 4-17. Summary of LUST Information for the Lake Skinner Watershed

Site ID	Report Date	Facility Name	Address	Distance to Lake Skinner (feet)	Contaminant	Status
T0606511682	11/13/2002	MWD Lake Skinner Work Area 7	33740 Borel Rd. Winchester, CA	1500	Gasoline and Diesel	Closed - As of 2/17/2012 Three USTs removed in 1991. Soil and groundwater treatment completed in 2010.

Regulation and Management

RCDEH manages the remediation of LUST sites in Riverside County. RCDEH also issues permits for tanks that will store hazardous materials. It is required that all unauthorized releases by USTs are reported to RCDEH. RCDEH works closely with the RWQCB-Santa Ana Region and San Diego Region on many LUST sites, but RCDEH is typically the lead agency.

Studies and Monitoring

In September 2002, during retrofit of the existing gasoline underground storage facilities at Metropolitan's Lake Skinner facility, a water sample was collected that indicated gasoline contamination. In February 2003, Metropolitan was required by RCDEH to complete a work plan for additional site assessment to determine the extent of soil contamination and possible impacts to groundwater. Monitoring wells were installed and sampled for several years. On April 23, 2009, a revised work plan for Interim Remedial Action Plan (IRAP) was submitted and approved by the RWQCB. The IRAP consisted of the installation of oxygen release compound socks in three monitoring wells to aid natural biological degradation. As of June 2011, MTBE has been detected in some monitoring well samples, but BTEX was not detected in any of the samples. On November 1, 2011, Metropolitan submitted a Site Closure Request Report, which documented minor levels of total petroleum hydrocarbons remaining in soil and groundwater [166]. RWQCB-San Diego Region confirmed closure of the site investigation and issued a No Further Action on February 17, 2012.

Septic Systems

Occurrence in Watershed

There is no centralized sewer system to serve residences in the Lake Skinner watershed; therefore, there are a number of individual septic systems in the watershed. As reported in the CRWSS 2010 Update, there were 127 active septic systems in the Diamond Valley Lake and Lake Skinner watersheds per the RCDEH database [147]. Metropolitan contacted RCDEH in 2016 to obtain an update on the number of septic system; however, due to limited staff resources, updated information could not be obtained for the current reporting period.

Within the Lake Skinner County Park, domestic sewage from 5 septic tanks and 16 portable restrooms is discharged to a 0.5-acre mechanically aerated oxidation pond. Sewage from the RV dump station is also pumped to the oxidation pond. Effluent from the oxidation pond is discharged to evaporation ponds with a total surface area of 4.25 acres. The bottom and sides of the evaporation pond are sealed to prevent percolation.

Wastewater at the Indian Oaks Trailer Ranch is treated and disposed of via seven 1,500-gallon septic tanks and one leach field. An impervious tank is provided for the RV dump station. The tank is not connected to the septic system and is pumped as needed. Wastewater at the Tucalota Springs RV Park is treated and disposed of via four septic tanks and approximately 12,500 gallons per day of septic tank effluent is produced.

Failed Systems

Information on the occurrence of failed septic systems was obtained from RCDEH. Information was only available through 2007 for the CRWSS 2010 Update. Therefore, **Table 4-18** contains information on failed systems from 2008 to 2015 [167]. RCDEH records all sewage complaints and follows up with a thorough investigation and appropriate response activities to resolve issues in a timely manner. Based on the records, RCDEH continues to oversee and respond to recurring issue with one of the properties, located in Hemet over 7 miles east from the lake.

Records indicate that, for all the failed systems reported in **Table 4-18**, the wastewater discharge appeared to have been confined to that specific property. None of them appeared to have flowed into the street or into a natural watercourse. However, if rain occurred at the same time, it is possible some sewage could have washed off into the watershed. Daily rainfall records were examined for the dates in **Figure 4-28**, rain did not coincide with any failed septic system. Over the period from 2008 to 2015, Tucalota Creek flowed into Lake Skinner infrequently in 2008, 2010, and 2011.

Table 4-18. Failed Septic Systems for Properties in Lake Skinner Watershed, 2008–2015

Complaint No.	Location	Date	Complaint	Date Case Abated
CO0025172	34102 Stage Rd, Temecula	6/23/2008	Open pit dug to dispose of waste on motor home on property.	7/8/2008
CO0027826	32841 Red Mountain Rd, Hemet	12/1/2008	Sewage spill over yard due to unavailable septic system.	12/10/2008
CO0028494	37455 Quarter Valley Rd. Temecula	1/30/2009	Sewage/trash on property.	2/25/2009
CO0029815	40950 Reseda Springs, Rd., Hemet	5/5/2009	Illicit construction of septic system and possible sewage leakage from a buried 55-gallon drum.	5/18/2009
CO0044247	31111 Red Mountain Road, Hemet	11/20/2012	Landlords unresponsive to tenant complaints of possible sewage backup issue.	2/28/2013
CO0045340	44568 Oak Glen, Hemet	3/4/2013	Illicit discharge connection of septic system to local stream.	7/3/2013
CO0049186	30561 Red Mountain Rd, Hemet	2/26/2014	Drain line from property discharging liquid over porch of home.	3/25/2014
CO0051896	38880 Green Meadow Rd, Temecula	11/6/2014	Sewage seepage observed on property ground.	12/23/2014
CO0052281	31111 Red Mountain Road, Hemet	12/29/2014	10-acre property with multiple homes and no septic tanks. Sewage released daily over property. One area is constantly over flowing with owners attempting to dig and cover the waste.	5/31/2016
CO0052341	31111 Red Mountain Rd, Hemet	1/7/2015	Sewage on ground.	3/4/2015
CO0053075	38880 Green Meadow Rd, Temecula	3/26/2015	Sewage odor coming from the property.	4/3/2015
CO0053428	38880 Green Meadow Rd, Temecula	4/28/2015	Wet patch over a leach field, two days after tenants occupy property.	11/25/2015
CO0053437	40025 Hanover Lane, Temecula	4/28/2015	Greywater from house is draining onto ground in backyard.	6/23/2015
CO0054447	37701 Warren Rd., Winchester	7/22/2015	San Diego Regional Water Quality Control Board incorrectly contacted to confirm that the system was under proper permit.	8/12/2015

Regulation and Management

The disposal of up to 0.6 million gallons per day of domestic wastewater via evaporation ponds at the Lake Skinner County Park is regulated by the RWQCB-San Diego Region under Order No. 95-18. Order No. 95-18 states that all waste treatment, containment, and disposal facilities shall be protected against 100-year peak stream flows. In addition, they are protected against erosion and overland runoff resulting from a 100-year frequency 24-hour storm.

Order No. 95-18 requires that effluent from the oxidation pond be sampled semiannually for total dissolved solids, pH, surfactants, and biweekly for dissolved oxygen. Also, the volume of septage pumped from the six septic tanks and the volume of sewage pumped from the 8 portable restrooms is reported semiannually to the RWQCB.

The subsurface disposal of 7,500 gallons per day of septic tank effluent at the Indian Oaks Trailer Ranch is regulated under Order No. 88-24 by the RWQCB-San Diego Region. Order No. 88-24 states that all waste treatment and disposal facilities shall be protected against 100-year peak stream flows as well as erosion and overland runoff resulting from a 100-year frequency 24-hour storm. Order No. 88-24 requires the submittal of an annual report, which should contain water consumption and visitor usage as well as a log of the type, quantity, and manner of disposal of wastes generated by the facility.

The subsurface disposal of 12,500 gallons per day of septic tank effluent at the Tucalota Springs RV Park is regulated under Order No. 95-84 by the RWQCB-San Diego Region. Order No. 95-84 requires sampling of the septic tank effluent once every four years for pH, total dissolved solids, total nitrogen, and surfactants. An annual report is also required to update park information (number of campsites, number of septic system, and number of visitors) and information regarding septic tank inspection.

County of Riverside General Plan Policies

Riverside County approved a revised General Plan, effective December 15, 2015. The Lake Skinner watershed is covered under the Riverside Extended Mountain Area Plan (REMAP) and the Southwest Area Plan of the General Plan. The eastern part of the watershed, which has less development is covered under the REMAP, which focuses on preserving less dense development while accommodating future growth. The REMAP includes policies to support public services for community and rural development including sewage improvement policies as described in **Table 4-19.**

Table 4-19. Sewage Policies for Lake Skinner Watershed under Riverside Extended Mountain Area Plan [168]

Reference	Policy
REMAP 4.7	Require sewage collection and treatment systems in present and future community development areas in order to protect water quality and to prevent pollution of streams.
REMAP 4.8	Meet or exceed sewage disposal standards of the Riverside County Health Department and the appropriate California Regional Water Quality Control Board (RWQCB). Three RWQCBs have jurisdiction in the REMAP planning area: the lower Colorado River Basin RWQCB, for the Colorado River Watershed; the Santa Ana RWQCB for the Santa Ana-San Jacinto River Watersheds; and the San Diego RWQCB for the Santa Margarita River Watershed.
REMAP 4.9	Require Community Development land uses with lots smaller than one-half acre to be connected to a community sewer system if the collection system has been extended to the site or to contiguous development and sufficient capacity is available. Promote connection by other development to the extent feasible. Promote construction of sewer facilities for community development projects.

Reference	Policy
REMAP 4.10	Prohibit development, which will rely on a community sewer if that system is over-capacity. If a land division is filed that proposes density of two or more lots per acre and if there is an implementation program for the wet sewer system that would serve the area within at least five years, the installation of a dry sewer system may be required.
REMAP 4.19	Require development not on community sewers to adequately dispose of sewage so that it will not harm community health or the environment.

Agriculture

Occurrence in Watershed

The majority of residences within the Lake Skinner watershed are ranches or hobby farms. Of the 32,300 acres within the watershed, 8,003 acres are zoned as residential agricultural, which allows for the noncommercial keeping of horses, cattle, sheep, and goats. Agricultural-related activities in other areas of the watershed include commercial equestrian facilities and crops. There are no poultry farms, dairies, or hog ranches in the watershed [169] .

Equestrian Properties

Commercial equestrian facilities are managed as a for-profit business and refer to horse farms where horses are bred, raised, and sold and to centers that offer horse boarding, training lessons, and other public equestrian uses. In contrast, hobby farms and ranches, with horses or other farm animals, are non-commercial facilities managed by private residences that are primarily operated for recreational use and not necessarily for profit. Hobby farms are also small-scale agricultural lands where operator's raise farm animals or grow crops for sustainability, but may yield a small profit from selling livestock or crops.

From past field visits, Metropolitan has noted that Tucalota Creek has the highest number of horse properties compared to Middle and Rawson creeks. Horse properties near Tucalota Creek are concentrated along Benton Road and Mesa Road in the southwest area of the watershed, east of the Reserve area [170].

The proximity of the creek to the various pen areas, as well as poor housekeeping practices, could be noted at many of the properties. Tucalota Creek appears to run directly through some of the properties. In addition, several of the residences along Tucalota Creek have made impoundments within the main channel of the creek. The specific purposes of the impoundments are unknown [171].

Pesticide Use

There are no row crops presently grown in the watershed. Approximately 300 acres have olive trees that are used for nursery stock. Pesticides are used for the treatment of individual trees, if needed, the day before they are shipped to buyers. The Riverside County Agricultural Commissioner's Office indicated that no area pesticide spraying of olive trees has been done in the past 20 years. Therefore, the pesticide use associated with these parcels is minimal.

Non-Native Vegetation Management

In addition to utilizing prescribed burns, herbicides, and mechanical means (i.e., mowing) to control non-native grasses in the Reserve, sheep grazing is also used. In late 2009, the Reserve coordinated with Metropolitan to conduct a pilot sheep-grazing program; 100 sheep were delivered to the Crown Valley area of the Reserve (northern edge of the Lake Skinner watershed boundary) on June 10, 2010. The pilot grazing area was 50 acres located within the Reserve on the northwest corner of Crown Valley Road and North Shipley Road. The sheep were on the 50-acre grazing plot for 43 days. Empirical observation at the time of removing the sheep indicated the target goals of habitat enhancement had been achieved.

During the reporting period, Metropolitan continued to approve sheep grazing on a case-by-case basis and allowed for an increase in the number of sheep. Due to dry conditions with no rain in forecast, Metropolitan also allowed for sheep grazing to occur during the rainy season, prior to May 1. **Table 4-20** summarizes the grazing activity during the reporting period. **Figure 4-33** shows 600 sheep being delivered to the Crown Valley Area on March 28, 2013 and **Figure 4-34** shows a straw wattle placed across a swale in the Crown Valley of the watershed to control stormwater runoff. There were no violations to the approved water quality protection criteria for each event. Metropolitan was not able to collect water quality samples since there was no runoff during and following grazing periods.

Table 4-20. Grazing Activity at Southwestern Riverside County Multi-Species Reserve, 2011–2015 [172]

Grazing Start Date	Grazing End Date	Locations	# of Sheep	Graze Area
March 28, 2013	June 3, 2013	Three zones in Crown Valley	600	300 acres
April 19, 2014	June 7, 2014	Three zones in Crown Valley	1,000	300 acres

Figure 4-33. Grazing Sheep Delivered to Crown Valley Area, March 28, 2013 [172]

Figure 4-34. Swale Protection from Grazing Activity, May 2013 [172]

Regulation and Management

As discussed in the *Lake Mathews Agriculture*, DDW granted Metropolitan approval to use AquaMaster® for vegetation control along the Colorado River Aqueduct, Lake Mathews, and Lake Skinner. Metropolitan did not apply AquaMaster® herbicide during the reporting period.

While there are large domesticated animals (e.g., cattle, horses, sheep, goats) on residential ranch land and a few orchards in the Lake Skinner watershed, none of the activities are required to be regulated by Riverside County. For activities that occur on Metropolitan's property, mutually beneficial agreements are developed to manage activities, as was done to allow sheep grazing.

Metropolitan approved use of sheep grazing as a vegetative management tool (as opposed to grazing of other livestock such as cattle, goats, etc.) with specific BMPs. The BMPs are listed below:

- Grazing site selection should maximize the distance from lakes and tributaries to the greatest extent possible and at no time shall be located within the protection zones. Protection zones are defined as those areas within 400 feet from reservoir shorelines and primary stream boundaries, 200 feet from smaller tributaries, and 2,500 feet from the raw water intake (i.e., reservoir outlet tower)
- Buffers are to be in place to mitigate site runoff to downstream waterbodies
- Only adult sheep shall be allowed to graze within the watershed; lambing or pregnant sheep shall not be permitted within grazing areas
- Sheep should be rotated within a grazing area to minimize localized fecal deposition, and shall only remain within a specified grazing area for a period of up to three months
- Fencing or other appropriate barriers shall be utilized to restrict movement of sheep outside specified areas, this shall include both nighttime corrals, as well as confinement of the overall grazing area to ensure sheep remain within the designated areas
- Sheep shall not be allowed to graze on Reserve lands within Metropolitan watersheds during the rainy season; grazing shall be permitted within the watershed only between May 1 and November 30

On October 10, 2007, the San Diego RWQCB adopted Conditional Waiver No. 4 for Discharge from Agricultural and Nursery Operations (Order No. R9-2007-0104). This waiver contains specific regulatory requirements that must be observed by all commercial growers in the San Diego region that employ irrigation. Commercial growers must enroll in the program, allow inspection by the RWQCB, and conduct one year of water quality monitoring. Enrollment was required by January 1, 2011, and monitoring was to be completed by December 31, 2012. As required, monitoring reports were submitted to San Diego RWQCB in 2013 by five monitoring groups. The San Diego Region Irrigated Lands Group and Upper Santa Margarita Irrigated Lands Group encompass the Lake Skinner watershed and other hydrologic areas. However, monitoring was not conducted in the Lake Skinner Watershed.

Order No. R9-2007-0104 expired in February 2014 and San Diego RWQCB will be establishing general waste discharge requirements for discharges from commercial agricultural operations under two tentative general waste discharge requirements, currently under public review:

- Tentative Order No. R9-2016-0004, General Waste Discharge Requirements for Discharges from Commercial Agricultural Operations for Dischargers that are Members of a Third-Party Group in the San Diego Region (Third Party General Order).
- Tentative Order No. R9-2016-0005, General Waste Discharge Requirements for Discharges from Commercial Agricultural Operations for Dischargers Not Participating in a Third-Party Group in the San Diego Region (Individual General Order).

The Tentative General Orders will require agricultural operations to implement best management practices to reduce or eliminate polluted runoff such as proper storage of agricultural chemicals, installation of vegetative buffers, application of fertilizers at agronomic rates and irrigation management [173]. In addition, the Tentative General Orders specify effluent limitations, monitoring requirements, development of water quality protection plans, and development of water quality restoration program plans if surface water quality benchmarks are exceeded.

The Tentative General Orders are anticipated for adoption on November 9, 2016 [174]. Metropolitan will track the future activities of this program if water quality monitoring is eventually conducted in the Santa Margarita/Lake Skinner watershed.

Fires

Occurrence in Watershed

The Riverside County General Plan has mapped wildfire susceptibility in the Southwest Area Plan, which includes the Lake Skinner watershed. The Lake Skinner watershed is predominantly classified as very high wildfire susceptibility, with a few areas classified as moderate. As shown in **Table 4-21** and **Figure 4-35**, there have been ten fires in the watershed during the reporting period. The CRWSS 2010 Update discussed the more significant fires—the 2006 Skinner Fire and the 2010 Skinner Fire—and reported that the fires did not impact Lake Skinner. Between 2011 and 2015, there were four small wildfires that did not have an impact on Lake Skinner. The larger fire of the four, the Sabina Fire, started on July 24, 2014 and burned approximately 78 acres in a semi-rural area south of Hemet, CA.

Table 4-21. Wildfires within the Lake Skinner Watershed, 2005-2015

Fire Name	Year	Burned Area (acres)
Bella Fire	2005	199
Borel Fire	2005	105
Oak 2 Fire	2006	283
Skinner Fire*	2006	317
Saddle Fire	2010	79
Skinner Fire	2010	522
Wayman Fire	2011	53
Red Fire	2012	46
Taffle Fire	2012	5
Sabina Fire	2014	78

* Fire information provided by CAL FIRE; fire map locations are not available. [175]

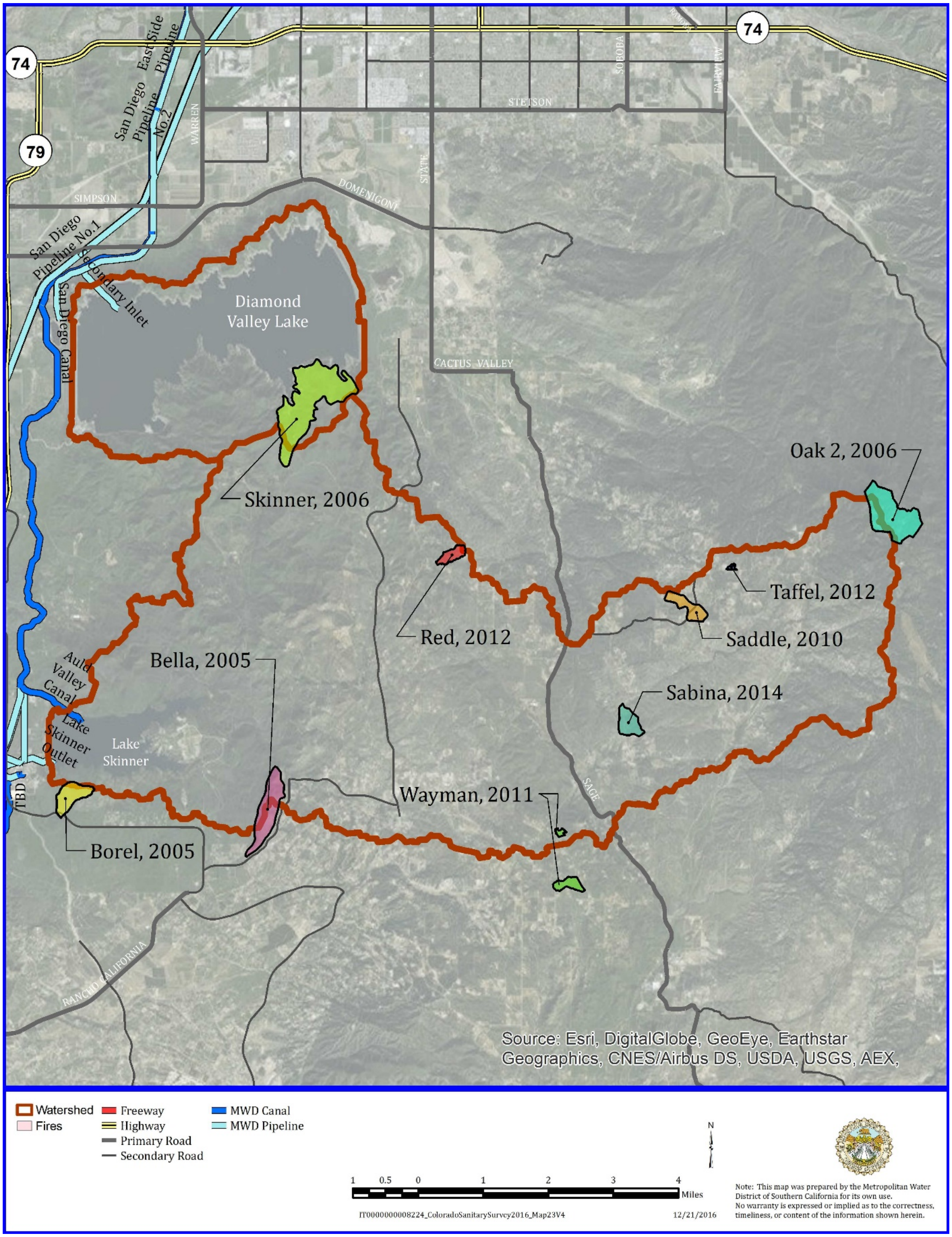


Figure 4-35. Lake Skinner Watershed Fires, 2005-2015

Tamarisk Pile Burning

The Reserve has a tamarisk eradication program as the presence of tamarisk causes many problems including 1) reduction of groundwater availability, 2) increased soil salinity, 3) increased fire frequency, 4) displacement of native vegetation, and 5) reduction of wildlife diversity. Due to the vegetative resprouting nature of the plant, once tamarisk is cut it must be burned or removed to prevent resprouting.

Burning tamarisk is the preferred disposal method for clippings in locations where manual removal would be difficult, impractical, and cause unnecessary harm to sensitive Reserve habitat. Tamarisk ash must be removed since runoff can wash it into source waters and impact water quality, similar to wildfires.

Non-Native Vegetation Control

Prescribed burns in addition to the use of herbicides and sheep grazing are also utilized to control the density of non-native grasses. Non-native grasses create habitats that are not supportive of native wildlife due to their heavy density and production of thatch at the ground surface. Burns are conducted within the prescribed area outlined in the Reserve Vegetation Management Plan developed by CAL FIRE.

Regulation and Management

Wildfires

Wildland fires in Lake Skinner watershed are managed cooperatively by the following agencies: CAL FIRE, Riverside County Fire Department, California Highway Patrol, and the Riverside County Sheriff's Department.

The 2016 *Riverside Unit Pre-Fire Management Plan* described in the *Regulation and Management* discussion within the *Fires* PCS section for the Lake Mathews watershed also applies to Lake Skinner. In addition, the *2016 Unit Strategic Fire Plan* references the *Fire Management Plan* (FMP) in the *2008 Southwest Riverside County Multi-Species Reserve Management Plan*. The intent of the FMP is to provide California Department of Forestry/CAL FIRE with information and recommendations for emergency fire response within and immediately adjacent to the Reserve boundaries, and identify necessary weed abatement and fuels management procedures that can be implemented as preventative measures. Additionally, the FMP provides a planning framework for pre-fire fuels management, fire prevention, fire suppression, and post-fire control activities within and adjacent to the Reserve lands [164].

Tamarisk Pile Burning

Metropolitan established several mitigation measures for the Reserve to implement when eradicating tamarisk in the watershed:

- Cut tamarisk and resultant ash should be hauled away and disposed of outside of the Lake Skinner watershed.
- When removal is absolutely not practical, ash should be buried above the maximum flood level.
- Ash should be buried sufficiently deep to prevent any future exposure caused by soil erosion or other means.

- Ash should be buried as great a distance from Lake Skinner as possible, which may necessitate the need to transport ash generated near the lake to areas further upstream for burial.

Prescribed Burns

Metropolitan is notified by the Reserve Manager when prescribed burns are conducted within the Reserve. Prescribed burns within the Reserve adhere to the FMP described in the *2008 Southwestern Riverside County Multi-Species Reserve Management Plan* [164]. The Reserve FMP specifies that minimum impact suppression techniques be utilized in all areas of the Reserve, except where necessary to save structures or protect human life. Every effort should be made to minimize stream course disturbance, sedimentation, and actions that will result in damaging the environment. The use of foams as a fire retardant should be completely avoided within the Reserve, and retardant drops should be at least 300 feet from all water sources. In addition, buffers such as hay bales are needed in advance of projected rains, if the burn area is upstream of the drainage course.

Reserve staff work closely with CAL FIRE to conduct prescribed burns to manage fuel loading and restore native habitat. Per the *2016 Unit Strategic Fire Plan*, the Reserve burned approximately 43 acres in May 2011 as part of the Vegetation Management Program.

Summary for Lake Skinner Watershed

Similar to Diamond Valley Lake, Metropolitan allows multiple recreational opportunities in the Lake Skinner area including boating, trails, and park space. Water quality impacts to the lake are minimized through boating guidelines and agreements with RCRPOSD for oversight of the recreational elements. An equestrian trail exists along the perimeter of the Lake Skinner Recreational Area and within the watershed. Trail use has been minimal during the CRWSS 2015 update period and riding is not permitted during the rainy season. The Reserve occupies a portion of the watershed and provides a buffer for development. Metropolitan coordinates with the Reserve on vegetation management practices to ensure water quality protection.

Outside of the lake area, the majority of the watershed is vacant land and the primary threat to water quality is due to the horse corrals on private properties and septic system failures. Although there are a number of equestrian and bovine related businesses in the Lake Skinner watershed, there are a greater number of hobby farms, defined as properties with ten horses or less. Many of these properties and horse corrals do not have adequate BMPs in place to ensure protection of downstream water quality. Local resource conservation districts provide educational outreach covering best management practices for the ranch community but do not specifically outreach to property owners, as information is widely available to the general community within the Lake Skinner watershed at local events.

Although development has slowed down in recent years, future build out could impact water quality within the Lake Skinner watershed. Metropolitan will continue to evaluate watershed conditions and work with local agencies and other stakeholders to develop and implement water quality improvement and protection plans to minimize impacts from existing properties and future development growth in the area.

Recommendations for Lake Skinner Watershed

Develop a Lake Skinner Source Water Protection Plan
Metropolitan has assessed various watershed activities with potential to impact Lake Skinner water quality as included in this CRWSS update. Metropolitan will develop a source water protection plan for the Lake Skinner watershed to further assess and document watershed activities and provide actions, policies, and practices necessary to ensure protection of Lake Skinner water quality.

Consider improvements to water quality and flow monitoring for Lake Skinner tributaries
Metropolitan will consider developing a monitoring framework to obtain data to better evaluate watershed pollution threats. Additional data is needed to better understand the hydrologic and water quality characteristics within the Lake Skinner watershed. Information could be used to develop a watershed model, as may be recommended in the Lake Skinner Source Water Protection Plan.

Identify and prioritize parcels for potential future land acquisition or conservation easements
Metropolitan previously acquired several properties within the Lake Skinner watershed for water quality protection. Metropolitan will evaluate the potential for future land acquisition and/or conservation easements and, if determined feasible, will rank properties based on their potential to impact lake water quality.

5 Surface Water Regulatory Compliance Evaluation

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Chapter 5 Surface Water Regulatory Compliance Evaluation

This chapter provides an overview of drinking water regulations pertinent to Metropolitan's five water treatment plants. Major regulations covered by this chapter include the Total Coliform Rule, Surface Water Treatment Rule (SWTR), Lead and Copper Rule, Disinfectants and Disinfection Byproducts (D/DBP) Rule, and Interim Enhanced Surface Water Treatment Rule (IESWTR). This chapter will also present regulatory changes adopted since the CRWSS 2010 Update. The drinking water quality regulations are presented as current as of the writing of this report. Lastly, this chapter provides water quality data demonstrating 100 percent regulatory compliance for both federal and state drinking water regulations for Metropolitan's three water treatment plants treating varying blends of Colorado River water (CRW) and California State Water Project (SWP) water.

Metropolitan imports water from two sources: the Colorado River through the Colorado River Aqueduct (CRA) and from northern California via the SWP aqueduct. Metropolitan owns and operates three water treatment plants (Robert B. Diemer, Robert A. Skinner, and F.E. Weymouth), which treat varying blends of CRW and SWP water. The two source waters are blended to take advantage of temporal variations in supply availability and water quality.

Due to the reorganization of the State's drinking water programs, original reference documents and correspondence created prior to July 1, 2014 will reference State Water Resources Control Board's new Division of Drinking Water (DDW), irrespective of activities completed under DDW's predecessors' authority. Prior to July 1, 2014, documents and regulatory activities were undertaken by the former California Department of Health Services and the California Department of Public Health.

Background

In 1914, the U.S. Public Health Service (PHS) promulgated the country's first drinking water standards. These standards sought to prevent transmission of communicable diseases in water supplies on interstate carriers. Community water systems were not forced to comply with the regulations; however, most states and municipalities adopted the PHS standards as guidelines. Over time, PHS updated its standards to include 28 constituents ranging from coliforms to inorganic chemicals such as arsenic, fluoride, lead, copper, and zinc. With minor modifications, all 50 states adopted the PHS standards either as regulations or as guidelines for public water systems. However, a study conducted by PHS in 1969 showed that only 60 percent of the systems surveyed delivered water that met all the PHS standards.

By the early 1970s, it was apparent that industrial and agricultural activities and the creation of new man-made chemicals also had negative impacts on the environment and public health. Researchers also discovered that the practice of water chlorination in the presence of organic material leads to the formation of a class of compounds referred to as trihalomethanes (THMs). The health effects of these disinfection byproducts (DBPs) were unknown at the time and led to concern for public safety, contributing to the creation of the Safe Drinking Water Act (SDWA) in 1974.

Safe Drinking Water Act

The United States Congress passed the SDWA in 1974. Under the provisions of the SDWA, the U.S. Environmental Protection Agency (USEPA), created in 1970, established primary standards to limit the levels of contaminants that affect public health and secondary standards for compounds that affect the taste or aesthetics of drinking water. For each contaminant that is regulated, USEPA is required to establish a maximum contaminant level (MCL) and maximum contaminant level goal (MCLG) or a treatment technique (TT) to limit the level of these compounds in drinking waters. USEPA is also required to recommend a best available technology for removal of each contaminant during treatment. In California, the State Water Resources Control Board Division of Drinking Water (DDW) has the primary responsibility, or primacy, to enforce these regulations. To maintain primacy, states must adopt the federal regulations by reference or make them more stringent. The Health and Safety Code of the California Administrative Code establishes DDW's authority and stipulates drinking water quality and monitoring standards.

The SDWA was amended in 1986 and 1996. The 1986 amendments required USEPA to regulate more than 80 contaminants in drinking water within three years and 25 more by 1991. The 1986 amendments also included monitoring requirements for unregulated contaminants and gave USEPA more enforcement powers.

In 1996, Congress amended the SDWA to emphasize sound science and risk-based standard setting, small water supply system flexibility and technical assistance, community-empowered source water assessment and protection, public right-to-know, and water system infrastructure assistance through a multi-billion-dollar state revolving loan fund. Main points of the 1996 amendments included the following [176]:

- Consumer Confidence Reports: All community water systems must prepare and distribute annual reports about the water they provide, including information on detected contaminants, possible health effects, and the water's source.
- Cost-benefit analysis: USEPA must conduct a thorough cost-benefit analysis for every new standard to determine whether the benefits of a drinking water standard justify the costs.
- Drinking Water State Revolving Fund: States can use this fund to help water systems make infrastructure or management improvements or to help systems assess and protect their source water.
- Microbial Contaminants and DBPs: USEPA was required to strengthen protection from microbial contaminants, including *Cryptosporidium*, while improving control over DBPs. USEPA promulgated the Stage 1 D/DBP Rule and the IESWTR to address these risks.
- Operator Certification: Water system operators must be certified to ensure that systems are operated safely. USEPA issued guidelines in 1999 specifying minimum standards for the certification and recertification of the operators of community and non-transient, non-community water systems.
- Public Information and Consultation: SDWA emphasizes that consumers have a right to know what is in their drinking water, where it comes from, how it is treated, and how to help protect it. USEPA distributes public information materials and holds public meetings, working with states, tribes, water systems, and environmental and civic groups, to encourage public involvement.

- Small Water Systems: Small water systems are given special consideration and resources under SDWA to make sure they have the managerial, financial, and technical ability to comply with drinking water standards.
- Source Water Assessment Program: States are required to conduct an assessment of its sources of drinking water (rivers, lakes, reservoirs, springs, and groundwater wells) to identify significant potential sources of contamination and to determine how susceptible the sources are to these threats.

Drinking Water Regulations

Federal Drinking Water Regulations

Table 5-1 provides a chronology of federal drinking water regulations since the SDWA's creation. A brief discussion of each drinking water regulation follows. USEPA regulates contaminants under primary or secondary standards, also referred to as National Primary Drinking Water Regulations (NPDWR) and National Secondary Drinking Water Regulations (NSDWR), respectively.

California Drinking Water Regulations

California adopted its own Safe Drinking Water Act in 1976 and established primacy to adopt drinking water regulations at least as stringent as the federal requirements. California drinking water standards, or MCLs, are found in Title 17 and Title 22 of the California Code of Regulations. The MCLs and corresponding regulatory dates for federal and California drinking water standards are included in **Appendix N**.

In California, the Office of Environmental Health Hazard Assessment (OEHHA) is responsible for establishing Public Health Goals (PHGs). A PHG is the level of a contaminant in drinking water that does not pose a significant risk to public health. PHGs are non-enforceable standards; however, DDW is required to adopt MCLs as close to the PHGs as economically and technically feasible, but not less stringent than the federal MCL if one exists. The process for adopting a new MCL begins after the PHG is finalized.

In the early 1980s, DDW established health-based advisory levels called "notification levels" (NLs) for drinking water contaminants that lack MCLs. NLs were referred to as "action levels" through 2004. NLs are established either in response to actual contamination of drinking water supplies or in anticipation of possible contamination. Chemicals for which notification levels are established may eventually be regulated by MCLs. California regulations require a drinking water system to notify the governing body of the local agency (city council and/or county board of supervisors) when a chemical in excess of a notification level is discovered in a drinking water source. However, DDW recommends that the utility should inform its customers directly about the presence of the contaminant and about the health concerns associated with exposure to it. DDW also recommends that the drinking water system should remove the source from service if a chemical is present at levels considerably higher than its notification level, referred to as the response level (RL).

Detailed information regarding USEPA and DDW regulated and unregulated contaminants, including MCLs, NLs, PHGs, and TTs under each statute is found on the USEPA [177] and DDW [178] websites, respectively.

Table 5-1. Federal Regulations under SDWA

Regulation	Year Promulgated	Number of New Contaminants	New or Revised Contaminants/ Contaminant Groups
National Primary Drinking Water Regulations	1975/76	22	Inorganics, Organics, Radionuclides
Total Trihalomethanes	1979	1	TTHMs
Fluoride Rule	1986	—	Fluoride*
Phase I Standards	1987	8	VOCs
Total Coliform Rule	1989	—	Total Coliform*
Surface Water Treatment Rule	1989	4	Microbiological and Turbidity*
Phase II Standards	1991	27	SOCs, and Inorganics (11 revisions*, 1 deletion: silver**)
Lead and Copper Rule	1991	1	Lead* and Copper
Phase V Standards	1992	22	SOCs (endrin*), and Inorganics
Stage 1 Disinfectants/Disinfection Byproducts Rule	1998	6	Disinfectants*, TTHM* and other DBPs, and DBP precursors (TOC)
Interim Enhanced Surface Water Treatment Rule	1998	1	*Cryptosporidium, Giardia**, and Turbidity*
Radionuclides Rule	2000	1	Gross alpha*, Gross beta*, Radium-226*, Radium-228*, Uranium
Revision to the Lead and Copper Rule	2000	—	Lead* and Copper*
Arsenic	2001	—	Arsenic*
Filter Backwash Recycling Rule	2001	—	Microbiological* and Turbidity*
Long Term 1 ESWTR	2002	—	Microbiological* and Turbidity*
Long Term 2 ESWTR	2006	—	Microbiological* and Turbidity*
Stage 2 D/DBP Rule	2006	—	Disinfectants*, DBPs*, and disinfection precursors*
Lead and Copper Rule	2007	—	Lead* and Copper*
Revised Total Coliform Rule†	2013		Total Coliform* *E. coli**
Cumulative # of federally regulated contaminants**		**91**	

† This rule became effective during the CRWSS 2015 update reporting period. It is discussed in this chapter under *New Drinking Water Regulations since CRWSS 2010 Update*
* Revised
** Silver was deleted in 1991; nickel was remanded in 1995

National Primary/Secondary Drinking Water Regulations

The SDWA required USEPA to establish primary standards for contaminants that may cause adverse public health effects. The regulations include both mandatory levels (MCLs) and non-enforceable health goals (MCLGs) for each contaminant. From 1975 to 1976, USEPA regulated 22 constituents in drinking water under the National Interim Primary Drinking Water Regulations (NIPDWR). These interim standards were updated and adopted under the SDWA as primary standards. Primary standards are health-related legally enforceable standards that apply to public water systems. Currently, 91 constituents are regulated under the National Primary Drinking Water Regulations (NPDWR).

In addition to the enforceable health-related MCLs set by the NPDWR, the act mandated USEPA to set non-enforceable secondary MCLs (SMCLs) under National Secondary Drinking Water Regulations for contaminants that may adversely affect the aesthetic quality of drinking water. The initial set of SMCLs was released in 1979. SMCLs regulate contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. USEPA recommends secondary standards to water systems, but does not require systems to comply. The regulations are intended as guidelines for the states; however, DDW enforces the SMCL and requires increased monitoring and other actions. If the average of four consecutive quarterly sample results exceeds the SMCL, the source of water that exceeds SMCL may be designated a standby source. If the average of four consecutive quarterly sample results is not greater than 20 percent of the SMCL or not greater than the state NL, a waiver may be granted. There are 16 constituents on California's list of secondary drinking water standards [179].

Total Trihalomethanes

In 1979, the first interim standard addressing disinfection byproducts was set by USEPA for total trihalomethanes (TTHM), a group of four volatile organic compounds formed when disinfectants react with natural organic matter in the water. This rule set an MCL of 0.1 mg/L for TTHM system-wide and applied it to water systems serving 10,000 or more people. It has since been updated and replaced by the subsequent Stage 1 D/DBP Rule in 1998 and Stage 2 D/DBP Rule established in 2006 and effective April 2012 for systems serving more than 100,000 people. For Stage 1 D/DBP Rule, compliance for the MCL of 0.080 mg/L was calculated using the running annual average (RAA) of all samples from all monitoring locations across the system. For Stage 2 D/DBP Rule, compliance for the MCL of 0.080 mg/L is calculated using the locational RAA (LRAA) for each monitoring location in the distribution system.

Fluoride

In 1986, USEPA promulgated both the fluoride MCL and MCLG at 4 mg/L to replace the interim standard of 1.4 to 2.4 mg/L that was established in 1975. At the same time, USEPA set a non-enforceable SMCL of 2 mg/L for fluoride in drinking water to protect against objectionable dental fluorosis, which was regarded as a cosmetic effect rather than a health effect. In April 2015, USHHS recommended that water systems adjust their fluoride content to 0.7 mg/L, as opposed to temperature-dependent optimal levels ranging from 0.7 to 1.2 mg/L based on scientific evidence provided by CDC. The 0.7 mg/L optimal level aims to provide the benefits of fluoridation while minimizing effects of dental fluorosis (teeth discoloration) in children.

DDW is consulting with public water systems to amend individual permits to reference CDC's recommended optimal level of 0.7 mg/L, which corresponds with the existing control range of 0.6 to 1.2 mg/L. DDW plans to develop amendments to the Code of Regulations to incorporate the new CDC recommendation.

California's primary MCL for fluoride is 2 mg/L. Fluoride is included under the *Anticipated Drinking Water Regulations* section of this chapter of the report since USEPA is currently reviewing both the primary and secondary standards for fluoride, which may result in federal and subsequently, California changes to the MCL.

Phase I Standards

The Phase I Standards were finalized by USEPA in July 1987 and compliance for large utilities was required by January 1989. The Phase I Regulations included MCLs for eight volatile organic compounds (VOCs) and required utilities to collect quarterly samples from each source of water supply for one year.

Utilities could qualify for reduced monitoring (one sample every three years) if any of the VOCs was not detected during the initial four quarters of monitoring. The Phase I Standards also included monitoring requirements for unregulated contaminants. All systems were required to monitor for a minimum of 34 unregulated volatile organic contaminants; 2 additional contaminants if the system is determined vulnerable; and 15 additional contaminants at the state's discretion.

Total Coliform Rule

The Total Coliform Rule (TCR) was published by USEPA in 1989, going into effect in 1990 as part of the NPDWR. The rule set both health goals and legal limits for the presence of total coliform in drinking water. The rule also detailed the type and frequency of testing that water systems must undertake. USEPA published revisions to the TCR on February 13, 2013, with minor changes on February 26, 2014. The Revised Total Coliform Rule is discussed further under the *New Drinking Water Regulations* section of this chapter.

Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) was promulgated by USEPA in 1989 to control the levels of turbidity, *Giardia lamblia*, viruses, *Legionella*, and heterotrophic plate count (HPC) bacteria in U.S. drinking waters by requiring disinfection as a TT for public water systems using surface water sources. The IESWTR, promulgated in 1998, complements the original SWTR requirements.

The California SWTR, based on USEPA's SWTR and incorporated into Chapter 17, California Title 22 on June 5, 1991, requires all utilities utilizing a surface water supply or a groundwater supply under direct influence of surface water (GWUDIS), to provide adequate disinfection and, under most conditions, filtration. Exemptions from filtration of surface water supplies are provided on rare occasions where the source water supply meets extremely rigid requirements for water quality and the utility possesses control of the watershed.

General Requirements

For systems using conventional treatment or direct filtration, the SWTR includes the following general requirements to minimize human exposure to microbial contaminants in drinking water:

- Filtered water turbidity must be less than or equal to 0.5 NTU in 95 percent of measurements taken every month.
- Filtered water turbidity may not exceed 5 NTU at any time.
- Utilities are required to achieve at least 99.9 percent removal and/or inactivation of *Giardia* cysts (3-log removal) and a minimum 99.99 percent removal and/or inactivation of viruses (4-log removal). The required level of removal/inactivation must occur between the point where the raw water ceases to be influenced by surface water runoff to the point at which the first customer is served.
- The disinfectant residual entering the distribution system must not fall below 0.2 mg/L for more than 4 hours during any 24-hour period.

- A disinfectant residual must be detectable in 95 percent of distribution system samples. An HPC concentration of less than 500 CFU per 100 mL can serve as a surrogate if disinfectant residual is not measurable.
- Each utility must perform a watershed sanitary survey at least every five years.

Giardia and Virus Reduction Requirements

The SWTR requires all surface water supplies to provide a minimum 3-log (99.9%) reduction of *Giardia* and 4-log (99.99%) reduction of viruses. In source waters that are subjected to significant recreational use, it may be necessary to provide higher levels of reduction.

DDW has determined that for source waters with monthly median total coliform levels less than 1,000 MPN per 100 mL, the 3- and 4-log reductions for *Giardia* and viruses, respectively, is satisfactory; otherwise, additional treatment or operational controls must be implemented.

Removal Credit

The type of treatment process used determines the level of removal credit given a utility for both *Giardia* and viruses. For a conventional filtration plant, the SWTR provides a 2.5-log removal credit for *Giardia* and a 2.0-log removal credit for viruses. For a direct filtration plant, the SWTR provides 2-log removal credit for *Giardia* and a 1-log removal credit for viruses. Both of these assume compliance with the operating criteria as well as the performance standards.

Disinfection Credit

Disinfection during conventional treatment (assuming all operational criteria and performance standards are met and the plant receives 2.5-log credit for physical removal of *Giardia* and 2.0-log credit for physical removal of viruses), must achieve 0.5-log inactivation of *Giardia* and 2.0-log inactivation of viruses. To determine the inactivation of *Giardia* and viruses achieved at a treatment plant, the SWTR established the concept of disinfection contact time (CT). CT is the product of the concentration of disinfectant remaining at the end of a treatment process ("C" in mg/L) and the contact time in which 10 percent of the water passes through the treatment process ("T" or "T_{10}" in minutes). DDW provides guidelines to determine a conservative estimate of the contact time in which 10 percent of the water travels through a unit process; however, a more accurate estimate can be determined by conducting a tracer study. The USEPA SWTR Guidance Manual includes tables that identify the log removal of both *Giardia* and viruses achieved for a calculated CT value based on the type of disinfectant, the water temperature, and pH.

Phase II Standards

The Phase II Standards were proposed in May 1989 and finalized in July 1991. Monitoring under the Phase II Standards was required to begin in January 1993. The Phase II Regulations established MCLs for 38 contaminants (7 inorganic compounds [IOCs], 10 VOCs, and 18 synthetic organic compounds [SOCs], plus nitrate, nitrite, and total nitrate and nitrite) and TT requirements for two additional treatment additives (polymers). In order to simplify the increasing number of monitoring requirements, the Standardized Monitoring Framework (SMF) was developed. The SMF is based on a 9-year cycle divided into three, 3-year monitoring periods. Under the monitoring schedule, initial monitoring, baseline monitoring, reduced monitoring, and increased monitoring requirements were established.

Lead and Copper Rule

In 1991, USEPA published the Lead and Copper Rule to minimize lead and copper in drinking water. The rule replaced the 1976 primary MCL of 0.05 mg/L for lead and created a new MCL for copper. Compliance is based on the 90^{th}-percentile action level of 0.015 mg/L and 1.3 mg/L for lead and copper, respectively, in samples collected at customer taps. If lead concentrations exceed the action level of 0.015 mg/L or copper concentrations exceed the action level of 1.3 mg/L in more than 10 percent of customer taps sampled, the system must undertake a number of actions to control corrosion and reduce lead and copper in the distribution system. If the action level for lead is exceeded, the system must also inform the public about steps they should take to protect their health, and lead service lines may have to be replaced. The rule also established an MCLG of zero for lead in drinking water. In November 2010, USEPA held a public meeting to discuss potential Long-Term Revisions to the Lead and Copper Rule. The proposed revisions to the Lead and Copper Rule are discussed further under the *Anticipated Drinking Water Regu*lations section of this chapter.

Phase V Standards

The Phase V Standards were proposed in July 1990 and finalized in July 1992. The SMF was incorporated into the Phase V Regulations with the first compliance period for large utilities beginning January 1994. Phase V established regulations for 23 contaminants including 22 from the original list of 83 included in the 1986 SDWA amendments, which originally included a proposal for sulfate that was not included in the final Phase V regulations. The 23 Phase V contaminants include 5 IOCs, 3 VOCs, and 15 SOCs. The U.S. Court of Appeals for the District of Columbia remanded the MCL for nickel, 0.1 mg/L, in February 1995. USEPA is required to reconsider the nickel MCLG and MCL, but no action has been taken yet; however, California maintains the 0.1 mg/L MCL for nickel.

Stage 1 Disinfectants and Disinfection Byproducts Rule

In December 1998, USEPA promulgated the Stage 1 D/DBP Rule. The rule became effective in February 1999 and required large systems to be in compliance by January 2002. The purpose of the Stage 1 D/DBP Rule was "to minimize risks from disinfection byproducts and still maintain adequate control over microbial contamination." This regulation consists of maximum residual disinfectant levels (MRDLs) for disinfectants, MCLs for DBPs, and TTs to control DBP precursors. Chlorine, chloramines, and chlorine dioxide are covered under the rule as alternative disinfectants for the control of DBP formation. The MCLs for DBPs resulting from chlorination are 0.080 mg/L for trihalomethanes (THMs) and 0.060 mg/L for the five regulated haloacetic acids (HAA5). These MCLs are currently based on a system-wide running annual average (RAA) of quarterly samples. The Stage 1 D/DBP Rule also includes monitoring, reporting, and public notification for any MRDL or MCL violation. California adopted the Stage 1 D/DBP Rule in April 2005 and it became effective on June 17, 2006.

Disinfectants

USEPA set maximum residual disinfectant level goals (MRDLGs) and MRDLs for chlorine, chloramines, and chlorine dioxide, respectively (**Table 5-2**). The MRDLGs are set at levels for which no known or anticipated adverse health effects occur, and are non-enforceable. MRDLs are enforceable limits.

Table 5-2. MRDLGs and MRDLs for Stage 1 D/DBP Rule, mg/L

Disinfectant	MRDLG	MRDL
Chlorine	4 (as Cl_2)	4.0* (as Cl_2)
Chloramines (as chlorine)	4 (as Cl_2)	4.0* (as Cl_2)
Chlorine Dioxide (consecutive daily samples)	0.8 as (ClO_2)	0.8 as (ClO_2)

* Compliance is based on running annual average, computed quarterly

Chlorine and Chloramines

The residual disinfectant level must be monitored at the same points in the distribution system and at the same time as total coliform sampling. Compliance with the MRDL will be based on the running annual average of the monthly average of all samples, computed quarterly. MRDLs for chlorine and chloramines may be exceeded to protect public health from specific microbiological contamination events.

Follow-up monitoring in the distribution system will be governed by the type of residual disinfectant used. Systems using chlorine as a residual disinfectant and operating booster stations after the entrance to the distribution system must take three samples in the distribution system: one close to the first customer, one at an average residence time, and one at the maximum residence time. Systems using chlorine without operating booster stations after the entrance to the distribution system must take three samples in the distribution system as close as possible to the first customer, and at intervals of not less than six hours. Systems using chloramines as a residual disinfectant must take three samples in the distribution system as close as possible to the first customer, and at intervals of not less than six hours.

Chlorine Dioxide

Systems that use chlorine dioxide must measure the residual disinfectant level on a daily basis at the entrance to the distribution system. Non-compliance with the MRDL can result in acute or non-acute violations. If the daily sample at the entrance exceeds the MRDL, then the system is required to take three additional samples in the distribution system on the next day. If any of the samples collected in the distribution system the second day exceed the MRDL, or if the distribution system samples are not collected, the system is in acute violation of the MRDL. If only the sample collected at the entrance to the distribution system on the second day exceeds the MRDL, or if the entrance sample was not collected, the system will be in a non-acute violation of the MRDL. Operators shall not increase the residual chlorine dioxide level in the distribution system above the MRDL under any circumstances.

Disinfection Byproducts

Under the Stage 1 D/DBP Rule, USEPA set MCLGs for four trihalomethanes, two haloacetic acids, chlorite, and bromate, and MCLs for total trihalomethanes (TTHMs), haloacetic acids (HAA5), chlorite, and bromate (**Table 5-3**). The MCLGs are set at levels for which no known or anticipated adverse health effects occur. MCLGs are non-enforceable health goals based only on health effects and exposure information.

Table 5-3. MCLGs and MCLs for DBPs, mg/L

Disinfection Byproduct	MCLG	MCL
Chloroform	—	—
Bromodichloromethane	0	—
Dibromochloromethane	0.06	—
Bromoform	0	—
TTHM[1]	—	0.080
Chloroacetic Acid	—	—
Dichloroacetic Acid	0	—
Trichloroacetic Acid	0.3	—
Bromoacetic Acid	—	—
Dibromoacetic Acid	—	—
HAA5[2]	—	0.060
Chlorite	0.8	1.0
Bromate	0	0.010

[1] TTHMs includes chloroform, bromodichloromethane, dibromochloromethane, bromoform
[2] HAA5 includes mono-, di- and tri-chloroacetic acids and mono- and di-bromoacetic acids

Total Trihalomethanes and Haloacetic Acids

TTHMs and HAA5 are formed when disinfectants react with naturally occurring organic matter in water. All systems must monitor the distribution system for TTHMs and HAA5. Compliance for surface water, GWUDIS, and groundwater systems with population greater than 10,000 is based on the running annual average of quarterly averages. The quarterly averages are calculated from of all samples taken in the distribution system within the quarter.

Chlorite

Chlorite is produced as a byproduct when chlorine dioxide is used for disinfection. Chlorine dioxide rapidly decomposes to chlorite, chlorate, and chloride ions in treated water, but chlorite is the predominant species. Systems using chlorine dioxide for disinfection are required to conduct sampling for chlorite. Systems are required to monitor chlorite on a daily basis at the point of entry to the distribution system and a three-sample set on a monthly basis at locations close to the first customer, representative of average residence time, and representative of maximum residence time. On each day following a routine sample result that exceeds 1.0 mg/L at the entrance to the distribution system, the system is required to take three chlorite distribution system samples on the following day at the three locations identified above.

Bromate

Bromate is produced when ozone reacts with naturally occurring bromide. Systems using ozone for disinfection are required to conduct sampling for bromate. One sample must be collected per month at the entrance to the distribution system while the ozonation system is operating. Compliance with the MCL is based on a running annual average of monthly samples computed quarterly.

Treatment Technique for Total Organic Carbon Removal

USEPA requires surface water or GWUDIS systems to use conventional filtration treatment to remove specific amounts of organic material by implementing a TT, either by enhanced coagulation or enhanced softening. The percent of removal required under the Step 1 TOC (total organic carbon) percent-removal depends on source water TOC and alkalinity. **Table 5-4** provides a summary of the Step 1 removal requirements.

Table 5-4. Step 1 TOC Removal Requirements

TOC, mg/L	Alkalinity, mg/L as $CaCO_3$		
	0–60	> 60–120	> 120
> 2.0–4.0	35%	25%	15%
> 4.0–8.0	45%	35%	25%
> 8.0	50%	40%	30%

Compliance with this TT must be calculated on a quarterly basis. Each month, the system must calculate actual percent TOC removal, determine the percent-required TOC removal (**Table 5-4**), and calculate the removal ratio (must be greater than 1.0).

As an alternative, the Step 2 method is available for systems when it is not technically feasible to meet the Step 1 requirements. The Step 2 method is used when source water is not amenable to TOC removal and therefore, cannot meet the Step 1 requirements. The Step 2 method entails the following:

- The alternative TOC removal percentage is determined by performing a minimum of quarterly jar tests.
- Alum or an equivalent dose of ferric chloride is added in increments of 10 mg/L until the pH is at or below the target value (**Table 5-5**). Once the Step 2 jar test is complete, the TOC removal (mg/L) is plotted versus coagulant dose (mg/L) (**Figure 5-1**). The alternate TOC removal percentage is set at the point of diminishing return identified on the plot. The point of diminishing return is defined as the point where the slope for the removal of TOC during jar tests transitions from being greater than 0.3 mg/L TOC removal per 10 mg/L of alum (or equivalent ferric chloride dose) to less than 0.3 mg/L of TOC removal.
- Source waters in which TOC removal is always less than 0.3 mg/L per incremental addition of 10 mg/L of alum dose are termed non-amenable to enhanced coagulation and the TOC removal requirement is set at 0 percent.

Table 5-5. pH Requirements for Amenable Water Sources

	Source-water alkalinity, mg/L as $CaCO_3$			
	0–60	> 60–120	> 120–240	> 240
Target pH	5.5	6.3	7.0	7.5

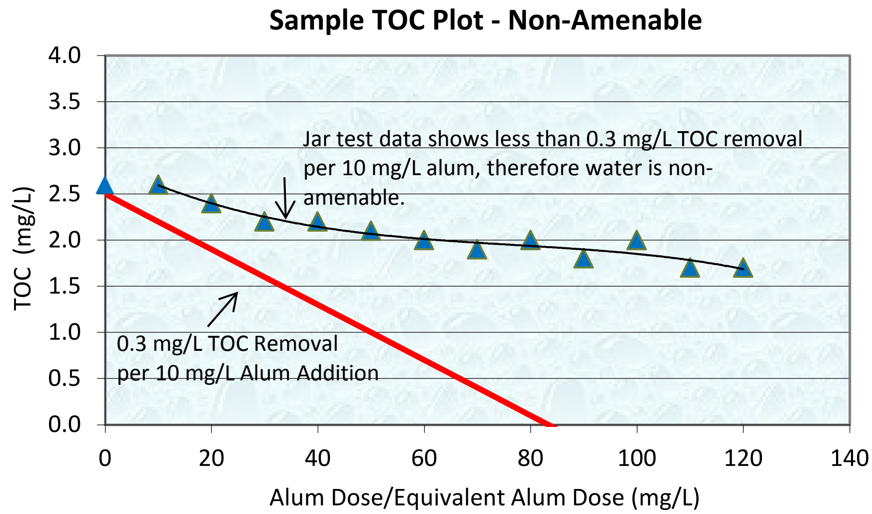


Figure 5-1. Example TOC Removal Plot for a Non-amenable Water

Systems can also use Alternative Compliance Criteria in lieu of the Step 1 and the Step 2 methods. Utilities will not be required to achieve the specified TOC removals provided one of the following conditions is met and the source water has not undergone any treatment regarding the criteria pertaining to the source water:

- Source water TOC RAA < 2.0 mg/L
- Treated water TOC RAA < 2.0 mg/L
- Source water TOC RAA < 4.0 mg/L, source water alkalinity is greater than 60 mg/L, distribution system TTHM RAA ≤ 0.040 mg/L and HAA5 RAA ≤ 0.030 mg/L (also referred to as the 40/30 rule)
- Distribution system TTHM RAA ≤ 0.040 mg/L and HAA5 RAA ≤ 0.030 mg/L and only chlorine is used for primary disinfection and distribution system residual
- Source water SUVA RAA, prior to any treatment, ≤ 2.0 L/mg-m
- Treated water SUVA RAA ≤ 2.0 L/mg-m

Interim Enhanced Surface Water Treatment Rule

USEPA published the Interim Enhanced Surface Water Treatment Rule (IESWTR) on December 16, 1998. The rule became effective on February 16, 1999, and applies to public water systems (PWSs) that use surface water or GWUDIS and serve a minimum of 10,000 people. The purpose of this regulation is "to improve control of microbial pathogens, including specifically *Cryptosporidium*, in drinking water; and address risk trade-offs with disinfection byproducts." In January 2008, DDW adopted the IESWTR. The IESWTR adopted by DDW contains the provisions of the federal IESWTR, federal Filter Backwash Recycling Rule, and additional state-only requirements. The federal IESWTR requirements were incorporated into Chapter 17, California Title 22.

Cryptosporidium

The rule set an MCLG of zero for *Cryptosporidium*. Since there was no reliable means for monitoring this constituent in drinking water at the time of promulgation, a TT requirement was established in lieu of setting an MCL. The TT requires 99 percent (2-log) *Cryptosporidium* removal for PWSs that are currently required to filter under the existing SWTR. This removal must be achieved between the raw water intake and the first customer.

The rule provides that systems with conventional or direct filtration water treatment plants will be granted the 2-log removal credit for *Cryptosporidium* provided turbidity requirements are met for the combined filter effluent (≤ 0.3 NTU in 95 percent of samples and never exceed 1 NTU).

For systems applying to use an "alternative filtration technology," the system must show that the treatment, in combination with disinfection, consistently achieves 99.9 percent (3-log) removal/ inactivation of *Giardia*, 99.99 percent (4-log) removal/inactivation of viruses, and 99 percent (2-log) removal of *Cryptosporidium*.

Turbidity

For surface water and GWUDIS systems that are required to filter their source water under the existing SWTR and employ conventional or direct filtration for treatment, the combined filter effluent turbidity requirements are more stringent under the IESWTR. For alternative filtration technologies, DDW has set turbidity performance requirements at a level that, in combination with disinfection, will consistently achieve 3-log removal/inactivation of *Giardia*, 4-log removal/inactivation of viruses, and 2-log removal of *Cryptosporidium*.

The combined filter effluent turbidity must be less than 0.3 NTU in 95 percent of measurements and should never exceed 1 NTU for more than one continuous hour and at four-hour intervals. The combined filter effluent turbidity shall not exceed 1.0 NTU for more than eight hours. Combined filter effluent and individual filter effluent continuous turbidity monitoring shall be recorded at a minimum every 15 minutes. Individual filter effluent turbidity shall be less than 0.3 NTU within 60 minutes after return to service.

Monthly reports must show total number of measurements taken and have two options for reporting:

- 15-minute measurements with 50^{th}, 90^{th}, 95^{th}, 98^{th}, and 99^{th} percentiles and all measurements greater than 1 NTU indicated.
- 4-hour measurements with all results greater than 0.3 NTU (based on 15-minute measurements) and percent of measurements less than or equal to 0.3 NTU (based on 15-minute measurements) indicated.

If there is a failure in the continuous turbidity monitoring system, or there are interruptions in continuous monitoring due to system maintenance, staff must conduct grab sampling every four hours in lieu of continuous monitoring. Continuous monitoring must be reinitiated within 48 hours of system failure or maintenance interruption for the combined filter effluent, and within five working days for individual filter effluents (Section 64655 of California Title 22).

If any individual filter has a measured turbidity level greater than 1.0 NTU in two consecutive measurements taken no more than 15 minutes apart, or greater than 0.3 NTU in two consecutive measurements taken no more than 15 minutes apart and after the filter has been in continuous operation for 60 minutes or more, the water system must produce a filter profile within 7 days unless there is an obvious reason for the abnormal filter performance (Section 64660(7) of California Title 22).

If any individual filter has a measured turbidity level greater than 1.0 NTU in two consecutive measurements taken no more than 15 minutes apart at any time in each of three consecutive months, the water system must conduct a self-assessment of the filter performance and develop a filter profile within 14 days (Section 64660(7) of California Title 22).

If any individual filter has a measured turbidity level greater than 2.0 NTU in two consecutive measurements taken no more than 15 minutes apart at any time in each of two consecutive months, the water system must arrange with DDW to conduct a comprehensive performance evaluation within 30 days. The evaluation must be completed and submitted within 90 days (Section 64660(7) of California Title 22).

During the first 4 hours of an individual filter operation after backwashing or other interruption, the turbidity must not exceed 2.0 NTU and must not exceed 0.5 NTU at the time that the filter has been in operation for 4 hours. An individual filter must not exceed 1.0 NTU at any time during the first 4 hours of filter operation following at least 90 percent of interruption events during any consecutive 12-month period (Section 64660(7) of California Title 22).

Disinfection Profiling and Benchmarking

The purpose of disinfection profiling and benchmarking is to develop a process to assure that there is no significant reduction in microbial protection as a result of significant disinfection process modifications to meet the new MCLs for TTHMs and HAA5 from the Stage 1 D/DBP Rule.

Profiling is required for surface water systems that have either TTHM levels greater than or equal to 80 percent of the new MCL (0.064 mg/L) or HAA5 levels greater than or equal to 80 percent of the new MCL (0.048 mg/L).

The disinfection profile is developed using a minimum of one year of weekly *Giardia* log inactivation. The month with the lowest average log inactivation will be identified as the critical period or benchmark.

After completing the profiling and benchmarking, the utility must submit a report to DDW as part of the sanitary survey. If a utility decides to make changes to the disinfection practices, then the utility must consult with DDW to ensure that microbial protection is not compromised. Changes that would require a benchmark analysis include changes in the point of disinfection, the type of disinfectant, the disinfection process, or any other modification identified by DDW.

Finished Water Reservoirs

Under the IESWTR, surface water and GWUDIS systems must cover all new treated water reservoirs, holding tanks, and other storage facilities.

Sanitary Surveys

Primacy states, such as California, must conduct sanitary surveys for all surface water and GWUDIS systems regardless of size. These surveys must be conducted every three years for community water systems (CWS) and every five years for non-community water systems (NCWS). DDW may grant a waiver to water utilities to perform the sanitary survey every five years if the system has outstanding performance based on previous sanitary surveys. DDW must determine how outstanding performance will be evaluated to allow for the reduced frequency of the sanitary survey.

Radionuclides Rule

USEPA published the Final Radionuclides Rule on December 7, 2000. The rule requires all initial monitoring samples to be collected in four consecutive quarters at the entry point to the distribution system by December 31, 2007. The rule applies to all community water systems and includes the following new standards:

- gross alpha, gross beta and photon, combined radium (226/228), and uranium MCLGs at 0 pCi/L
- gross alpha MCL at 15 pCi/L
- gross beta and photon MCL at 4 mrem/yr
- combined radium MCL at 5 pCi/L
- uranium MCL at 0.030 mg/L

The rule also clarified that gross beta and photon require monitoring only by vulnerable systems. The frequency of repeat monitoring is determined by initial quarterly monitoring results.

It should be noted that California's MCL for uranium is 20 pCi/L. DDW changed the gross beta MCL from 50 pCi/L to 4 mrem/yr (calculated total body or organ dose equivalent) on June 11, 2006. A gross beta concentration of less than 50 pCi/L is considered to be in compliance with the regulation.

In October 2014, USEPA made a preliminary determination to regulate strontium. Further information on the final regulatory determination for strontium is discussed in the *Anticipated Drinking Water Regulations* section of this chapter.

Arsenic Rule

The Final Arsenic Rule was promulgated by USEPA on January 22, 2001, and was put into effect on January 23, 2006. The rule set an arsenic MCLG of 0 mg/L and MCL of 0.010 mg/L to replace the previous MCL of 0.050 mg/L. DDW adopted the federal MCL effective November 28, 2008, after OEHHA finalized the arsenic PHG of 0.000004 mg/L in April 2004. Surface water systems are required to collect an annual sample. Quarterly sampling is triggered if the sample results are greater than the MCL. Waivers are available if the analytical results are less than the MCL after three rounds of monitoring. With a waiver, sampling can be reduced to once every nine years.

Filter Backwash Recycling Rule

The FBRR was promulgated by USEPA on June 8, 2001, and was put into effect on June 8, 2004. The rule allowed any capital improvement that ensures compliance with the rule to be completed by June 8, 2006. The FBRR requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes be returned to a location such that all processes of a system's conventional or direct filtration including coagulation, flocculation, sedimentation (conventional filtration only), and filtration are employed. Systems may apply to DDW for approval to recycle at an alternate location.

The FBRR also requires that systems notify DDW in writing that they practice recycling. When notifying DDW, systems must also provide the following information:

- A plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the location where they are recycled back into the plant.
- Typical recycle flow, highest observed plant flow experienced in the previous year, design flow for the treatment plant, and the DDW-approved operating capacity for the plant where DDW has made such determinations.

Finally, systems must collect and maintain the following information for review by DDW, which after evaluating the information, may require a system to modify recycle locations or recycling practices:

- Copy of the recycle notification and information submitted to DDW
- List of all recycle flows and the frequency with which they are returned
- Average and maximum backwash flow rate through the filters and the average and maximum duration of the filter backwash process in minutes
- Typical filter run length and a written summary of how filter run length is determined (head loss, turbidity, time, etc.)
- The type of treatment provided for the recycle flow
- Data on the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used and average dose and frequency of use, and frequency at which solids are removed where such units are used

Long Term 1 Enhanced Surface Water Treatment Rule

USEPA finalized the LT1ESWTR in January 2002. The rule applies to public water systems that use surface water or GWUDIS, serving fewer than 10,000 persons. The LT1ESWTR sets an MCLG of zero for *Cryptosporidium*; sets 2-log *Cryptosporidium* requirements for systems that filter; requires water protection programs to address *Cryptosporidium* for systems that are not required to provide filtration; requires public water systems to meet strengthened filtration requirements; and requires systems to calculate levels of microbial inactivation to address risk trade-offs with disinfection byproducts. DDW adopted the LT1ESWTR, effective July 1, 2013.

Long Term 2 Enhanced Surface Water Treatment Rule

USEPA promulgated the LT2ESWTR in August 2003 and finalized the rule in January 2006. The rule applies to all public water systems that use surface water or GWUDIS. Systems must be in compliance within six years of the date of the final rule; two additional years are available for capital improvement projects. For Schedule 1 systems, such as Metropolitan, the start of the two-year monitoring period was October 2006. DDW adopted the LT2ESWTR, effective July 1, 2013.

The major provisions of the rule are summarized below:

- Source water monitoring once per month for *Cryptosporidium*, *E. coli*, and turbidity for two years for large filtered systems (≥ 10,000 population), *Cryptosporidium* monitoring once per month for two years for large unfiltered systems, and *E. coli* monitoring for small filtered systems (< 10,000 population) every two weeks for one year. Systems may collect more than one *Cryptosporidium* sample per month if sampling is evenly spaced over the monitoring period. Small filtered systems that exceed designated *E. coli* trigger levels must conduct 12 months of *Cryptosporidium* monitoring.
- Compliance for monthly sampling is based on the maximum running annual average. Compliance for sampling greater than once per month is based on the mean of all samples collected.
- Additional action for *Cryptosporidium* removal is based on source water concentrations of the protozoa. **Table 5-6** provides a summary of the additional action requirements for conventional and direct filtration water treatment plants.
- Action credit options are provided. **Table 5-7** provides a summary of these action credit options.
- All uncovered treated water reservoirs must be covered or distribution systems originating from uncovered treated water reservoirs must achieve 4-log virus inactivation.
- After completing the initial round of source water monitoring, systems that plan to make a significant change to their disinfection practice must notify DDW, develop disinfection profiles, and calculate disinfection benchmarks for *Giardia* and viruses.
- Systems will conduct a second round of source water monitoring for *Cryptosporidium* six years after the initial bin classification is completed.

Table 5-6. Cryptosporidium Occurrence and Additional Treatment Requirements for Filtered Systems

Bin Classification	*Cryptosporidium* concentration (oocysts/L)	Required Additional Action	
	(Maximum RAA)	Conventional Filtration	Direct Filtration
1	< 0.075	None	None
2	0.075–< 1.0	1.0-log treatment	1.5-log treatment
3	1.0–< 3.0	2.0-log treatment*	2.5-log treatment*
4	≥ 3.0	2.5-log treatment*	3.0-log treatment*

* System must provide at least 1.0-log treatment by ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or bank filtration.

Table 5-7. LT2ESWTR Microbial Toolbox Options with Log Credits

Category	Actions	Additional Credit
Watershed Control Program	State-approved program containing specific elements	0.5-log
Alternate Source/Intake Management	Improved management of source water and/or intake location	no credit; may reevaluate bin classification
Prefiltration Components	Bank filtration	0.5 to 1.0-log
	Pre-settling basins with coagulant addition	0.5-log
	Two-stage lime softening	0.5-log
Treatment Performance Components	Combined filter effluent ≤ 0.15 NTU (95% of samples)	0.5-log
	Individual filter effluent ≤ 0.15 NTU (95% of daily maximum NTU samples)	1.0-log
	Demonstration of performance (using state-approved protocol)	Dependent on test results
Inactivation Components	Ultraviolet light	0.5 to 4-log
	Ozone	0.25 to 3-log
	Chlorine Dioxide	0.25 to 3-log
Additional Filtration Components	Bag Filters	Up to 2.0-log
	Cartridge Filters	Up to 2.0-log
	Membrane filtration	Dependent on test results
	Second stage filtration	0.5-log
	Slow sand filtration	2.5-log

Stage 2 Disinfectants and Disinfection Byproducts Rule

USEPA published the Stage 2 D/DBP Rule in August 2003 and finalized it in January 2006. It required some systems to submit an Initial Distribution System Evaluation (IDSE) plan by October 1, 2006, and complete the IDSE report by January 1, 2009. The report must characterize DBP levels in the distribution system and identify monitoring locations for DBPs under Stage 2 D/DBP Rule. The Stage 2 D/DBP Rule bases TTHM and HAA compliance on annual average calculated at each monitoring location and applies to all PWSs, non-transient non-community water systems, and transient non-community water systems that use disinfectants other than ultraviolet light. Regulated contaminants under Stage 2 D/DBP Rule are shown in **Table 5-8**. DDW adopted the Stage 2 D/DBP Rule, effective June 21, 2012.

In January 2013, after three quarters of monitoring, systems were required to begin complying with the rule requirements to determine compliance with the operational evaluation levels (OELs) for TTHMs and HAA5. Operational evaluation requirements are initiated by the TTHM and HAA5 levels found during Stage 2 D/DBP Rule compliance monitoring period. Compliance with the MCLs is based on the average of four individual quarterly DBP measurements collected at a given location, referred to as locational running annual average (LRAA). However, a system that is in compliance with the MCLs, based on the LRAA, may still have individual (i.e., not averaged) DBP measurements at that location that exceed the Stage 2 D/DBP Rule MCLs. USEPA and the Stage 2 Microbial/Disinfection Byproducts Advisory Committee were concerned about these higher levels of DBPs. The operational evaluation requirements of the Stage 2 D/DBP Rule were established to address just these concerns. They are intended as an indicator of operational performance to allow systems to take proactive steps in maintaining compliance with the rule.

Table 5-8. Regulated Contaminants under Stage 2 D/DBP Rule, mg/L

Regulated Contaminants	MCLG	MCL
TTHM		0.080 LRAA
Chloroform	0.07	
Bromodichloromethane	zero	
Dibromochloromethane	0.06	
Bromoform	zero	
HAA5		0.060 LRAA
Monochloroacetic acid	0.07	
Dichloroacetic acid	zero	
Trichloroacetic acid	0.02	
Bromoacetic acid	-	
Dibromoacetic acid	-	

A system exceeds the OEL if one of the following occurs at any compliance monitoring location:

- TTHM compliance monitoring results for the two previous quarters plus two times the TTHM result for the current quarter, divided by 4, exceeds 0.080 mg/L; or
- HAA5 compliance monitoring results for the two previous quarters plus two times the HAA5 result for the current quarter, divided by 4, exceeds 0.060 mg/L.

The formula below determines if an OEL exceedance exists for either TTHM or HAA5.

$$[A + B + (2 * C)] / 4 = D$$

Where:

A = TTHM or HAA5 result for the quarter before the previous quarter (mg/L)
B = TTHM or HAA5 result for the previous quarter (mg/L)
C = TTHM or HAA5 result for the current quarter (mg/L)
D = Operational Evaluation Value (mg/L)
If D for TTHM is > 0.080 mg/L, there is an OEL Exceedance
If D for HAA5 is > 0.060 mg/L, there is an OEL Exceedance

The OELs initiate a comprehensive review of system operations and act as an early warning for a possible Stage 2 D/DBP Rule violation in the following quarter. This early warning allows systems to act to prevent the violation. The Stage 2 D/DBP Rule process for initiating an operational evaluation is not based on health effects information. If a system exceeds an OEL it must report the exceedance to DDW within 10 days of the end of the quarter, conduct an operational evaluation, submit a written report of the evaluation to DDW no later than 90 days after being notified of the analytical result causing the exceedance, keep a copy of the report, and make it available to the public upon request.

New Drinking Water Regulations since the CRWSS 2010 Update

A number of fecal and California MCLs and other regulatory requirements have been revised or added since the CRWSS 2010 Update was completed. **Table 5-9** contains a list of contaminants with new or revised MCLs; revised MCLs that did not result in any change to existing levels are not included. A brief discussion of the regulatory changes follows the tables.

Table 5-9. New or Revised MCLs and Treatment Techniques since the CRWSS 2010 Update

Contaminant	Federal MCL or Requirement	Effective Date	California MCL or Requirement	Effective Date
Inorganics				
Chromium-6	—	—	0.010	7/1/2014
Microbiological				
Cryptosporidium	Monitoring	6/1/2006	Monitoring	7/1/2013
Revised Total Coliform (including *E. coli*)	*E. coli* MCL (see section on Revised Total Coliform Rule)	4/1/2016	Pending Approval	Pending Approval
Disinfectant Residuals, Disinfection Byproducts, and Disinfection Byproduct Precursors				
TTHM –Locational RAA	0.080 mg/L	4/1/2012	0.080 mg/L	6/21/2012
HAA 5– Locational RAA	0.060 mg/L	4/1/2012	0.060 mg/L	6/21/2012

* Revised

[1] Systems serving at least 100,000 people and not conducting *Cryptosporidium* monitoring under LT2ESWTR were required to begin monitoring locational RAA for TTHM and HAA5, under the Stage 2 D/DBP Rule by April 1, 2012.

[2] The Stage 2 D/DBP Rule was adopted for California, effective June 21, 2012.

Chromium-6

On December 31, 2010, OEHHA released a revised draft chromium-6 PHG for public comment. The document revised an earlier draft issued in August 2009 that proposed a PHG of 0.00006 mg/L. The revised draft proposed a PHG of 0.00002 mg/L. New research has documented that young children and other sensitive populations are more susceptible than the general population to health risks from exposure to carcinogens. The changes were recommended by a peer review panel and reflect OEHHA's new guidelines for early-in-life exposures, which acknowledge this susceptibility. On July 27, 2011, OEHHA finalized the document and established the PHG for chromium-6 at 0.00002 mg/L. In August 2013, DDW proposed an MCL of 0.010 mg/L and in April 2014 submitted a regulations package to the Office of Administrative Law (OAL). OAL approved the 0.010 mg/L MCL, effective July 1, 2014. Refer to **Chapter 3** for more information on chromium-6 in Colorado River. Further information on chromium-6 levels in treated plant effluent is provided later in this chapter.

Disinfectant Residuals, Disinfection Byproducts, and Disinfection Byproduct Precursors

Pursuant to federal primary requirements, DDW included revisions in Title 22 to adopt federal requirements under the Stage 2 D/DBP Rule. The Disinfectant Residual, Disinfection Byproducts, and Disinfection Byproduct Precursors (DPH-09-004) changes became effective on June 21, 2012. There were no changes to the MCL for TTHM (0.080 mg/L) or HAA5 (0.060 mg/L). However, the Stage 2 D/DBP Rule modified the monitoring frequencies and requires computation of locational running annual average to determine compliance with the TTHM and HAA5 MCLs.

Revised Total Coliform Rule

USEPA published the final version of the Revised TCR in February 2014 to protect public health by ensuring the integrity of the drinking water distribution system and monitoring for the presence of microbial contamination. USEPA anticipates greater public health protection under the revised requirements, which became effective in April 2016 and are based on recommendations by a federal advisory committee. The revisions to the TCR include the following:

- Upon the presence of a total coliform and/or *E. coli* sample, Level 1 or Level 2 assessments are required to be completed within 30 days of triggering the assessment or within a state-approved timeframe
  - Level 1 assessment for systems taking ≥ 40 samples per month and exceeds 5 percent total coliform positive in the monthly samples
  - Level 1 assessment for systems taking < 40 samples per month and has ≥ 2 total coliform positive results
  - Level 1 assessment for systems that failed to take required repeat sample after any single routine total coliform positive sample
  - Level 2 assessment, conducted either by DDW or a DDW-approved third party, for systems with *E. coli* MCL violation
- Major violations are *E. coli* MCL Violation and Treatment Technique Violation
  - *E. coli* MCL Violation when any of the following occurs: *E. coli* positive repeat sample following a total coliform positive routine sample, total coliform positive repeat sample following an *E. coli* positive routine sample, failure to take all required repeat samples following an *E. coli* positive routine sample, or failure to test for *E. coli* when any repeat sample is total coliform positive
  - Treatment Technique Violation when failure to conduct a Level 1 or Level 2 Assessment within 30 days of a trigger; failure to correct all sanitary defects within 30 days of a trigger or state-approved timeframe

California water systems are required to comply with USEPA's Revised TCR and the California TCR while DDW finalizes its version of the Revised TCR, anticipated in late 2017, for inclusion in Title 22.

Long-Term 2 Enhanced Surface Water Treatment Rule

DDW adopted the federal LT2ESWTR, effective July 1, 2013, including *Cryptosporidium* monitoring and treatment requirements. The federal LT2ESWTR is discussed further in the *Drinking Water Regulations* section of this chapter.

New Public Health Goals

Table 5-10 contains a list of contaminants with new or revised PHGs since the CRWSS 2010 Update; revised PHGs that did not result in any change to existing levels are not included in the tables. The only new PHG was for chromium-6 and the PHGs were revised for chlorobenzene, endothall, hexachlorocyclopentadiene, silvex, and trichlorofluoromethane.

Table 5-10. New or Revised PHGs since the CRWSS 2010 Update

Contaminant	PHG (mg/L) (previous PHG)	Date Published
Chromium-6*	0.00002	7/27/2011
*Chlorobenzene	0.07 (0.2)	4/24/2014
Endothall	0.094 (0.580)	4/24/2014
Hexachlorocyclopentadiene	0.002 (0.05)	4/24/2014
Silvex	0.003 (0.025)	4/24/2014
Trichlorofluoromethane (or Freon 11)	1.3 (0.7)	4/24/2014
Perchlorate	0.001 (0.006)	2/1/2015

* New PHG

PHGs are non-enforceable goals that trigger DDW into setting MCLs for regulated constituents. No new or revised PHG during this CRWSS update period has any impact on the operations at the Diemer, Skinner, and Weymouth plants.

Chromium-6

In March 1999, OEHHA established a PHG of 0.0025 mg/L for total chromium, reflecting a view that chromium-6 as part of total chromium poses a cancer risk when ingested. Per Senate Bill 2127, DDW was required to determine the levels of chromium-6 in drinking water and assess associated exposures and risks to the public. In March 2001, DDW requested OEHHA to establish a PHG for chromium-6, as would be needed for the development of a specific chromium-6 MCL. In August 2009, OEHHA proposed a PHG for chromium-6 at 0.00006 mg/L, based on tumor incidence data from rodent cancer bioassays, and revised the PHG to 0.00002 mg/L after considering early-in-life exposures for cancer potency. On July 27, 2011, OEHHA established the PHG for chromium-6 at 0.00002 mg/L. In August 2013, DDW proposed an MCL of 0.010 mg/L, which was approved by OAL, effective July 1, 2014 as discussed earlier in this section.

Chlorobenzene, Endothall, Hexachlorocyclopentadiene, Silvex, and Trichlorofluoromethane

In November 2013, OEHHA released the first public review draft PHG document for chlorobenzene, endothall, hexachlorocyclopentadiene, silvex, and trichlorofluoromethane. The proposed PHG updates for these constituents was based on non-cancer effects and considered recent toxicological literature. The second draft PHG document was released in March 2014. On April 24, 2014, OEHHA finalized the revised PHGs as 0.070 mg/L for chlorobenzene, 0.094 mg/L for endothall, 0.002 mg/L for hexachlorocyclopentadiene, 0.003 mg/L for silvex, and 1.3 mg/L for trichlorofluoromethane.

Perchlorate

DDW published the notice of proposed rulemaking for perchlorate on September 1, 2006. The regulation was finalized and was put into effect on October 18, 2007. The regulation, based on OEHHA's 2004 PHG of 0.006 mg/L, set an MCL of 0.006 mg/L for perchlorate.

OEHHA identified four sensitive subpopulations in 2004: pregnant women and their fetuses, lactating women, infants, and individuals with thyroid problems. In January 2011, OEHHA proposed a revised perchlorate PHG of 0.001 mg/L based on new research that focused on the effects of perchlorate on infants. On February 1, 2015, OEHHA published the updated perchlorate PHG of 0.001 mg/L.

On February 11, 2011, USEPA decided to regulate perchlorate because it meets SDWA's three criteria for regulating a contaminant: possibility of adverse health effects, significant occurrence data, and meaningful opportunity for health risk reduction. The Natural Resources Defense Council entered into a lawsuit with USEPA in February 2016 claiming USEPA failed to meet the deadlines for promulgating perchlorate regulations. In October 2016, USEPA filed a settlement agreement with NRDC agreeing to issue a proposed perchlorate rule by October 31, 2018 and a final rule by December 19, 2019.

The Colorado River is known to be vulnerable to perchlorate contamination from past chemical manufacturing uses in Nevada. Perchlorate has been detected in CRW at Lake Mead. Remediation efforts to reduce perchlorate from entering Las Vegas Wash are ongoing. More information on perchlorate in the Colorado River can be found in **Chapter 3** and **Chapter 6** of this document. Perchlorate was not detected at any level of concern in Metropolitan's treatment plant effluents during this review period. More information on perchlorate at the water treatment plants can found in the *Individual Water Treatment Plant Evaluations* section of this chapter.

New Notification Levels

Since the CRWSS 2010 Update report was completed, there were no NLs that have been revised or added. There are currently 30 chemicals with NLs, as included in **Appendix O**. Currently, only 1,2,3-trichloropropane is going through the formal regulatory process to develop an MCL. During this reporting period, there was no actual contamination or threat of contamination of CRW by any chemical identified in **Appendix O.**

Anticipated Drinking Water Regulations

USEPA and DDW continue to develop new drinking water regulations. Currently, there are over 90 federally regulated drinking water contaminants. To ensure that USEPA continues to identify and regulate future contaminants, the SDWA includes a process that USEPA must follow to identify and list unregulated contaminants that may require national drinking water regulation in the future. In March 2010, USEPA announced a new Drinking Water Strategy aimed at finding ways to strengthen public health protection from contaminants in drinking water. The new strategy was intended to streamline decision-making, expand protection under existing laws, and promote cost-effective new technologies to meet the needs of rural, urban, and other water-stressed communities.

USEPA's Drinking Water Strategy focuses on the following four principles:

- Address contaminants as groups rather than one at a time so that enhancement of drinking water protection can be achieved cost-effectively
- Foster development of new drinking water technologies to address health risks posed by a broad array of contaminants
- Use the authority of multiple statutes to help protect drinking water
- Partner with states to share more complete data from monitoring at public water systems

As mentioned above, under *New Public Health Goals*, the process for adopting new MCLs in California begins after PHGs are finalized. In 1986, California voters approved an initiative to address their growing concerns about exposure to toxic chemicals. That initiative became the Safe Drinking Water and Toxic Enforcement Act of 1986, better known by its ballot name of Proposition 65. The California State Drinking Water Act of 1996 (Health and Safety Code, Section 116365) requires OEHHA to perform risk assessments and adopt PHGs for contaminants in drinking water based exclusively on public health considerations. DDW uses PHGs adopted by OEHHA to establish state MCLs.

Anticipated federal and California drinking water regulations are discussed below.

Drinking Water Contaminant Candidate List/Unregulated Contaminant Monitoring Rule

The Contaminant Candidate List (CCL) is the primary mechanism for the identification of contaminants that may require regulation while the Unregulated Contaminant Monitoring Rule (UCMR) provides USEPA with the data necessary to determine if a contaminant occurs at a frequency and concentration that would be a public health concern. The CCL and UCMR are coordinated parts of USEPA's risk management process and support each other. The CCL is a list of contaminants that are not regulated by national primary drinking water regulations, but are known or anticipated to occur in drinking water sources and are known or anticipated to adversely affect human health, and may warrant regulation under the SDWA. The UCMR requires CWSs to conduct treated water monitoring of specified unregulated constituents. The data collected through the UCMR are stored in the National Contaminant Occurrence Database (NCOD) to support analysis and review of contaminant occurrence, guide the CCL selection process, and support the administrator's decision to regulate a contaminant in the interest of protecting public health. USEPA is required to update the list every five years, select at least five constituents for evaluation, and determine whether to regulate.

The rule for the first cycle of the UCMR (UCMR 1) was published in September 1999 and required monitoring of 26 contaminants between 2001 and 2003. UCMR 1 consisted of Assessment Monitoring (List 1) and Screening Survey monitoring (List 2). List 1 included 12 chemical contaminants for which analytical methods exist. USEPA had information on their occurrence in drinking water for some PWSs, but not a national estimate of the extent of their occurrence. List 2 contaminants included those for which analytical methods had just been developed and for which USEPA had less occurrence data than the contaminants on List 1. There were 13 organic chemicals and one microorganism monitored for List 2. Monitoring of List 1 contaminants occurred at approximately 2,800 large systems and a representative sample of 800 (out of 66,000) small systems. Monitoring of List 2 contaminants occurred at a randomly selected set of 300 large systems and small systems.

The rule for the second cycle of the UCMR (UCMR 2) was published in January 2007 and required monitoring of 25 contaminants between 2008 and 2010, using five analytical methods. Assessment Monitoring uses common analytical method technologies used by drinking water laboratories. All systems serving more than 10,000 people and 800 representative systems serving 10,000 or fewer people were required to monitor for the 10 List 1 Assessment Monitoring contaminants during a 12-month period between January 2008 to December 2010. List 2 Screening Survey monitoring used specialized analytical method technologies not commonly used by drinking water laboratories. All PWSs serving more than 100,000 people and 800 representative PWSs serving 100,000 or fewer people were required to monitor for the 15 List 2 Screening Survey contaminants during a 12-month period between March 2008 to August 2009.

The third CCL (CCL3) was published in October 2009 and included 104 chemicals or chemical groups and 12 microbiological contaminants. In May 2012, USEPA published UCMR 3 largely based on CCL3 and required monitoring for 30 contaminants within a 12-month period during 2013 to 2015. All systems serving more than 10,000 people and 800 representative systems serving 10,000 or fewer people were required to monitor for the 21 List 1 contaminants. Systems serving more than 100,000 people, 320 randomly selected systems serving 10,001 to 100,000, and 480 randomly selected systems serving 10,000 or fewer were required to monitor the seven List 2 contaminants. A representative sample of 800 PWSs serving 1,000 or fewer people were required to monitor the two List 3 contaminants. UCMR 3 monitoring occurred through December 2015 and the data will be reported through summer 2016. Wholesalers without retail connections, like Metropolitan, were exempt from UCMR 3.

USEPA proposed the fourth CCL (CCL4) on February 4, 2015. CCL4 includes 100 chemicals or chemical groups and 12 microbial contaminants that are not currently regulated under SDWA. USEPA included the following toxins on CCL4: anatoxin-a, cylindrospermopsin and microcystin-LR. Also, USEPA developed health advisories for microcystins and cylindrospermopsin, which recommend levels at or below 0.0003 mg/L for microcystins and 0.0007 mg/L for cylindrospermopsin in drinking water for children pre-school age and younger.

Forty-three of the chemicals on CCL4 are newly nominated and the remaining were included in CCL3. Final publication of CCL4 is anticipated by the end of 2016. USEPA published the fourth UCMR (UCMR 4) on December 20, 2016. UCMR 4 includes 30 chemicals or chemical groups and 10 List 1 cyanotoxins that will be monitored during a 12-month period from January 2018 through December 2020.

California had a regulation that identified nine chemicals under California UCMR, which became effective on January 3, 2001, and was repealed on October 18, 2007. Under the defunct California UCMR, boron, chromium-6, dichlorodifluoromethane, ethyl *tertiary* butyl ether (ETBE), perchlorate, *tertiary* amyl methyl ether (TAME), *tertiary* butyl alcohol (TBA), 1,2,3-trichloropropane (1,2,3-TCP), and vanadium were monitored by all vulnerable community and non-transient non-community water systems. The monitoring results from the UCMR process is being used by DDW for cost estimates of monitoring and treatment, as part of the MCL process, if an MCL is considered appropriate. Perchlorate and chromium-6 are now regulated contaminants and a PHG has been established for 1,2,3-TCP.

Fluoride

On April 27, 2015, the U.S. Department of Health and Human Services (DHHS) announced a final recommendation of 0.7 mg/L to replace the current recommended range of 0.7 to 1.2 mg/L of fluoride in treated drinking water. This updated recommendation is based on USEPA and DHHS scientific assessments to balance the benefits of preventing tooth decay while limiting any unwanted health effects. These scientific assessments will also guide USEPA in making a determination of whether to lower the maximum amount of fluoride allowed in drinking water, which is set to prevent adverse health effects. USEPA is currently reviewing both the primary and secondary standards for fluoride but has not established a timeline for releasing the final recommended fluoride level for drinking water. As the primacy agency, DDW will adopt any new fluoride MCL set by USEPA or set a more stringent fluoride MCL.

N-Nitrosodimethylamine

Neither USEPA nor DDW has established an MCL for *N*-nitrosodimethylamine (NDMA) at this time. In 2002, DDW set NDMA notification and response levels of 10 ng/L and 300 ng/L respectively, as RAA. OEHHA set a PHG of 3 ng/L for NDMA in December 2006. USEPA added NDMA to UCMR 2 in 2007 and included it on the CCL3 in 2009 and the draft CCL4 in 2015. NDMA can be produced and released from industrial sources. NDMA is also formed as a DBP and its concentration tends to increase with increasing distribution system detention time. Under the new DWS described above, USEPA will evaluate how best to address nitrosamines since data from UCMR 2 indicate that these compounds are being found in public water systems. Refer to the section below for information on NDMA in treated water, and **Chapter 3** for information on NDMA in source water.

Revised Lead and Copper Rule

USEPA is currently evaluating and developing supporting materials for a proposed Revised Lead and Copper Rule. The primary goals in considering long-term revisions are to improve the effectiveness of the corrosion control treatment in reducing exposure to lead and copper; and trigger additional actions that equitably reduce the public's exposure to lead and copper when corrosion control treatment alone is not effective. A public meeting was held on November 4, 2010, to obtain stakeholder input on key issues and options to address the issues. In March 2014, the National Drinking Water Advisory Council Lead and Copper Rule Working Group was convened to provide advice on addressing five key issues: sample site selection criteria; lead sampling protocols; public education for copper; measures to ensure optimal corrosion control treatment; and lead service line replacement. The Advisory Council recommendations were submitted to USEPA on December 15, 2015.

A recent lead crisis in Flint, Michigan has increased attention on regulating lead in drinking water. The lead crisis began when the city of Flint changed its drinking water source in April 2014 and did not apply corrosion inhibitors, which resulted in lead contamination, exposing the public to health risks. In its most recent October 2016 White Paper describing regulatory options for the Long-Term Revisions to the Lead and Copper Rule, USEPA indicates evaluating recommendations from the Advisory Council while also giving consideration to experience with the lead crisis in Flint. The White Paper evaluated various issues including replacing lead service lines, improving optimal corrosion control treatment requirements, considering a health-based benchmark, strengthening tap sampling requirements, and increasing transparency and public education requirements.

USEPA anticipates developing a Notice of Proposed Rulemaking of Lead and Copper Rule Revisions for public review in 2017.

Perchlorate

On January 7, 2011, OEHHA released a revised perchlorate PHG of 0.001 mg/L for public comment. On February 1, 2015, OEHHA published the updated perchlorate PHG of 0.001 mg/L. The new PHG is lower than the previous PHG of 0.006 mg/L because it incorporates new information about the effects of perchlorate on infants. As part of their MCL review process, DDW is conducting an in-depth risk management analysis to determine whether or not to propose a revision to the perchlorate MCL of 0.006 mg/L. As mentioned earlier, USEPA intends to publish a proposed perchlorate regulation for public review by October 31, 2018 and a final rule by December 19, 2019.

Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS)

In 2009, USEPA published provisional health advisories for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), both on the CCL3, based on available health assessments at the time. PFOA and PFOS are both surfactants used in consumer products such as carpets, textiles, leather, non-stick cookware, and paper coatings [180]. In 2014, USEPA completed draft health assessments of PFOA and PFOS. The health assessments were based on peer-reviewed studies of the effects of PFOA and PFOS on laboratory animals and epidemiological studies of human populations exposed to these. On May 25, 2016, USEPA announced the release of lifetime health advisories for PFOA and PFOS at 70 parts for trillion. The health advisories provide non- regulatory recommended actions for drinking water systems to assess contamination, notify state drinking water safety agencies, inform the public when water sampling results contain PFOA and PFOS at individual or combined concentrations greater than 70 parts per trillion [181]. USEPA will continue to evaluate PFOA and PFOS as drinking water contaminants in accordance with the SDWA process.

Pharmaceuticals and Personal Care Products

At this time, neither USEPA nor DDW has established MCL(s) for pharmaceuticals and personal care products (PPCPs). Some PPCPs are compounds that interfere with natural hormonal functions; some hormonal chemicals are included in the UCMR 3 Assessment Monitoring list. These chemicals are 17-β-estradiol, 17-α-ethynylestradiol (ethinyl estradiol), 16-α-hydroxyestradiol (estriol), equilin, estrone, testosterone, and 4-androstene-3,17-dione. Currently, there is no evidence of human health risks from long-term exposure to the low concentrations (parts per trillion) of PPCPs found in some drinking water; however, USEPA regulates chemicals upon confirming the possibility of adverse health effects, significant occurrence data, and meaningful opportunity for health risk reduction. Some PPCPs may potentially be regulated in the future. More information on PPCPs can be found in **Chapter 3** of this report.

1,2,3-Trichloropropane (1,2,3-TCP)

In August 2009, OEHHA established a PHG of 0.0000007 mg/L for 1,2,3-Trichloropropane (1,2,3-TCP). 1,2,3-TCP is a carcinogenic chemical found at industrial and hazardous waste sites from uses in cleaning and degreasing solvents as well as pesticide products. A notification level for 1,2,3-TCP of 0.000005 mg/L was established in 1999 after it was detected at a Superfund site, Burbank Operable Unit, in San Fernando Valley. The California UCMR required monitoring of 1,2,3-TCP between 2001 and 2003 and the federal UCMR required monitoring between 2012 and 2015. Monitoring results detected 1,2,3-TCP above the notification level (0.000005 mg/L) in a vast majority of groundwater wells. DDW held public workshops in July 2016 as part of the MCL development process and presented their preliminary recommendation to establish an MCL for 1,2,3-TCP of 0.000005 mg/L due to technical feasibility, economic feasibility, and protection of Public Health [182]. DDW anticipates that an MCL for 1,2,3-TCP would be approved in 2017.

Strontium

In October 2014, USEPA published an initial regulatory determination to regulate strontium from CCL3. Strontium is a naturally-occurring element that is used as strontium carbonate in pyrotechnics, in steel production, as a catalysis, and as a lead scavenger [183]. Per USEPA, elevated levels of strontium can impact bone strength and affect skeletal development. USEPA proposes to reduce the Health Reference Level for strontium from 4.2 mg/L to 1.5 mg/L. On January 4, 2016, USEPA announced a delay in the final determination to regulate strontium in order to consider additional data and decide whether there is a meaningful opportunity for health-risk reduction by regulating strontium in drinking water.

Water Treatment Plant Evaluations

This section evaluates the ability of Metropolitan's three water treatment plants that treat a blend of CRW and SWP water to meet existing and anticipated drinking water regulations. The plants included in these evaluations are the following:

- Robert B. Diemer Water Treatment Plant
- Robert A. Skinner Water Treatment Plant
- F. E. Weymouth Water Treatment Plant

The treatment plant flow diagrams are shown in **Figure 5-2**, **Figure 5-3**, and **Figure 5-4**, respectively, and the plant schematics are included in **Appendix P**. A brief description of each water treatment plant follows.

Description of Treatment Plant Operations

Robert B. Diemer Water Treatment Plant

The Robert B. Diemer Water Treatment Plant (Diemer) is a 520-MGD conventional surface water treatment facility (rapid mix, coagulation, flocculation, sedimentation, filtration, and secondary disinfection) retrofitted with pre-ozonation (primary disinfection). The Diemer plant is comprised of a rapid mixer, eight flocculation basins, eight sedimentation basins, 48 filters, and a 24.2-MG finished water reservoir. In addition, spent washwater is treated in the washwater reclamation plant (WWRP) that is designed to treat 25 MGD of backwash water.

The Diemer plant uses aluminum sulfate as the primary coagulant. Coagulant aid (polyDADMAC) is also added to improve floc formation and floc strength. Coagulant and coagulant aid dosages are adjusted to optimize particle and turbidity removal. Solids removed from the sedimentation process and filter washwater are treated for water reclamation. Filter washwater passes through a coal removal structure that can process 25 MGD flow before entering the WWRP. The WWRP facility has the capability to feed coagulant or polymer at the WWRP influent. WWRP treatment includes flocculation and sedimentation. WWRP effluent is pumped back to the treatment plant influent conduit at the standpipe before ozonation. Solids collected from the sedimentation basins of Diemer plant and WWRP are sent to the solids handling facility where it is thickened, dewatered by belt presses, and trucked offsite for disposal or recycling. Decant from the thickeners and filtrate from the belt presses are pumped to head of WWRP and ultimately recycled to the plant influent at the standpipe. Return backwash is monitored in compliance with FBRR.

Diemer plant treatment processes meet or exceed the disinfection and coagulation-filtration treatment requirements (i.e., turbidity removal) in the California SWTR, which adopted the federal SWTR and IESWTR. The California SWTR requires require 3.0-log removal/inactivation of *Giardia*, 4-log removal/inactivation of viruses, and 2-log removal of *Cryptosporidium* oocysts. Diemer plant is credited with 2.5-log removal of *Giardia*, 2-log removal of viruses, and 2-log removal of *Cryptosporidium* oocysts. The remainder of the required removal/inactivation (0.5- and 2-log for *Giardia* and viruses, respectively) at the Diemer plant is met through disinfection.

In July 2015, the Diemer plant began utilizing ozone as the primary disinfectant for treating blends of CRW and State Water Project water. The main driver for switching to ozone was to maintain compliance with Stage 1 and Stage 2 D/DBP Rules. When Diemer plant switched to using ozone as the primary disinfectant, Diemer plant also switched to the Alternative Compliance Criteria option (source water TOC < 4.0 mg/L, alkalinity > 60 mg/L, TTHM ≤ 0.040 mg/L [40 µg/L] and HAA5 ≤ 0.030 mg/L [30 µg/L]) to satisfy the Stage 1 and Stage 2 D/DBP Rules. Prior to Diemer's ozone retrofit, enhanced coagulation (Step 1 TOC removal) or Step 2 (demonstrating non-amenability for TOC removal) compliance was used to meet the DBP precursor removal requirements of Stage 1 and Stage 2 D/DBP Rules. If a change in source or source water characteristics to the Diemer plant precludes the use of this Alternative Compliance Criteria, Diemer plant still maintains the capability to ensure sufficient TOC removal in order to meet the TT requirements for conventional treatment under Stage 1 and Stage 2 D/DBP Rules. Free chlorine addition can be used when needed for emergency operation or a period of extended loss of ozone production.

With the implementation of ozone disinfection, free chlorine dosage has been eliminated from the flocculation, sedimentation, and filtration processes, except for emergency operation, algae control, or during the loss of ozone production. Without filter influent chlorine addition, the filters operate biologically. In addition, ozonation at the Diemer plant removes source water blend restrictions and enhances taste and odor control in the treatment process. Sulfuric acid addition is located upstream of ozone addition in the standpipe for bromate control or enhanced coagulation. Sodium hypochlorite is automatically injected downstream of ozone and upstream of rapid mix by the plant control system to provide emergency back-up disinfection in the event of an ozone outage.

Total chlorine is the secondary disinfectant at the Diemer plant. A brief free chlorine contact time is provided between the filter effluent and the finished water reservoir for additional disinfection credit. It is injected in the combined filter effluent channel, downstream where the east side filter effluent and west side filter effluent combine and upstream of the finished water reservoir. The free chlorine contact time is used to achieve additional virus disinfection and to inactivate heterotrophic bacteria that may slough off the biological filters. Ammonia and caustic soda are applied downstream from the chlorine injection point in the reservoir influent channel to convert the free chlorine residual to total chlorine as chloramines and adjust treated water pH for corrosion control, respectively. Total chlorine residual is maintained within the finished water reservoir and in the distribution system. Treated water fluoridation began in November 2007. Per DDW's recommendations, on June 1, 2015, Metropolitan reduced the previous fluoride target of 0.8 mg/L to the new optimal fluoride target of 0.7 mg/L (with a new control range of 0.6 to 1.2 mg/L) leaving the Diemer plant.

Diemer plant complied with Round 1 monitoring for the LT2ESWTR, which included plant influent monitoring for *E. coli* and *Cryptosporidium* from October 2006 through September 2008. Round two of treatment plant influent monitoring of *E. coli* and *Cryptosporidium* began April 2015 and will continue through March 2017.

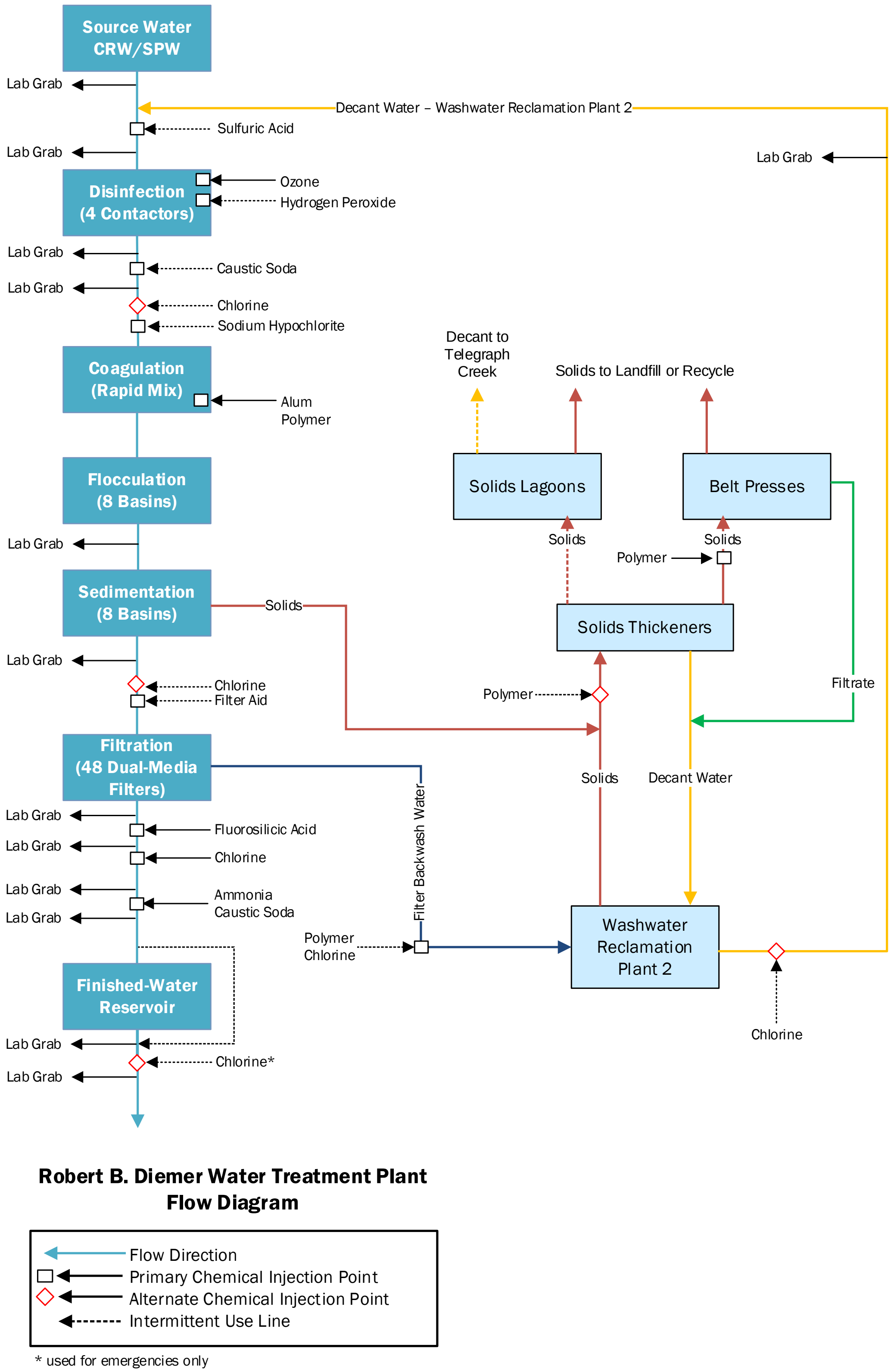


Figure 5-2. Robert B. Diemer Water Treatment Plant Flow Diagram

Robert A. Skinner Water Treatment Plant

The Robert A. Skinner Water Treatment Plant (Skinner) is a 630-MGD surface water treatment facility that operates as three independent plants: Plant No. 1, Plant No. 2, and Plant No. 3. The Skinner plant is comprised of seven modules with a total of 11 flocculation basins, eight settling basins, 124 filters, and a 110-MG finished water reservoir. In addition, spent washwater is treated in the washwater reclamation plant (WWRP) that consists of a pump station rated at 60 MGD; washwater reclamation plant (WWRP 2) is rated at 43.5 MGD capacity and WWRP 3 is rated at 34 MGD. WWRP 1 has been decommissioned. WWRP 2 has three independent treatment trains and WWRP 3 has two independent treatment trains.

Plant No. 1, with three modules (Modules 1–3), and Plant No. 3, with one module (Module 7), provide conventional treatment (rapid mix, coagulation, flocculation, sedimentation, filtration, and disinfection). The design capacity is 75 MGD each for Modules 1 and 2 and 90 MGD for Module 3 for a total design capacity of 240 MGD for Plant 1. Plant No. 2, which consists of three modules (Modules 4–6) is a direct filtration plant because the modules do not have sedimentation basins. Module 4 has a capacity of 80 MGD. Modules 5 and 6 have capacities of 100 MGD each resulting in a total capacity of 280 MGD for Plant 2. Plant No. 3, which was placed into service in 2007, has a capacity of 110 MGD. The Skinner plant has 124 filters with 18 filters per module in Modules 1–6 and 16 filters in Module 7. The original dual-media filters in Modules 1 and 2 have been replaced with tri-media filters while Modules 3 and 4 maintain the original dual-media configuration, with the exception of two filters in Module 3, which were converted to tri-media. Modules 5, 6, and 7 have tri-media filters.

The Skinner plant currently uses ferric chloride as the primary coagulant, but has the capability to use aluminum sulfate. PolyDADMAC (coagulant aid) is added almost simultaneously to improve floc formation and floc strength. Primary coagulant and coagulant aid dosages for both the conventional and direct filtration modules are adjusted to optimize particle count and turbidity removal. Spent washwater passes through a coal (grit) removal structure before entering the WWRPs. Chlorine can be added at the coal removal structure. The WWRP facilities have the capability to feed polymer at the influent and chlorine at the return washwater structure. WWRP treatment includes flocculation and tube settler-assisted sedimentation. WWRP effluent is then pumped back to the influent control structure. Solids collected from the sedimentation basins of Plants 1 and 3, WWRP 2, and WWRP 3 are thickened, dewatered by the belt press, stored in drying beds, and trucked offsite for disposal or recycling. The belt press filtrate and decant water from the thickeners is returned to the influent of the coal removal structure before entering WWRP treatment. Washwater flow is ultimately returned to the influent control structure and mixed with raw water upstream of the ozone contactors and Plants 1, 2, and 3. Return backwash is monitored in compliance with FBRR.

Skinner plant treatment processes meet or exceed the disinfection and coagulation-filtration treatment requirements (i.e., turbidity removal) in the California SWTR, which adopted the federal SWTR and the IESWTR. The California SWTR requires require 3.0-log removal/inactivation of *Giardia*, 4-log removal/inactivation of viruses, and 2-log removal of *Cryptosporidium* oocysts. Skinner plant is credited with 2.5-log removal of *Giardia*, 2-log removal of viruses, and 2-log removal of *Cryptosporidium* oocysts for Plants 1 and 3, which provide conventional treatment, and since Plant 2 uses direct filtration, additional disinfection is required. The remainder of the required removal/inactivation (0.5- and 2-log for *Giardia* and viruses, respectively) at the Skinner plant is met through disinfection.

In October 2010, the Skinner plant became the first of Metropolitan's water treatment plants treating CRW to utilize ozone as a primary disinfectant. The main driver for switching to ozone was to maintain compliance with Stage 1 and Stage 2 D/DBP Rules. When Skinner plant switched to using ozone as the primary disinfectant, Skinner plant also switched to the Alternative Compliance Criteria option (source water TOC < 4.0 mg/L, alkalinity > 60 mg/L, TTHM ≤ 0.040 mg/L [40 μg/L] and HAA5 ≤ 0.030 mg/L [30 μg/L]) to satisfy the Stage 1 and Stage 2 D/DBP Rules. Ozone addition is located upstream of all the plant influents to provide disinfection credit. Prior to Skinner's ozone retrofit, enhanced coagulation (Step 1 TOC removal) or Step 2 (demonstrating non-amenability for TOC removal) compliance was used to meet the DBP precursor removal requirements of Stage 1 and Stage 2 D/DBP Rules. If a change in source or source water characteristics to the Skinner plant precludes the use of this Alternative Compliance Criteria, Skinner plant still maintains the capability to ensure sufficient TOC removal in order to meet the TT requirements for conventional treatment under Stage 1 and Stage 2 D/DBP Rules. Free chlorine addition can be used when needed for emergency operation or a period of extended loss of ozone production.

With the implementation of ozone disinfection, free chlorine dosage has been eliminated from the flocculation, sedimentation, and filtration processes, except for emergency operation, algae control, or during the loss of ozone production. Without filter influent chlorine addition, the filters operate biologically. In addition, ozonation at the Skinner plant removes source water blend restrictions and enhances taste and odor control in the treatment process. Sulfuric acid addition is located upstream of ozone addition for bromate control or enhanced coagulation. Sodium hypochlorite is automatically injected downstream of ozone and upstream of rapid mix by the plant control system to provide emergency back-up disinfection in the event of an ozone outage.

Total chlorine is the secondary disinfectant at the Skinner plant. It is injected at the filter effluent channel, which is common to all three plant effluents, upstream of the finished water reservoir. The free chlorine contact time is used to achieve additional virus disinfection and to inactivate heterotrophic bacteria that may slough off the biological filters. Ammonia and caustic soda are applied downstream from the chlorine injection point in the reservoir influent channel to convert the free chlorine residual to total chlorine as chloramines and adjust treated water pH for corrosion control, respectively. Total chlorine residual is maintained within the finished water reservoir and in the distribution system. Treated water fluoridation began in November 2007. Per DDW's recommendations, on June 1, 2015, Metropolitan reduced the previous fluoride target of 0.8 mg/L to the new optimal fluoride target of 0.7 mg/L (with a new control range of 0.6 to 1.2 mg/L) leaving the Skinner plant.

Skinner plant complied with Round 1 monitoring for the LT2ESWTR, which included plant influent monitoring for *E. coli* and *Cryptosporidium* from October 2006 through September 2008. Round two of treatment plant influent monitoring of *E. coli* and *Cryptosporidium* began April 2015 and will continue through March 2017.

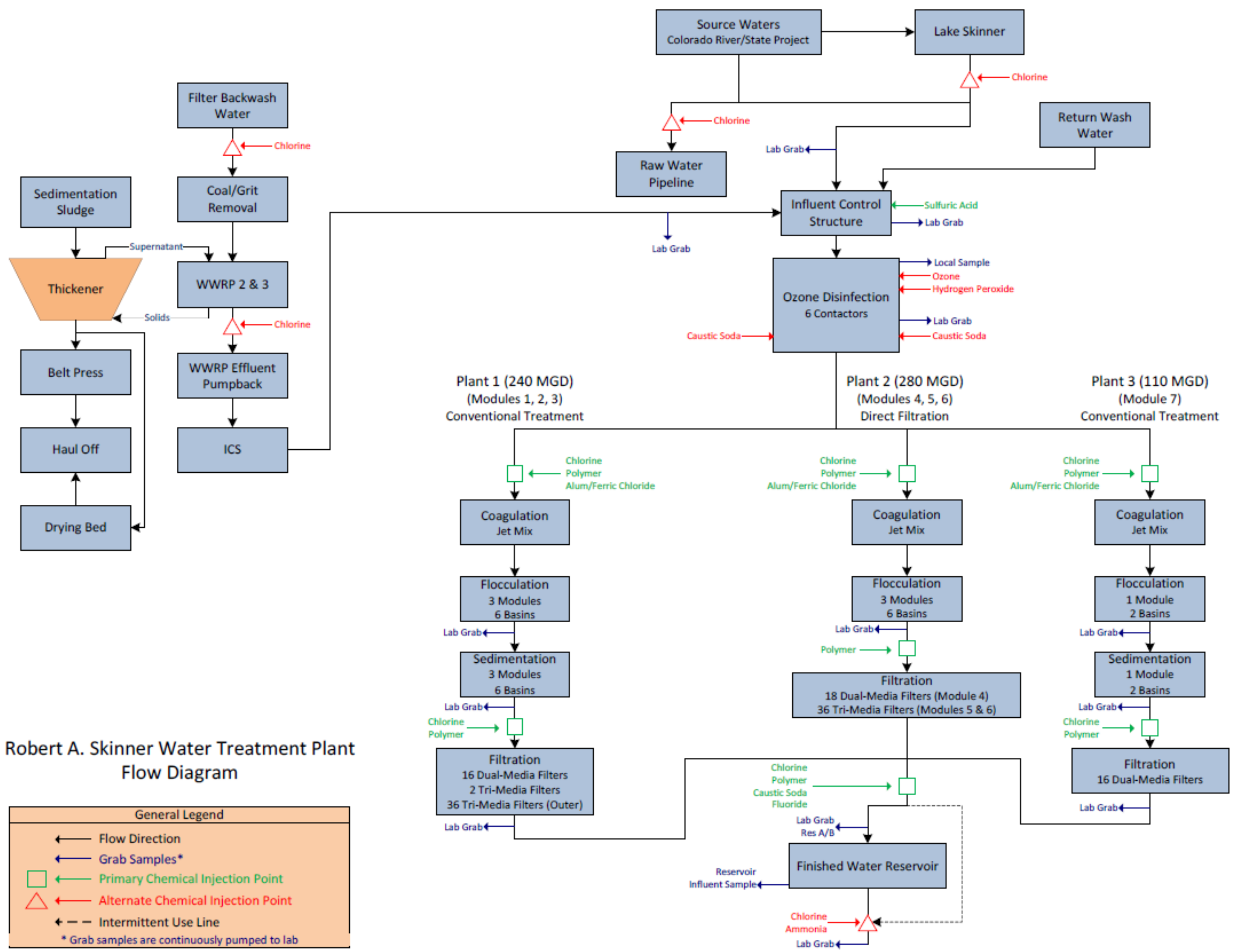


Figure 5-3. Robert A. Skinner Water Treatment Plant Flow Diagram

F. E. Weymouth Water Treatment Plant

The F. E. Weymouth Water Treatment Plant (Weymouth) is a 520-MGD conventional surface water treatment facility. It consists of eight flocculation and sedimentation basins, treatment trains, with a total of eight flocculation basins, eight sedimentation basins, 48 dual-media filters, and a 50-MG finished water reservoir. In addition, the facility has a wash water reclamation plant (WWRP), which can treat 22 MGD of filter backwash water and solids removed from the sedimentation basins.

The Weymouth plant uses aluminum sulfate as the primary coagulant. Coagulant aid (polyDADMAC) is also added to improve floc formation and floc strength. Coagulant and coagulant aid dosages are adjusted to optimize both particle and turbidity removal. Solids removed from the sedimentation process and filter washwater are treated for water reclamation. Filter washwater passes through a vortex coal removal structure that can process 22 MGD flow before entering the WWRP. Currently only the "new" WWRP, referred to as Modules 1 through 3, is in service. The WWRP facility has the capability to feed coagulant or polymer at the WWRP influent and includes flocculation and sedimentation. Supernatant from the reclamation plant sedimentation basins is returned to the treatment plant influent channel immediately following coagulant injection, but before flocculation. Solids collected from the sedimentation basins of Weymouth plant and WWRP are sent to the solids handling facility where it is thickened, dewatered by belt presses, and trucked offsite for disposal or recycling or discharged to a Los Angeles County Sanitation District "brine line". Decant from the thickeners and filtrate from the belt presses are pumped to the sewer or recycled to the WWRP headworks. Return backwash is monitored in compliance with FBRR.

Weymouth plant treatment processes meet or exceed the disinfection and coagulation-filtration treatment requirements (i.e., turbidity removal) in the California SWTR, which adopted the federal SWTR and the IESWTR. The California SWTR requires require 3.0-log removal/inactivation of *Giardia*, 4-log removal/inactivation of viruses, and 2-log removal of *Cryptosporidium* oocysts. Weymouth plant is credited with 2.5-log removal of *Giardia*, 2-log removal of viruses, and 2-log removal of *Cryptosporidium* oocysts. The remainder of the required removal/inactivation (0.5- and 2-log for *Giardia* and viruses, respectively) at the Weymouth plant is met through disinfection.

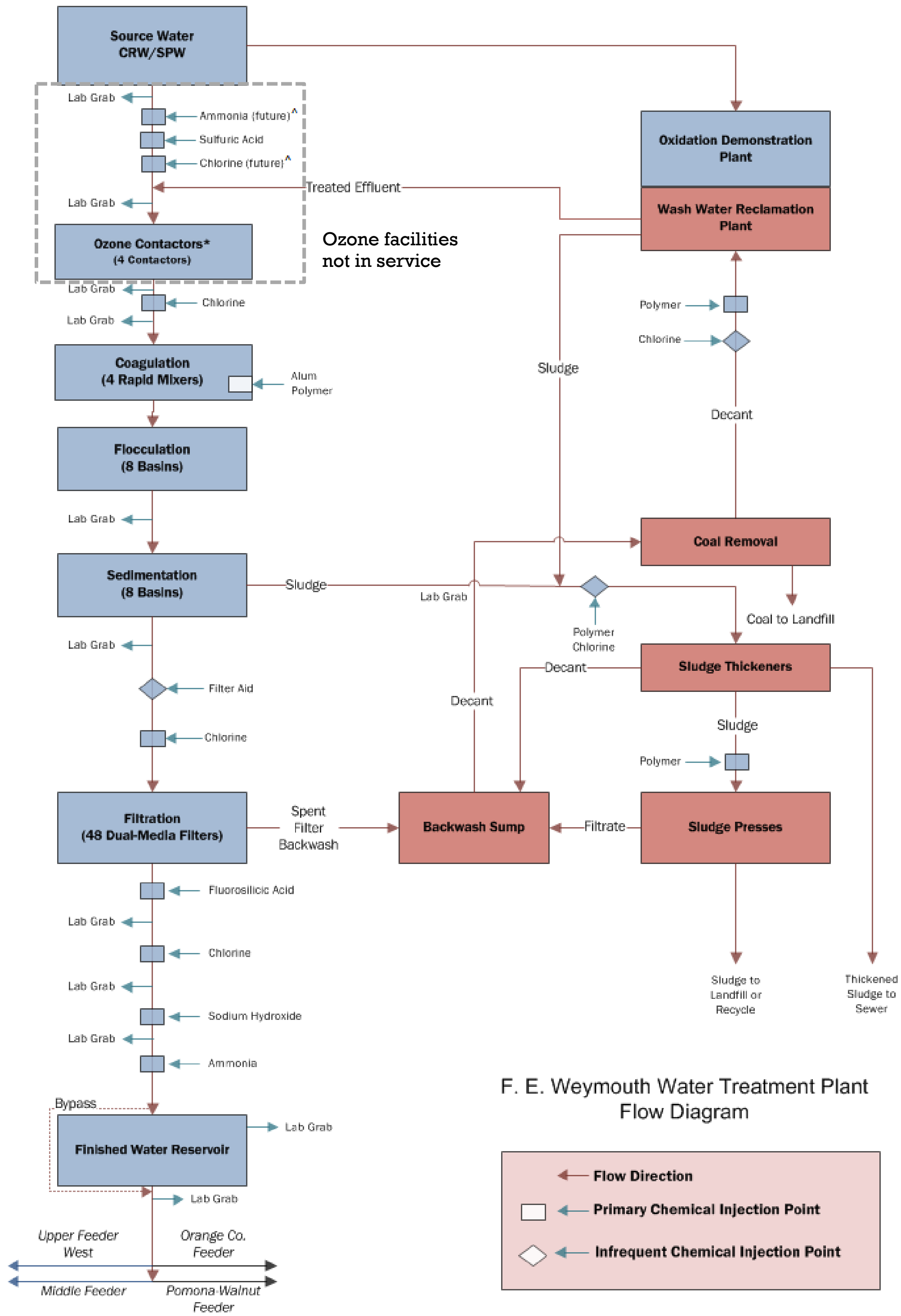
Currently, chlorine is Weymouth's primary disinfectant and is applied so that residual levels are maintained within the operating guidelines. Chlorine can be applied at multiple locations throughout the plant, including the plant influent, filter influent, and combined filter effluent (CFE). Chlorine is typically applied at the plant influent and a free chlorine residual is maintained through the flocculation and sedimentation basin. Chlorine is reapplied at the filter influent to maintain free chlorine within a range of 2.3 to 2.7 mg/L across the filters. Small amounts of chlorine may also be added to the combined filter effluent for trim.

Weymouth plant complies with the DBP precursor removal requirement of Stage 1 and Stage 2 D/DBP Rules using the enhanced coagulation Step 2 method. The use of chlorine to control quagga mussel proliferation in the source water has precluded the use of SUVA as mentioned earlier under Stage 1 and Stage 2 D/DBP Rules. Sulfuric acid can be fed, as necessary, at the plant influent to enhance TOC removal. If chlorination of source water is stopped it would be possible to return to utilizing finished water SUVA of ≤ 2.0 for compliance. Also, if the SPW blends at the plants increase sufficiently, the source water may become amenable to enhanced coagulation. Additional strategies for minimizing DBP formation include conversion to delayed chlorination during warmer months when THM formation is greater.

Currently, chlorine is Weymouth's primary disinfectant used to achieve compliance with *Giardia* and virus inactivation regulations. Chlorine can be applied at multiple locations throughout the plant, including the plant influent, filter influent, and combined filter effluent (CFE). Chlorine is typically applied at the plant influent and a free chlorine residual is maintained through the flocculation and sedimentation basin. Chlorine is reapplied at the filter influent to maintain free chlorine residuals of 2.5 mg/L. Ammonia is applied in the CFE channel to convert free chlorine to chloramines. Chloramine residual is maintained within the finished water reservoir and in the distribution system. These chlorination practices ensure compliance with disinfection regulations while reducing the formation of regulated DBPs. Treated water fluoridation began in November 2007. Per DDW's recommendations, on June 1, 2015, Metropolitan reduced the previous fluoride target of 0.8 mg/L to the new optimal fluoride target of 0.7 mg/L (with a new control range of 0.6 to 1.2 mg/L) leaving the Weymouth plant

Weymouth plant complied with Round 1 monitoring for the LT2ESWTR, which included plant influent monitoring for *E. coli* and *Cryptosporidium* from October 2006 through September 2008. Round two of treatment plant influent monitoring of *E. coli* and *Cryptosporidium* began April 2015 and will continue through March 2017.

Construction of ozone facilities is anticipated to be completed at the end of 2017. When the ozone system is fully operational, ozone will be used as the primary disinfectant. Chlorine will continue to be injected in the CFE to form chloramines and will serve as the backup primary disinfectant. The use of ozone will provide more flexibility for treating a wide range of source water blends, improve taste and odor control, and minimize DBP formation. After ozone is operational, ammonia followed by chlorine may be injected prior to ozonation to minimize bromate formation.



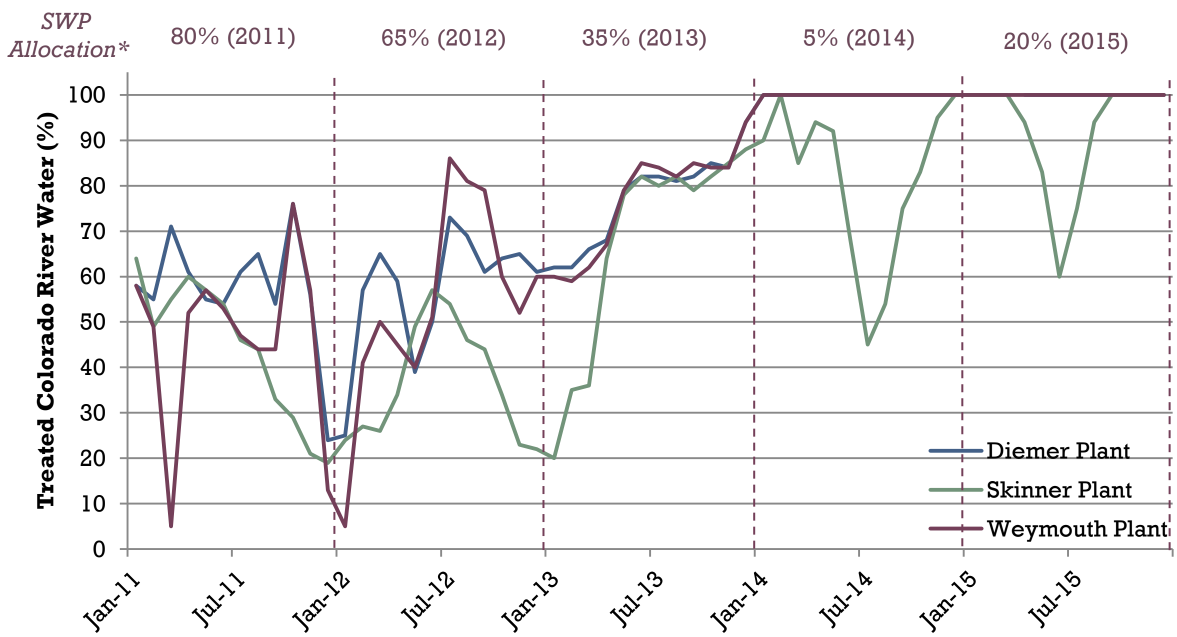
^ Ammonia and chlorine may be injected to form chloramine upstream of ozonation to minimize bromate formation.

* Ozone is not currently dosed in the contactors. Construction of the ozone facilities is anticipated to be completed at the end of 2017.

Figure 5-4. F. E. Weymouth Water Treatment Plant Flow Diagram

Target Blends at Water Treatment Plants

As discussed in Chapter 2, drought conditions have impacted the availability of water supplies, which in turn affect the target blends at the Diemer, Skinner, and Weymouth plants. During the CRWSS reporting period, the annual SWP allocation decreased from 80 percent in 2011 to a historical low of five percent in 2014 (**Figure 5-5**). Under low SWP allocations, Diemer, Skinner, and Weymouth plants treated greater blends of CRW (**Figure 5-5**). In 2014 and 2015, Diemer and Weymouth plants treated 100 percent CRW. As such, water quality at the treatment plants was highly influenced by Colorado River source water quality. Skinner plant received varying levels of SWP water from storage at Diamond Valley Lake and experienced algae related issues as has been attributed to high-nutrient SWP water.



*Represents final SWP allocation for calendar year.

Figure 5-5. Treated Colorado River Water at Treatment Plants, 2011–2015 (%)

Compliance with Drinking Water Regulations

The following section provides an overview of treated water quality compliance data for Metropolitan's three blended water treatment plants. As stated earlier, the three plants are Diemer, Skinner, and Weymouth. **Table 5-25** provides a summary of existing and anticipated drinking water regulations and Metropolitan's compliance status or potential impacts at the three plants.

Constituents are monitored according to DDW-approved *Chemical Compliance Monitoring Plan*, *DBP Monitoring Plan*, *Total Coliform Rule Sample Siting Plan*, and other monitoring requirements of California Title 22. **Table 3-5** provides Metropolitan's baseline compliance reporting schedule for the treatment plant effluents. Metropolitan conducts additional monitoring of some constituents to collect historical data and for an internal review of compliance with anticipated drinking water regulations, as applicable. The water quality data from the three treatment plants, based on regulations under SDWA (**Table 5-1**), constituents with new or revised NLs, and constituents under anticipated drinking water regulations, are presented below. The data summaries are based on routine monitoring that may exceed the frequency of the compliance reporting schedule. Constituents that are not detected at or above the detection limit for purpose of reporting (DLR) are not presented.

It should be noted that all three of Metropolitan's water treatment plants that treat blends of CRW and SWP water comply with the requirements of the monitoring or sampling plans and comply with all drinking water regulations.

Water Quality Summary for Compliance with Drinking Water Regulations

National Primary Drinking Water Regulations

USEPA regulates over 90 constituents in drinking water under the National Primary Drinking Water Regulations (NPDWR), with enforceable MCLs or requiring specific treatment techniques. The regulations group contaminants into six classifications, which include organic contaminants, inorganic contaminants, microbiological contaminants, disinfection byproducts, disinfectants, and radionuclides. Some of the NDPWR constituents are regulated as a group of contaminants under a drinking water rule; these constituents will be discussed later in this section. Constituents regulated as a rule are included in the NPDWR as a subpart in the Code of Federal Regulations and include arsenic, barium, lead, total coliform, radionuclides, and turbidity, which are currently regulated under the *Arsenic Rule*, *Phase II Rule, Lead and Copper Rule, Total Coliform Rule and Revised Total Coliform Rule, Radionuclides Rule, and IESWTR,* respectively. The summary of results for detected constituents at the Diemer, Skinner, and Weymouth plants, under NPDWR, are presented below. The three plants complied with the standards for all regulated contaminants under NPDWR.

Inorganic Constituents

Table 5-11 provides a summary of results for detected inorganic constituents under NPDWR and *California Title 22*.

Table 5-11. Summary of Inorganic Constituents Detected in Diemer, Skinner, and Weymouth Plants under NPDWR, 2011–2015, mg/L

Constituents	MCL*	Plant	Minimum	Median	Average	Maximum
Aluminum[1]	1	Diemer	< 0.050	0.140	0.150	0.340
		Skinner	< 0.050	< 0.050	< 0.050	< 0.050
		Weymouth	< 0.050	0.125	0.131	0.230
Arsenic	0.01 (0.01)	Diemer	< 0.002	0.002	0.002	0.003
		Skinner	< 0.002	< 0.002	< 0.002	< 0.002
		Weymouth	< 0.002	< 0.002	< 0.002	0.003
Barium	1 (2)	Diemer	< 0.100	< 0.100	0.105	0.137
		Skinner	< 0.100	< 0.100	< 0.100	0.136
		Weymouth	< 0.100	< 0.100	0.104	0.139
Fluoride	2 (4)	Diemer	0.8	0.9	0.9	1.0
		Skinner	0.6	0.8	0.8	0.9
		Weymouth	< 0.1	0.8	0.8	1.0
Nitrate (as Nitrogen)	10 (10)	Diemer	< 0.4	< 0.4	< 0.4	0.6
		Skinner	< 0.4	< 0.4	< 0.4	< 0.4
		Weymouth	< 0.4	< 0.4	< 0.4	0.6

* California MCL (Federal MCL)
[1] Aluminum is not a NPDWR; USEPA has a secondary MCL for aluminum of 0.05 to 0.2 mg/L.

Aluminum

California's MCL for aluminum is 1.0 mg/L. Metropolitan collects monthly water samples at the treatment plant effluents for aluminum. Aluminum concentrations for this reporting period ranged from < 0.050 to 0.340 mg/L at the Diemer, Skinner, and Weymouth plants.

Arsenic

Both the federal and California MCL for arsenic is 0.01 mg/L. Metropolitan collects monthly water samples at the treatment plant effluents for arsenic. Arsenic concentrations for this reporting period ranged from < 0.002 to 0.003 mg/L at the Diemer, Skinner, and Weymouth plants.

Barium

The federal MCL for barium is 2.0 mg/L. California's MCL for barium is 1.0 mg/L. Metropolitan collects biannual water samples at the treatment plant effluents for barium. Barium concentrations for this reporting period ranged from < 0.100 to 0.139 mg/L at the Diemer, Skinner, and Weymouth plants.

Chromium-6

Table 5-12 shows the summary of results for chromium-6 from 2011 to 2015. As of July 1, 2014, the California MCL for chromium-6 is 0.010 mg/L.

Table 5-12. Chromium-6 Summary for Diemer, Skinner, and Weymouth Plant Effluents 2011–2015, mg/L

Constituents	MCL	Plant	Minimum (mg/L)	Median (mg/L)	Average (mg/L)	Maximum (mg/L)
Chromium-6	0.010 mg/L	Diemer	0.00004	0.00006	0.00006	0.00012
		Skinner	0.00004	0.00007	0.00008	0.00016
		Weymouth	0.00004	0.00006	0.00007	0.00015

Chromium-6 levels at the plant effluents were between 0.00004 and 0.00016 mg/L. A plume of chromium-6 was discovered in the groundwater near PG&E's Topock Compressor Station near Needles, California in 2003. To date, chromium-6 has only been sporadically detected at low levels in CRW just downstream of PG&E's site. The elevated chromium-6 at the Diemer, Skinner, and Weymouth plants was most likely caused by blending of other source waters, most notably from groundwater pump-in programs along the California SWP system.

Fluoride

The federal MCL for fluoride is 4 mg/L and California's MCL for fluoride is 2.0 mg/L. In April 2015, DHHS recommended that water systems adjust their fluoride content to 0.7 mg/L, as opposed to temperature-dependent optimal levels ranging from 0.7 to 1.2 mg/L based on scientific evidence provided by CDC. The 0.7 mg/L optimal level aims to provide the benefits of fluoridation while minimizing effects of dental fluorosis (teeth discoloration) in children. DDW is consulting with public water systems to amend individual permits to reference CDC's recommended optimal level of 0.7 mg/L, which corresponds with the existing control range of 0.6 to 1.2 mg/L. DDW also plans to develop amendments to the Code of Regulations to incorporate the new CDC recommendation.

On December 21, 2015, Metropolitan submitted a revision to its Fluoridation Plan, updating the plan to reference the new fluoride target goal of 0.7 mg/L (with a new control range of 0.6 to 1.2 mg/L) leaving Metropolitan's treatment plants. Eighty percent or more of daily fluoride samples collected in a month must fall within this range. Metropolitan maintains fluoride concentrations within the optimal range at the Diemer, Skinner, and Weymouth plants, with a maximum of 1.0 mg/L in the period covered by this report.

Nitrate (as Nitrogen)

Both the federal and California MCL for nitrate (as nitrogen) is 10 mg/L. Metropolitan collects monthly water samples at the treatment plant effluents for nitrate (as nitrogen). Nitrate (as nitrogen) concentrations for this reporting period ranged from < 0.4 to 0.6 mg/L at the Diemer, Skinner, and Weymouth plants.

Organic Constituents

No regulated organic constituents other than DBPs were detected in any of the treatment plant effluents during the review period for this CRWSS update. DBPs will be discussed later under *Stage 1 Disinfectants and Disinfection Byproducts Rule*.

Microbiological Constituents

Total coliform results are discussed below under *Total Coliform Rule*.

Radionuclides

Radionuclides results are discussed below under *Radionuclides Rule*.

Phase I, II, and V Standards

The Diemer, Skinner, and Weymouth plants complied with the standards for all regulated contaminants under Phase I, II, and V Standards, which include organic and inorganic compounds.

Constituents under Phase I Standards are eight volatile organic compounds (VOC), none of which is detected in the effluents of the Diemer, Weymouth, or Skinner plants.

Constituents under Phase II Standards include 10 VOCs, 18 SOCs and 10 IOCs. None of the VOCs or SOCs were detected in the effluents of the Diemer, Skinner, or Weymouth plants. Three out of the nine IOCs, barium, fluoride and nitrate (as nitrogen), were detected at maximum levels of 0.139 mg/L, 1.0 mg/L, and 0.6 mg/L, respectively, which is well below their respective MCLs of 1 mg/L, 2 mg/L, and 10 mg/L. These three constituents were part of the original 22 constituents included under NPDWR.

A summary of results for detected constituents under Phase II Standards are presented in **Table 5-11** for inorganic constituents under NPDWR. Phase V Standards include three VOCs, 15 SOCs and 5 IOCs. None of the Phase V constituents was detected at the effluents of the Diemer, Skinner, or Weymouth plants.

Total Coliform Rule

During the reporting period, there were no detections of total coliform and *E. coli* levels at Diemer, Skinner, or Weymouth plant effluents.

A summary of coliform test results within Metropolitan's distribution system is presented in **Table 5-13**. In 2011, two samples in the distribution system were total coliform positive, one out of 823 in August and one out of 679 in October. In 2012 total coliform positive samples occurred in the distribution system in January, April, and May at one out of 674, one out of 656, and four out of 741, respectively. The positive total coliform samples were traced to the Willits Pressure Control Structure, which was disinfected. On any occasion when a routine total coliform sample tests positive, three repeat samples from the same location are collected and tested for coliforms. The process is repeated until all repeat samples are total coliform negative. In 2013, three samples were total coliform positive: one out of 543 in February, one out of 626 in June, and one out of 811 in July. In 2014, six samples were total coliform positive: one out of 687 in January, two out of 743 in July, two out of 729 in September, and one out of 598 in December. In 2015, three samples were total coliform positive: one out of 566 in February, one out of 641 in July, and one out of 697 in September. It is pertinent to mention that no MCL violation occurred during the month when the coliform samples were positive since less than 5.0 percent of the samples collected during the months were positive. With the exception of discovering the source of contamination for the 2012 positive total coliform samples, the reason for each of these positive coliform bacteria results was not apparent.

Table 5-13. Summary of Coliform Test Results within Metropolitan's Distribution System, 2011–2015

Constituents		Total Number of samples collected	Total Number of repeat samples collected	Total Number of Total Coliform positive samples	Maximum Monthly % Total Coliform positive
Total Coliform	2011	8,014	6	2	0.1%
	2012	8,037	12	6	0.5%
	2013	7,981	9	3	0.2%
	2014	7,641	18	6	0.3%
	2015	7,509	9	3	0.2%

Surface Water Treatment Rule

Constituents under the SWTR that apply to the water treatment plants are *Giardia*, turbidity, *Legionella*, viruses, and disinfectant residual. Compliance under the SWTR is based on TTs instead of MCLs. The Diemer, Weymouth, and Skinner plants comply with the TT requirements of the SWTR and always achieve the turbidity requirements and the CT (disinfectant concentration multiplied by contact time) requirements for 3-log (99.9%) reduction for *Giardia* and 4-log (99.99%) reduction for viruses.

The Diemer, Weymouth and Skinner Plants 1 and 3 receive 2.5-log credit for physical removal of *Giardia* and 2.0-log credit for physical removal of viruses because they utilize conventional treatment. The additional 0.5-log inactivation of *Giardia* and 2.0-log inactivation of viruses is achieved through disinfection/inactivation. The Skinner Plant 2 is a direct filtration plant (no sedimentation process); therefore, it receives 2.0-log credit for physical removal of *Giardia* and 1.0-log credit for physical removal of viruses. The additional 1.0-log inactivation of *Giardia* and 3.0-log inactivation of viruses is achieved through disinfection/inactivation.

USEPA indicates that if *Giardia* and viruses are removed or inactivated according to the TTs in the SWTR, *Legionella* will be controlled; therefore, no limit is set for *Legionella*. The SWTR also requires that disinfectant residual entering the distribution system must not fall below 0.2 mg/L for more than 4 hours during any 24-hour period. Metropolitan's target for chlorine residual entering the distribution system from the treatment plants is 2.5 mg/L and it did not fall below 0.2 mg/L at any time in any of the plant effluents during this CRWSS review period. Since turbidity requirements were made more stringent under the IESWTR, results for turbidity are presented under *Interim Enhanced Surface Water Treatment Rule* below.

Metropolitan showed that total coliform enumeration is a poor indicator for pathogens in Metropolitan's water supply sources. DDW agreed that source water weekly *E. coli* median levels that do not exceed 100 MPN per 100 mL would support the 3-log reduction for *Giardia* and 4-log reduction for viruses.

Lead and Copper Rule

Sampling under the Lead and Copper Rule is conducted at taps in homes and other buildings; therefore, the Lead and Copper Rule does not directly apply to Metropolitan's water treatment plant effluents. However, corrosivity of water leaving the treatment plants could potentially impact the level of lead and copper in the distribution system and customer taps. Also, exceedance of the lead or copper action level can trigger other requirements, which include water quality parameter monitoring, corrosion control treatment, source water monitoring/treatment, public education, and lead service line replacement.

Metropolitan adjusts the pH of the plant effluent with a target pH ≥ 8.0, dictated by the Langelier Saturation Index (LSI). A positive LSI is maintained for corrosion control in the distribution system. Neither lead nor copper was detected at the effluent of the Diemer, Skinner, or Weymouth plants.

Stage 1 Disinfectants/Disinfection Byproducts Rule

DBP Precursor – Total Organic Carbon

Table 5-14 provides a summary of the TTs used at the Diemer, Skinner, and Weymouth plants to comply with TOC removal requirements of Stage 1 and 2 D/DBP Rules.

Table 5-14. Summary of Treatment Technique used for TOC removal at Diemer, Skinner, and Weymouth Plants, 2011–2015

Year	Treatment Technique*			
	Plant	Diemer	Skinner	Weymouth
2011	1st Quarter	Step 2	Step 2	Step 2
	2nd Quarter	Step 2	Step 2	Step 2
	3rd Quarter	Step 2	Step 1	Step 2
	4th Quarter	Step 2	Step 1	Step 2
2012	1st Quarter	Step 2	Step 1	Step 2
	2nd Quarter	Step 2	Step 1	Step 2
	3rd Quarter	Step 2	Step 1	Step 2
	4th Quarter	Step 2	Step 1	Step 2
2013	1st Quarter	Step 2	Step 1	Step 2
	2nd Quarter	Step 2	Step 1	Step 2
	3rd Quarter	Step 2	Step 1	Step 2

Year	Treatment Technique*			
	Plant	Diemer	Skinner	Weymouth
	4th Quarter	Step 2	Step 1	Step 2
2014	1st Quarter	Step 2	Step 1	Step 2
	2nd Quarter	Step 2	Step 1	Step 2
	3rd Quarter	Step 2	Step 1	Step 2
	4th Quarter	Step 2	Step 1	Step 2
2015	1st Quarter	Step 2	Step 1	Step 2
	2nd Quarter	Step 2	Step 1	Step 2
	3rd Quarter	Step 1	Step 1	Step 2
	4th Quarter	Step 1	Step 1	Step 2

Step 1 (Alternative Compliance Criteria): TTHM/HAAS ≤ 0.040 mg/L/ 0.030 mg/L and TOC RAA < 4.0 mg/L and alkalinity > 60 mg/L

Step 2 (Alternative Performance Criteria): Jar test showed that the water was not amenable to TOC removal

Metropolitan utilizes different alternative methods, and has complied with the TOC removal requirements of Stage 1 D/DBP Rule at the treatment plants since the inception of the rule in 2002. Metropolitan began using chlorine to control the proliferation of quagga mussels in the CRA, the Lake Skinner outlet conduit, and at the Lake Mathews headworks or outlet tower in July 2007. Since 2007, Metropolitan has used the Step 2 method for compliance due to the effects of chlorinated CRW. As noted in **Table 5-14** , during the reporting period, the Step 2 method was used at Diemer, Skinner, and Weymouth plants until the 3rd quarter of 2011 for Skinner plant and the 2nd quarter of 2015 for Diemer plant, following ozone treatment. With ozone treatment, Diemer and Skinner plants use the 40/30 Alternative Compliance Criteria, which does not require achievement of specified TOC removals when TOC RAA < 4.0 mg/L, alkalinity > 60 mg/L, TTHM RAA ≤ 0.040 mg/L and HAA5 ≤ 0.030 mg/L.

DBPs

Table 5-15 provides a summary of the THM and HAA5 data for the four core distribution system locations of each plant.

Table 5-15. Summary of Distribution System DBP Monitoring Data, 2011–2015, mg/L

	TTHM		HAA5	
	Range	Highest LRAA	Range	Highest LRAA
Diemer Plant				
CM-1	0.023-0.064	0.050	0.006-0.034	0.025
CM-10	0.023-0.061	0.052	0.007-0.035	0.027
OC-88	0.024-0.056	0.052	0.006-0.028	0.024
SA-6	0.023-0.056	0.050	0.002-0.030	0.024
Skinner Plant				
EM-17	0.012-0.066	0.022	0.001-0.013	0.007
SD-1A	0.014-0.035	0.023	0.001-0.013	0.007
SD-7	0.013-0.032	0.024	0.001-0.012	0.007
WR-26	0.014-0.038	0.023	0.001-0.012	0.007
Weymouth Plant				
CenB-14	0.027-0.069	0.061	0.009-0.052	0.034
FM-1	0.030-0.077	0.060	0.008-0.047	0.033
PM-22/9	0.025-0.057	0.050	0.005-0.036	0.026
Ramona PCS	0.030-0.069	0.059	0.008-0.054	0.034

The core locations receive water primarily from their respective treatment plants. It must be noted that in addition to the four core sites for each water treatment plant, a group of primary/central pool locations are also monitored quarterly for THMs and HAA5. **Figure 5-6**, from the IDSE Report, provides the locations of the core and central pool sites. The calculated LRAAs for each of the core locations are below the MCL for TTHM (0.080 mg/L) and MCL for HAA5 (0.060 mg/L), respectively. The maximum LRAAs for the Skinner plant core distribution system locations are generally lower than previously reported numbers in the 2010 CRWSS. This is in contrast to the Diemer and Weymouth plant core locations, where LRAAs have not changed significantly. The decrease in LRAAs in the Skinner plant distribution system can be attributed to less distribution system detention time caused by higher water demand.

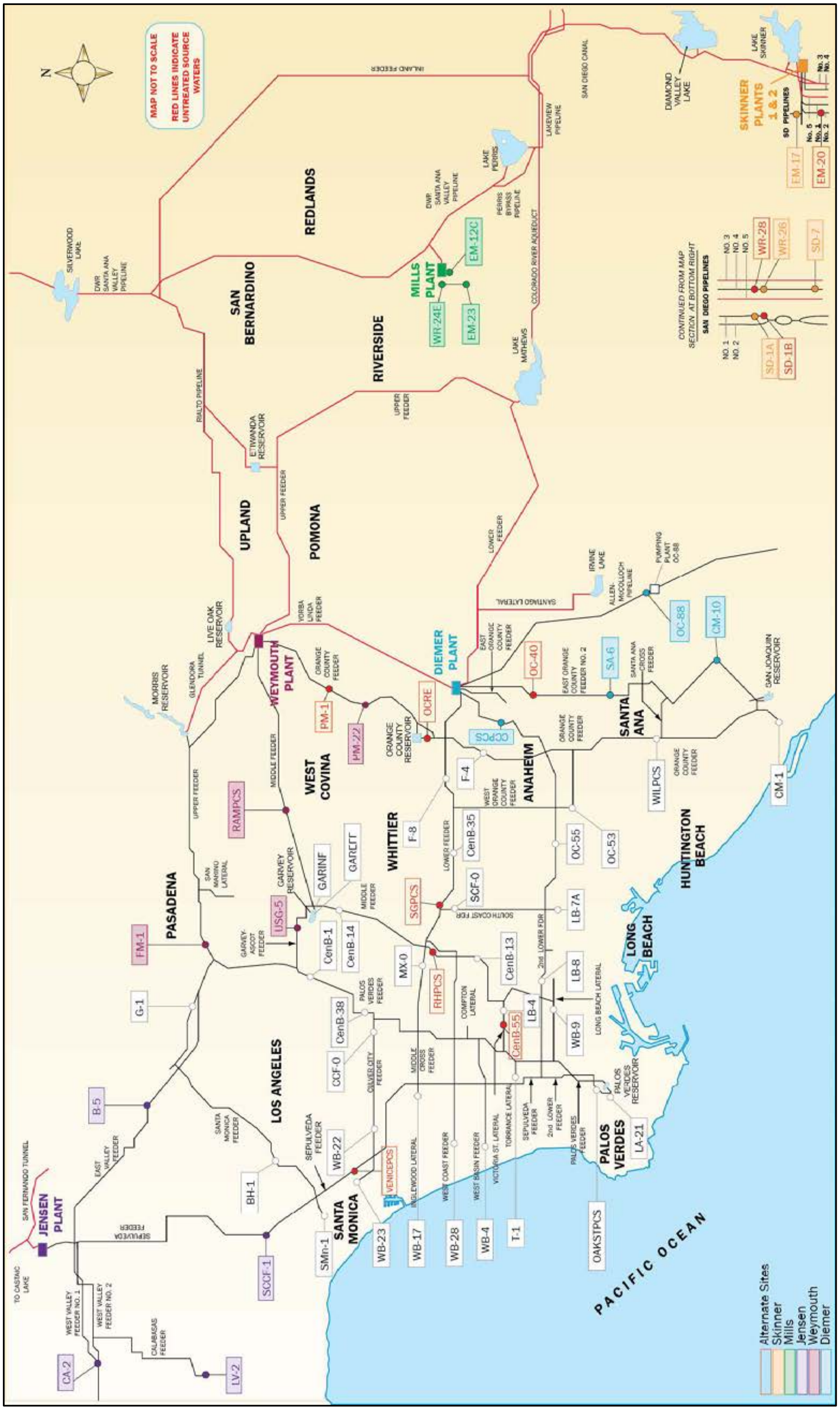


Figure 5-6. Distribution System DBP Monitoring Site Map [211]

A review of the D/DBP Rule monitoring locations shows that Metropolitan's distribution system complies with the MCLs based on a RAA of all quarterly averages. During the reporting period, there were only two individual TTHM results that were ≥ 0.080 mg/L and no individual HAA5 results that were ≥ 0.060 mg/L. The two high TTHM results were from site FM-1, associated with the Weymouth plant, with single TTHM results of 0.080 mg/L and 0.082 mg/L in May 2012. The FM-1 site has maintained LRAA < 0.080 mg/L; therefore, it meets the requirements of the more stringent Stage 2 D/DBP Rule, which became effective in April 2012.

Ozone treatment was implemented at the Skinner plant in October 2010 making it the first plant that treats CRW, or a blend of CRW and SWP water, to use ozone disinfection. Ozone treatment at Diemer plant followed in July 2015 and construction of ozone facilities at Weymouth plant is anticipated to be completed at the end of 2017.

Bromate formation is associated with ozone treatment because ozone reacts with bromide to form bromate. The detection limit for purpose of reporting is 0.001 mg/L while the MCL is 0.010 mg/L as a RAA. During the reporting period, the bromate level ranged from ND–0.012 mg/L with the highest RAA of 0.0065 mg/L for Skinner plant (**Table 5-16**). Monitoring for Diemer plant began in July 2015 when the plant went online, and bromate levels have not been detectable (< 0.001 mg/L) (**Table 5-17**). Skinner and Diemer plants comply with the 0.040 mg/L TTHM/0.030 mg/L HAA5 rule of the Stage 1 D/DBP Rule and the requirements of the Stage 2 D/DBP Rule.

Table 5-16. Summary of Bromate Levels at Skinner Plant Effluent, 2011-2015, mg/L

	MCL	Minimum	Maximum	Median[1]	Highest RAA[2]
Skinner Plant	0.010 mg/L as RAA	< 0.001	0.012	0.0044	0.0065

[1] Median values calculated assuming non-detects (NDs) equaled one-half the RDL
RDL = 0.001 mg/L using USEPA Method 326; quarterly
[2] RAA reflects average of monthly averages for the last 12 months, calculated on a quarterly basis since the 3rd quarter of 2011

Table 5-17. Bromate Levels at Diemer Plant Effluent[1], 2015, mg/L

	MCL	Minimum	Maximum	Median	Highest RAA
Diemer Plant	0.010 mg/L as RAA	< 0.001	< 0.001	NA	NA

[1] Monitoring for bromate at Diemer plant began in July 2015
NA - Not applicable.

Interim Enhanced Surface Water Treatment Rule

Table 5-18 provides a summary of the monthly 95th percentile turbidity data for the combined filter effluent (CFE) of each plant from 2011 to 2015.

Table 5-18. Summary of Monthly 95th Percentile Turbidity Data for Combined Filter Effluent at Diemer, Skinner, and Weymouth Plants 2011–2015, NTU

	Minimum	Median	Average	Maximum
Diemer Plant CFE	0.02	0.04	0.04	0.08
Skinner Plant CFE	0.01	0.04	0.04	0.10
Weymouth Plant CFE	0.02	0.03	0.03	0.07

The IESWTR grants 2.0-log *Cryptosporidium* removal credit for systems with conventional or direct filtration water treatment plants provided turbidity requirements are met under the CFE requirements of the IESWTR (≤ 0.3 NTU in 95 percent of samples based on 15-minute sampling intervals and never to exceed 1 NTU). The plants achieved 100-percent compliance with the IESWTR requirements based on 5-minute sampling intervals. The maximum 95th percentile CFE turbidity of 0.10 NTU occurred at the Skinner plant in July 2015. At the three plants, there were instances when individual filter effluent turbidity exceeded 1.0 NTU in two consecutive measurements taken no more than 15 minutes apart or greater than 0.3 NTU in two consecutive measurements taken no more than 15 minutes apart after 60 minutes of continuous operation. Explanations were included in monthly reports to DDW, for these abnormal filter performances; therefore, no further actions were required. The specific reasons for these instances included filter and module start-up spikes, backwash chlorination valve malfunction, and start-up of a new caustic soda feed line for the CFE channel at the Weymouth plant. When filters spike for the mentioned reasons, other than under start-up conditions, they are taken out of service and backwashed.

The IESWTR requires utilities to complete disinfection profiling and benchmarking to assure that there is no significant reduction in microbial protection as a result of significant disinfection process modifications. The Skinner plant converted from pre-chlorination to pre-ozonation; therefore, disinfection profiling and benchmarking was completed and submitted to DDW prior to implementation of ozone in October 2010. Similarly, disinfection profiling and benchmarking was completed for Diemer plant and submitted to DDW in May 2012 prior to implementation of ozone.

Radionuclides Rule

Metropolitan satisfied the initial compliance monitoring for the Radionuclides Rule by December 31, 2007 as required, and completed the first compliance sampling event in 2008. Radionuclides at any level of concern were not detected. The second and third compliance sampling events were completed during the reporting period in 2011 and 2014, respectively. **Table 5-19** shows the summary of results for gross alpha, gross beta, and uranium for the combined 2011 and 2014 sampling events. Subsequent sampling events will continue to be conducted every three years.

Table 5-19. Summary of Quarterly Radionuclide Data for Diemer, Skinner, and Weymouth Plant Effluents, 2011 and 2014

Constituents	MCL	Plant	Minimum	Median	Average	Maximum
Gross Alpha Emitters	15 pCi/L	Diemer	< 3	< 3	< 3	4.1
		Skinner	< 3	< 3	< 3	5.0
		Weymouth	< 3	< 3	< 3	3.6
Gross Beta Emitters reported as pCi/L	4 mrem/yr*	Diemer	< 4	4.1	4.1	6.5
		Skinner	< 4	4.7	4.3	5.5
		Weymouth	< 4	4.6	4.4	6.1
Uranium	20 pCi/L	Diemer	1.7	2.2	2.2	2.8
		Skinner	1.3	1.8	1.9	2.5
		Weymouth	1.2	2.1	2.1	2.8

* Gross beta concentration of less than 50 pCi/L is considered to be in compliance with the regulation.

Average detected radionuclides at the Diemer, Skinner, and Weymouth plants are well below their respective MCLs. Gross alpha, gross beta, and uranium, sampled four consecutive quarters every 3 years, have MCLs of 15 pCi/L, 4 mrem/yr, and 20 pCi/L, respectively. Gross alpha has a detection limit of 3 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from < 3 to 5.0 pCi/L. Gross beta has a detection limit of 4 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from < 4–6.5 pCi/L. Uranium has a detection limit of 1 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from 1.2–2.8 pCi/L.

Filter Backwash Recycling Rule

Weymouth, Diemer, and Skinner plants have WWRPs that treat filter backwash water, sludge thickener supernatant, and liquids from dewatering processes and return the reclaimed water to the plant influent prior to any treatment in compliance with the FBRR. In addition, DDW established goals that no more than 10 percent of the total plant flow should come from washwater return and that the WWRP effluent turbidity should be less than 2.0 NTU. Metropolitan strives to achieve these goals at its treatment plants. For the December 2015 FBRR form submitted to DDW, the average recycled water turbidities were 0.41 NTU, 0.54 NTU, and 0.73 NTU at the Diemer, Skinner, and Weymouth plants, respectively. The average recycled water flows were 1.2 percent, 13.4 percent, and 2.3 percent at the Diemer, Skinner, and Weymouth plants, respectively.

Arsenic Rule

Table 5-20 shows the summary of results for arsenic from 2011 to 2015. Arsenic was not detected at any level of concern in Metropolitan's treatment plant effluents during this review period. The arsenic MCL, originally set at 0.050 mg/L under NIPDWR, was revised to 0.010 mg/L in 2001. Arsenic was tested monthly at the water treatment plant effluents during the review period for this CRWSS update.

Table 5-20. Summary of Arsenic Data for Diemer, Skinner, and Weymouth Plant Effluents 2011–2015, mg/L

Constituents	MCL	Plant	Minimum	Median	Average	Maximum
Arsenic	0.010 mg/L	Diemer	< 0.002	0.002	0.002	0.003
		Skinner	< 0.002	< 0.002	< 0.002	< 0.002
		Weymouth	< 0.002	< 0.002	< 0.002	0.003

For this reporting period, the maximum arsenic concentration at each of the Diemer and Weymouth plant effluents was 0.003 mg/L, which is well below the MCL. Arsenic was not detected in the Skinner plant effluent at the DLR value of 0.002 mg/L.

Long Term 2 Enhanced Surface Water Treatment Rule

Metropolitan completed Round 1 monitoring under the LT2ESWTR in 2008. Pathogen monitoring at the plant influents between 2006 and 2008 indicated that the Diemer, Skinner, and Weymouth plants fall into Bin 1 classification as *Cryptosporidium* was not detected in any samples over the 24-month period. Therefore, the plants do not require additional actions under the LT2ESWTR (**Appendix Q**). The LT2ESWTR Round 2 monitoring began in April 2015 for the treatment plants. During the period covered by this report, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples. During the period from April 2015 to December 2015, monthly monitoring of treatment plant influents was mandated and reported under the LT2ESWTR Round 2 monitoring. The Round 2 monitoring will continue through March 2017. As required by the LT2ESTWR, *Cryptosporidium* concentrations, turbidity, and *E. coli* concentrations were monitored. *Cryptosporidium* oocysts were not detected in any of the treatment plant influents receiving Colorado River water.

Stage 2 D/DBP Rule

Metropolitan completed and submitted the initial IDSE Report to DDW on September 27, 2006. The Disinfectant/Disinfection Byproducts Compliance Plan was last updated on December 20, 2013 (**Appendix R**). The plan requires monitoring at 50 locations for Stage 1 and Stage 2 D/DBP Rules; the locations covered by each of Metropolitan's treatment plants were approved by DDW in 2009. Metropolitan had already been monitoring the 50 locations under Stage 1 D/DBP Rule, prior to Stage 2 compliance beginning in April 2012 and results have shown that Metropolitan complies with the LRAA of TTHM (0.080 mg/L) and HAA5 (0.060 mg/L) for each monitoring location under Stage 2 D/DBP Rule.

To further ensure compliance with the Stage 2 D/DBP Rule, Metropolitan has implemented ozone disinfection at the Skinner plant in 2010 and at Diemer plant in 2015, which both treat a blend of Colorado River and SWP water. Metropolitan is also in the process constructing ozone facilities at the Weymouth plant. By using ozone in place of chlorine as the primary disinfectant, the formation of TTHMs and HAA5 will be reduced significantly. These treatment modifications will ensure compliance with both current and proposed disinfection requirements and DBP regulations.

Perchlorate

California's MCL for perchlorate is 0.006 mg/L effective October 2007. USEPA has no MCL for perchlorate at this time. Perchlorate samples are collected quarterly at the treatment plant effluent. Perchlorate was detected at 0.004 mg/L and 0.005 mg/L at the Diemer and Skinner plants, respectively, during California UCMR monitoring in 2004. This is attributed to perchlorate entering the Colorado River via Las Vegas Wash at that time. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants at the DLR of 0.004 mg/L during the reporting period for this CRWSS update (2011–2015). More information about perchlorate in the Colorado River can be found in **Chapter 3** and **Chapter 6** of this report.

National Secondary Drinking Water Regulations

Summary of results for detected constituents under the NSDWRs and California Title 22 are presented in **Table 5-21**. All constituents complied with their respective secondary MCLs except at the Skinner plant and Weymouth plant where the threshold odor number (TON) was higher than the recommended secondary MCL of 3 TON. The TON test is conducted under controlled conditions at 60 °C, which may exacerbate odors that would not be detected at ambient temperature. In addition to TON, Metropolitan voluntarily conducts weekly aesthetic evaluations of both odor and flavor using the flavor profile analysis (FPA) method. FPA is conducted at ambient temperature and employs a panel of highly trained sensory assessors.

The Skinner plant effluent exceeded the recommended secondary MCL of 3 TON in April 2008 and quarterly samples were collected until the 1st quarter of 2012 when the running annual average (RAA) for TON was at or below 3 TON. An intensive investigation was conducted to determine the source and cause for increased TON, but no sources were found and the event dissipated naturally. In April 2013, the Weymouth plant effluent exceeded the recommended secondary MCL of 3 TON and quarterly samples were collected until the 2nd quarter of 2014 when the RAA for TON was at or below 3 TON. There were no significant treatment or water quality changes during this period and no specific cause was identified for the increase in TON. During this period, the FPA did not indicate any odor events. In addition, the elevated TON did not extend to Skinner's or Weymouth's distribution system, and there were no consumer complaints. Annual sampling resumed in April 2015 and the TON was below 3 TON at Diemer, Skinner, and Weymouth treatment plants.

Table 5-21. Summary of constituents detected at Diemer, Skinner, and Weymouth Plants under Secondary Drinking Water Regulation, 2011–2015

Constituents	SMCL*	Plant	Minimum	Median	Average	Maximum
Aluminum[1]	0.2 mg/L	Diemer	< 0.050	0.140	0.150	0.340
		Skinner	< 0.050	< 0.050	< 0.050	< 0.050
		Weymouth	< 0.050	0.125	0.131	0.230
Chloride	250–500 mg/L	Diemer	47	87	85	102
		Skinner	58	86	85	108
		Weymouth	38	87	84	103
Color	15 units	Diemer	0	1	1	2
		Skinner	1	1	1	2
		Weymouth	1	1	1	2
Corrosivity[2]	Non-Corrosive	Diemer	0.17	0.49	0.45	0.69
		Skinner	0.09	0.51	0.50	0.94
		Weymouth	0.05	0.46	0.40	0.64
Odor	3 TON	Diemer	1	2	2	3
		Skinner	1	3	5	24
		Weymouth	2	2	3	6
Specific Conductance	900–1,600 µS/cm	Diemer	487	893	880	1070
		Skinner	468	832	807	1080
		Weymouth	370	893	861	1080
Sulfate	250–500 mg/L	Diemer	81	203	196	263
		Skinner	49	165	161	258
		Weymouth	43	198	189	264
TDS	500–1,000 mg/L	Diemer	276	541	529	664
		Skinner	261	488	478	668
		Weymouth	214	533	517	668

* Lower number of the range is the recommended consumer acceptance level while the higher number is the upper limit for consumer acceptance

1 Aluminum has both primary and secondary standards

2 Saturation (Langelier) Index - positive indices indicate the tendency to precipitate and/or deposit scale on pipes and are assumed to be non-corrosive. Negative indices indicate the tendency to dissolve calcium carbonate and are assumed to be corrosive

Aluminum, which has a secondary MCL of 0.2 mg/L with compliance based on Running Annual Average (RAA), ranged from < 0.050–0.340 mg/L at the treatment plant effluents with the highest single treatment plant RAA of 0.167 mg/L at Diemer plant. Chloride levels for the treatment plant effluents ranged from 38-108 mg/L, which is well below the recommended consumer acceptance level for chloride (i.e., the lower secondary MCL limit) of 250 mg/L. Color for the treatment plant effluents ranged from 0–2 units for the treatment plant effluents, below the MCL of 15 units.

Specific conductance and total dissolved solids (TDS) vary from year to year, mostly because of the blending of CRW and SWP water, but they are always below the upper limits of their respective consumer acceptance range of 1,600 µS/cm and 1,000 mg/L. Between 2011 and 2015, treated water specific conductance ranged from 370–1,080 µS/cm and TDS ranged from 214–668 mg/L. The availability of SWP supplies has decreased in recent years due to drought conditions and Delta pumping restrictions. Under low SWP allocations, Metropolitan has increased its reliance on higher salinity CRW to meet water demands. As a result, the plant effluent TDS at the Diemer, Skinner, and Weymouth plants has increased, primarily exceeding 500 mg/L since April 2013 and reflecting CRW salinity levels under no blend conditions. Since sulfate is the primary component of TDS in Colorado River water, sulfate trends are similar to TDS trends. Sulfate levels at the treatment plant effluents ranged from 43 to 264 mg/L, below the upper limit of the consumer acceptance level of 500 mg/L.

At the treatment plant effluents, the saturation index is maintained in the positive range, as a distribution system corrosion control measure, with a target finished water pH ≥ 8.0.

Water Quality Summary for Constituents under Anticipated Drinking Water Regulations

Fluoride

A summary of results for fluoride at the Diemer, Skinner, and Weymouth plants was presented under *Compliance with Drinking Water Regulations* earlier in this section. Metropolitan maintains plant effluent fluoride concentrations within the current recommended optimal range of 0.6 to 1.2 mg/L with a maximum of 1.0 mg/L and did not exceed California's fluoride MCL of 2.0 mg/L in the period covered by this report. As mentioned earlier, on January 7, 2011, DHHS proposed a recommendation of 0.7 mg/L to replace the current recommended range of fluoride in treated drinking water. Metropolitan will make necessary adjustments at each of the water treatment plants to feed fluoride at the level recommended in the future. No impact is expected.

NDMA

Table 5-22 provides the summary of results for NDMA at the water treatment plant effluents and some distribution system locations, between 2011 and 2015. There is no federal or state MCL for NDMA.

Table 5-22. NDMA Summary under Voluntary Monitoring for Plants and some Distribution System Locations, 2011–2015, ng/L

NL as RAA ng/L	Plant & Distribution System Locations	Minimum	Median	Average	Maximum	Highest RAA
10	Diemer plant	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
	SA-6	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
	CM-1	2.1	3	3.2	5.5	3
	Skinner plant	< 2.0	3	3.4	6.5	3.6
	EM-17	2.7	3.5	4.6	11	3.7
	SD-7	2.0	3.6	4.0	8.4	5
	Weymouth plant	2.5	2.5	2.5	2.5	< 2.0
	PM-22	< 2.0	< 2.0	< 2.0	< 2.0	2.9
	CenB-14	< 2.0	3.0	3.1	5.3	4.5
	Garvey Res. Influent	< 2.0	2.4	2.6	3.5	2
	Garvey Res. Effluent	< 2.0	3.1	3.5	6.7	4.2
	FM-1	< 2.0	2.1	2.4	3.3	2.4

California's NL for NDMA is 10 ng/L as RAA. Metropolitan began voluntarily sampling NDMA on a quarterly basis in 2005 and completed special monitoring under UCMR 2 in 2008. Since 2014, Metropolitan has conducted voluntary NDMA monitoring at treatment plant effluents and representative distribution system locations twice per year. During the CRWSS reporting period, NDMA did not exceed 10 ng/L as RAA at any monitoring location.

Under voluntary monitoring, Diemer plant effluent had an NDMA peak concentration of < 2 ng/L and Diemer's distribution system had NDMA concentrations ranging from < 2 to 5.5 ng/L. The Skinner plant effluent had an NDMA peak concentration of 6.5 ng/L and Skinner's distribution system had NDMA concentrations ranging from 2.0 to 11 ng/L. The Weymouth plant effluent had an NDMA peak concentration of 2.5 ng/L and Weymouth's distribution system had NDMA concentrations ranging from < 2 to 6.7 ng/L. In general, NDMA concentration tends to increase with increasing distribution system detention time. A future NDMA MCL will determine Metropolitan's strategy for compliance.

Perchlorate

As mentioned under *Perchlorate* above, perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants during the reporting period for this CRWSS update. Perchlorate's DLR is 0.004 mg/L and the current California perchlorate MCL is 0.006 mg/L. A revised perchlorate MCL may be established in the future in response to the January 7, 2011, revised draft perchlorate PHG of 0.001 mg/L by OEHHA. USEPA intends to publish a proposed perchlorate regulation for public review by October 31, 2018, and a final rule by December 19, 2019. Maintaining low perchlorate levels in the Colorado River through remediation efforts in Henderson, Nevada will be crucial in meeting a potentially more stringent perchlorate MCL in the future. Metropolitan's compliance strategy will be based on the future MCL.

PPCPs

PPCPs, together with other organic wastewater contaminants (OWCs) such as pesticides and polycyclic aromatic hydrocarbons (PAHs), are a group of Constituents of Emerging Concern (CECs), and are not currently regulated at either the Federal or the State levels. In the CRWSS 2005 Update, PPCPs were identified as a class of constituents of interest. Metropolitan had implemented a monitoring program since 2007 to determine the occurrence of PPCPs in Metropolitan's source waters and treatment plant effluents. The monitoring frequency was semi-annual in 2011, and annual from 2012 to 2015. The results from Diemer, Skinner, and Weymouth plant effluents are shown in **Table 5-23** for 2011–2014, as tested by Metropolitan, and **Table 5-24** for 2015, as reported by a contract library.

The highest concentration detected in treated effluents was 790 ng/L of sucralose at the Weymouth plant in 2015. Sucralose (together with acesulfame-K) is an artificial sweetener often used as a wastewater indicator to estimate the contribution of treated wastewater effluents in a given sample. Sucralose concentration at 790 ng/L indicated that treated wastewater discharges comprised approximately 2.9 percent of the sample, based on a previously published average value of 27,000 ng/L in treated wastewater effluents [184].

Diuron, an herbicide, had the second highest concentration of 720 ng/L in a sample collected at the Diemer plant in 2011. Diuron is commonly used in California and is frequently detected in SWP water samples. There is no MCL for diuron.

Overall, only a limited number of PPCPs were detected. When detected, the concentrations in treated effluent samples were generally in the low ng/L range, much lower than applicable MCLs. Detected concentrations of pharmaceutical chemicals were found orders of magnitude lower than therapeutic doses, which are in milligrams per dose. If PPCPs are eventually regulated, Metropolitan's compliance strategy will be based on the future MCL.

1,2,3-TCP

As discussed under the *Anticipated Drinking Water Regulations* section, DDW has recommended an MCL for 1,2,3-TCP of 0.000005 mg/L. Metropolitan completed compliance monitoring under the UCMR regulation and continues to conduct internal monitoring of 1,2,3-TCP. 1,2,3-TCP has not been detected in any samples. Metropolitan will begin compliance monitoring for1,2,3-TCP after the drinking water standard is adopted.

Strontium

As discussed under the *Anticipated Drinking Water Regulations* section, USEPA proposes to reduce the Health Reference Level for strontium from 4.2 mg/L to 1.5 mg/L. In addition to monitoring for gross alpha, gross beta, and uranium, as discussed under the *Radionuclides Rule* section, Metropolitan also monitored for strontium during the reporting period. The strontium levels in Diemer, Skinner, and Weymouth plant effluents were between 0.4 and 1.2 mg/L, below the proposed Health Reference Level of 1.5 mg/L for strontium.

Table 5-23. Detected PPCPs and OWCs at Diemer, Skinner, and Weymouth Plant Effluents, 2011–2014*

Analyte	Use	# of Samples	Detection Frequency (percent)	Minimum Concentration	Median Concentration	Maximum Concentration
Atrazine	Herbicide	9	33	< 1	< 1	3.4
Caffeine	Stimulant	15	40	< 5	< 5	15
DEET (Diethyltoluamide)	Insect repellant	15	47	<2	<2	4.4
Diuron	Herbicide	15	67	< 5	12	720
Primidone	Anti-convulsant	15	13	< 2	<2	2.7
Sulfamethoxazole	Antibiotic	15	7	<1	<1	5.5
TCEP (tris 2- chlorethyl)-phosphate	Flame retardant	15	7	< 3	< 3	3.1

* Analytes that were not detected are not shown in this table. Nineteen PPCPs and OWCs were analyzed in 2011, 20 were analyzed in 2012, and 11 were analyzed in 2013 and 2014.

Table 5-24. Detected PPCPs and OWCs at Diemer, Skinner, and Weymouth Plant Effluents, 2015*

Analyte	Use	Number of Samples	Detection Frequency (percent)	Minimum Concentration (ng/L)	Median Concentration (ng/L)	Maximum Concentration (ng/L)
Acesulfame-K	Artificial sweetener	3	100	47	51	83
Caffeine	Stimulant	3	33	<5	<5	210
Sucralose‡	Artificial sweetener	3	100	520	730	790

* Analytes that were not detected are not shown in this table. Ninety-five PPCPs and OWCs were analyzed in 2015 by a contract laboratory.

Table 5-25. Diemer, Skinner, and Weymouth Water Treatment Plants - Drinking Water Regulatory Compliance

Existing Regulations	Compliance Status
National Primary/Secondary Drinking Water Regulations	All three plants complied with the standards for all regulated contaminants under NPDWR. At the Skinner plant and Weymouth plant, threshold odor number (TON) sometimes exceeded the SMCL limit of 3 under the NSDWR. The odor did not extend into the distribution system.
Phases I, II, and V Standards	All three plants complied with the standards for all regulated contaminants under Phase I, II, and V.
Total Coliform Rule	All three plants complied with the standards under the Total Coliform Rule. Under the Total Coliform Rule, no more than 5.0 percent of the samples collected from the distribution system during the month can be positive for total coliform bacteria.
Surface Water Treatment Rule	All operating, monitoring, and reporting requirements under the SWTR are met at each of the three plants. Therefore, 3-log and 4-log removal of *Giardia* and viruses are achieved.
Lead and Copper Rule	Metropolitan adjusts the pH of the plant effluent with a target pH ≥ 8.0, dictated by the LSI. A positive LSI is maintained for corrosion control in the distribution system.
Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule	All three plants complied with TT requirements of Stage 1 and Stage 2 D/DBP Rules. During the reporting period, the Step 2 method was used at Diemer, Skinner, and Weymouth plants until the 3rd quarter of 2011 for Skinner plant and the 2nd quarter of 2015 for Diemer plant, following ozone treatment. With ozone treatment, Diemer and Skinner plants use the 40/30 Alternative Compliance Criteria which does not require achievement of specified TOC removals when TOC LRAA < 4.0 mg/L, alkalinity > 60 mg/L, TTHM LRAA ≤ 0.040 mg/L and HAA5 LRAA ≤ 0.030 mg/L.
Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rule – Round 2 Monitoring	All three plants were classified as Bin 1 under Round 1 LT2ESWTR monitoring, and required no additional treatment for compliance with regulations. The Round 2 monitoring began in April 2015 and will continue through March 2017. During the period covered by this report, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples.
Interim Enhanced Surface Water Treatment Rule	All three plants meet treated water turbidity standards (combined filter effluent turbidity below 0.3 NTU ≥ 95 percent of the time); therefore, 2-log reduction credit for *Cryptosporidium* was achieved. There were instances when individual filter effluent turbidity exceeded 1.0 NTU in two consecutive measurements taken no more than 15 minutes apart or greater than 0.3 NTU in two consecutive measurements taken no more than 15 minutes apart after 60 minutes of continuous operation. Explanations for these abnormal filter performances were provided to DDW; no further actions were required. All monitoring and reporting requirements are met.
Radionuclides Rule	All three plants completed the required 4 consecutive quarters of monitoring in 2011 and 2014 at entry points to the distribution system. Subsequent sampling will continue to be conducted every three years. All levels are below MCLs.
Filter Backwash Recycling Rule	Filter backwash water and sludge thickener supernatant are treated at the washwater reclamation plants of each of the three plants and returned upstream of any treatment process in compliance with the FBRR.

Table 5-25. Diemer, Skinner, and Weymouth Water Treatment Plants - Drinking Water Regulatory Compliance continued

Existing Regulations	**Compliance Status**
Arsenic Rule	All three plant effluents complied with the MCL for arsenic (0.010 mg/L) between 2011 and 2015; arsenic levels were ≤ 0.003 mg/L.
Perchlorate	All results from the three plant effluents between 2011 and 2015 are less than the DLR of 0.004 mg/L. The MCL is 0.006 mg/L.
Chromium-6	All three plant effluents complied with the MCL for chromium-6 (0.010 mg/L), which became effective July 1, 2014.
Anticipated Regulations	**Anticipated Compliance**
Drinking Water Contaminant Candidate List/Unregulated Contaminant Monitoring Rule 4	USEPA published the UCMR 4 on December 201, 2016. UCMR 4 includes 30 chemicals or chemical groups and 10 List 1 cyanotoxins. Metropolitan is not required to monitor under UCMR 4; therefore, no impact is expected at any of the three plants.
Fluoride	On January 7, 2011, DHHS proposed a recommendation of 0.7 mg/L to replace the current recommended range of fluoride in treated drinking water. Metropolitan will make necessary adjustments at each of the water treatment plants to feed fluoride at the approved level in the future. Currently, Metropolitan maintains plant effluent fluoride concentrations within the current recommended optimal range of 0.6 to 1.2 mg/L with a maximum of 1.0 mg/L and did not exceed California's fluoride MCL of 2.0 mg/L in the period covered by this report.
N-Nitrosodimethylamine (NDMA)	NDMA for all three plant effluents ranged from ND (< 0.2 ng/L) to 6.5 ng/L, below California's NL for NDMA of 10 ng/L as RAA. A future NDMA MCL will determine Metropolitan's strategy for compliance.
Perchlorate	Perchlorate was not detected at any of the three plant effluents. Perchlorate's DLR is 0.004 mg/L and the current California perchlorate MCL is 0.006 mg/L; USEPA proposes to develop a federal MCL by 2019. Maintaining low perchlorate levels in the Colorado River through remediation efforts in Henderson, Nevada will be crucial in meeting a potentially more stringent perchlorate MCL in the future. Metropolitan's compliance strategy will be based on the future MCL.
PPCPs	Existing analytical methods indicate that PPCP detections are at levels that are too low to create any health concerns. No impact is expected; however, the compliance strategy will be based on possible future regulation.
1,2,3-TCP	Metropolitan completed compliance monitoring under the UCMR regulation and continues to conduct internal monitoring of 1,2,3-TCP. 1,2,3-TCP has not been detected in any samples. Metropolitan will begin compliance monitoring for1,2,3-TCP after the drinking water standard is adopted.
Strontium	The strontium levels in Diemer, Skinner, and Weymouth plant effluents were between 0.4 and 1.2 mg/L, below the proposed Health Reference Level of 1.5 mg/L for strontium. Metropolitan's compliance strategy will be based on possible future regulation.

Findings and Conclusions

Metropolitan's treatment plants treating CRW (blended with SWP water) meet all the regulations under the Safe Drinking Water Act.

- Since the implementation of Metropolitan's IESWTR Action Plan in 2002, Metropolitan's plants treating CRW have consistently met the CFE turbidity removal requirements of the IESWTR. There were instances when individual filter effluent turbidity exceeded 1.0 NTU in two consecutive measurements taken no more than 15 minutes apart or greater than 0.3 NTU in two consecutive measurements taken no more than 15 minutes apart after 60 minutes of continuous operation. The reasons for these exceedances include filter start-up conditions, new media placement in the filter, sudden change in source water blend ratio, low plant flow rate/mixing energy, and impact of storm runoff from the watershed on source water turbidity. No further actions were required. Filters with turbidity spikes after the start-up period are removed and backwashed before returning to service.
- Since the effective date of the Stage 1 D/DBP Rule in 2002, Metropolitan's three plants treating CRW have complied with TT requirements. During the reporting period, the Step 2 method was used at Diemer, Skinner, and Weymouth plants until the 3rd quarter of 2011 for Skinner plant and the 2nd quarter of 2015 for Diemer plant, following ozone treatment. With ozone treatment, Diemer and Skinner plants use the 40/30 Alternative Compliance Criteria, which does not require achievement of specified TOC removals when TOC RAA < 4.0 mg/L, alkalinity > 60 mg/L, TTHM RAA ≤ 0.040 mg/L and HAA5 ≤ 0.030 mg/L.
- Since Stage 2 D/DBP Rule compliance requirements began in April 2012, locational running annual averages of currently monitored sites for TTHM and HAA5 indicate that all locations are less than 0.080 mg/L and 0.060 mg/L, respectively,
- One core distribution system location (FM-1), associated with the Weymouth plant, exceeded the TTHM level of 0.080 mg/L twice in May 2012. However, the TTHM LRAA at the FM-1 site remained below 0.080 mg/L. Metropolitan has started using ozone as the primary disinfectant at the Skinner plant, reducing reliance on free chlorine for disinfection and thus reducing TTHM formation potential. Ozonation facilities were completed at the Diemer plant in 2015 and are under construction at the Weymouth plant. These changes in disinfection practices will further ensure compliance with the Stage 2 D/DBP Rule.
- The Diemer, Skinner, and Weymouth plants are in Bin 1 classification (highest 12-month average at the plant influents was < 0.075 oocysts/L) under the LT2ESWTR because *Cryptosporidium* was not detected in any LT2ESWTR Round 1 monitoring samples. Therefore, no additional action is required to improve the treatment process in order to comply with the LT2ESWTR at any of the treatment plants. The LT2ESWTR Round 2 monitoring began in April 2015 and will continue through March 2017.
- Arsenic levels in the effluent of the three water treatment are well below regulatory thresholds.
- During the CRWSS reporting period, NDMA did not exceed 10 ng/L as RAA at any monitoring location. The peak levels detected at the Diemer, Skinner, and Weymouth plants between 2011 and 2015 are < 2 ng/L, 6.5 ng/L and 2.5 ng/L, respectively.

- Perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants during the reporting period (DLR is 0.004 mg/L). Maintaining low perchlorate levels in the Colorado River through remediation efforts in Henderson, Nevada will be crucial in meeting a potentially more stringent perchlorate MCL in the future.
- Chromium-6 levels at the Diemer, Skinner, and Weymouth plants ranged from 0.00004 to 0.00016 mg/L between 2011 and 2015. Chromium-6 has only been sporadically detected at low levels in CRW downstream of the PG&E's Topock Compressor Station site.
- PPCP detections at plant effluents are at parts per trillion levels, orders of magnitude lower than therapeutic doses. Currently, there is no evidence of human health risks from long-term exposure to PPCPs at these levels. Also, no standardized analytical methods currently exist.

6 Key Watershed Management Activities

Colorado River Watershed Sanitary Survey
2015 Update

Chapter 6 Key Watershed Management Activities

This chapter includes key watershed management activities from within Metropolitan's source waters associated with the Colorado River Aqueduct (CRA) system. The key watershed management activities are presented as current as of the writing of this report. Metropolitan's involvement in these watershed management efforts has had a positive impact on protecting source water quality for the Colorado River and Metropolitan's downstream watersheds. Metropolitan has actively participated in the following watershed management projects and programs:

- Colorado River Stakeholder Partnerships
- Colorado River Basin Salinity Control Program
- Uranium Mill Tailings Removal near Moab, Utah
- Energy Exploration and Development
- Perchlorate Remediation in Henderson, Nevada
- Wastewater Management in the Las Vegas Valley
- Las Vegas Wash Stabilization Program
- Chromium-6 Remediation at PG&E's Topock Gas Compressor Station
- Lake Mathews Watershed Planning and Management

Colorado River Stakeholder Partnerships

Program Description

Previous CRWSS updates have included discussions on Metropolitan's involvement with key stakeholder partnerships including the Lower Colorado River Water Quality Partnership and the Clean Colorado River Sustainability Coalition. These partnerships provide a forum for Metropolitan to actively engage with external partners and collaborate on various Colorado River water quality and watershed management issues. This new section, *Colorado River Stakeholder Partnerships*, summarizes Metropolitan's engagement in key stakeholder partnerships and provides a discussion on Metropolitan's recent and ongoing activities and involvement.

Table 6-1 provides a summary of key stakeholder partnerships that Metropolitan engages in to support protection of Colorado River water quality. Metropolitan participates in regular meetings with these entities.

Table 6-1. Colorado River Water Quality Protection Stakeholder Partnership

Stakeholder Partnership	Description	Reference
Colorado River Basin Salinity Control Forum	CRBSCF was created in 1973 by the Colorado River Basin states to act as a common voice for the states on salinity matters and to coordinate with federal agencies in the implementation of the Colorado River Basin Salinity Control Program.	http://coloradoriversalinity.org/
Clean Colorado River Sustainability Coalition	CCRSCo, formed in 1997, is a non-profit organization comprised of Arizona, California, and Nevada communities, local governments, Tribal nations, and regional water providers in the lower Colorado River Basin. CCRSCo focuses on protecting and enhancing the Colorado River through monitoring and analysis of water quality to assure and sustain high quality water for all users of the Colorado River.	Website under development
Lake Mead Water Quality Forum	LMWQF, formed in 1997, is comprised of local, state and federal agencies. LMWQF's goals are to support the protection of human health and the environment and to preserve and improve the water quality of the Las Vegas Wash, Las Vegas Bay and Lake Mead.	http://lmwqf.nv.gov/
Lake Mead Ecosystem Monitoring Work Group	LaMEM Workgroup, formed in 2012, is a sub-committee of the Lake Mead Water Quality Forum. LaMEM is comprised of local, state, and federal agencies that share a mutual interest in understanding and protecting the ecosystems of Lake Mead and Lake Mohave.	https://ndep.nv.gov/forum/ecosystem.htm
Lower Colorado River Water Quality Partnership	The Partnership was formed in 2011 between Metropolitan, Southern Nevada Water Authority, and Central Arizona Project to identify and implement collaborative solutions to address water quality issues facing the Colorado River.	http://www.cap-az.com/ http://www.mwdh2o.com/ https://www.snwa.com/
Nevada Environmental Response Trust Stakeholder Group	NERT was created in 2011 from a bankruptcy settlement reached between Tronox and its predecessors over environmental liabilities to clean up perchlorate from a site near Henderson, Nevada. The stakeholder group monitors and provides input on the ongoing investigation and remediation activities.	https://ndep.nv.gov/bmi/tronox.htm

Table6-1. Colorado River Water Quality Protection Stakeholder Partnership continued

Stakeholder Partnership	Description	Reference
Topock Stakeholder Forums	Department of Toxic Substances Control established focused advisory forums to facilitate communication and coordination on environmental investigation and cleanup activities for Pacific Gas and Electric's chromium-6 groundwater remediation near Topock, Arizona. The forums, which include a Consultative Workgroup, Technical Workgroup, Clearinghouse Task Force, and Topock Leadership, are comprised of representatives from local, state, and federal agencies, 10 Tribal nations, and other stakeholders.	http://dtsc-topock.com/

Colorado River Basin Salinity Control Forum

The Colorado River Salinity Control Forum is discussed under the *Colorado River Basin Salinity Control Program* section of this chapter.

Clean Colorado River Sustainability Coalition

When the Colorado River Regional Sewer Coalition (CRRSCo), first formed in 1997, its mission was to protect and enhance the Colorado River through the improvement of wastewater management practices to ensure a high quality of water for all users. In specific, CRRSCo's focus was centered on the conversion of septic systems to centralized wastewater treatment in lower Colorado River communities. As discussed in the CRWSS 2010 Update, CRRSCo assessed the collection and treatment needs for lower Colorado River region and actively lobbied for legislation and federal funding to support centralized wastewater management systems for lower Colorado River communities. CRRSCo's efforts brought awareness to the need for improved wastewater management along the Colorado River, and prompted Lake Havasu City and Bullhead City to take the lead in mitigating against nitrate loading by expanding their sewer collection systems.

CRRSCo's focus on Colorado River water quality also prompted a project in cooperation with the U.S. Bureau of Reclamation (USBR) to develop a water quality database for surface and groundwater data. The Cooperative Water Quality Database Program was established to assist in the development of future monitoring programs and serve as a central data repository for all users along the lower Colorado River. SNWA (also a CRRSCo member) already maintained a database that provided similar functionality and supported USBR and CRRSCo members by utilizing their database to include a broader range of lower Colorado River monitoring data provided by CRRSCo members, including Metropolitan.

In 2012, CRRSCo changed its name to Clean Colorado River Sustainability Coalition (CCRSCo) and adopted revised bylaws in 2013 to focus on the protection and enhancement of the lower Colorado River through monitoring and analysis of water quality. Metropolitan continues to be a member of CCRSCo and has provided letters of support for CCRSCo to pursue grant funding to enhance watershed planning efforts for the lower Colorado River.

In August 2016, USBR awarded CCRSCo a WaterSMART: Cooperative Watershed Management Program grant to develop a watershed management plan for the lower Colorado River and assist CCRSCo with expanding its membership. The two-year project would focus on expanding CCRSCo's membership within the Havasu-Mohave Lakes and Imperial hydrologic units. As part of its outreach efforts, CCRSCo will identify and prioritize critical watershed issues to develop a watershed management plan.

Lake Mead Water Quality Forum

The Nevada Division of Environmental Protection formed the Lake Mead Water Quality Forum (Forum) in 1997 to protect public health and preserve the water quality of the Las Vegas Wash, Las Vegas Bay, and Lake Mead. The Forum was historically involved with identifying water quality issues and providing a forum to build consensus and share information. The Forum serves as a clearinghouse for water quality issues and established subcommittees to focus on specific issues such as an Algae Task Force (2001), a Selenium Subcommittee (2002), and the Lake Mead Ecosystem Monitoring (LaMEM) Workgroup (2012).

In August 2013, the Forum decided to reduce their meeting frequency and only meet on an annual basis unless issues required additional meetings. The Algae Task Force, which had been convened to investigate the causes of a green algae bloom in Lake Mead in 2001 and in 2010 indicated that they would reconvene as necessary in the future. The Selenium Subcommittee and Ecosystem Monitoring Workgroup would continue to meet quarterly. Due to organizational changes, the Forum has not met since October 2014. However, as discussed below, the LaMEM Workgroup continues to provide a forum to share information on Lake Mead water quality.

Lake Mead Ecosystem Monitoring Workgroup

Since its formation in 2012, the LaMEM Workgroup has provided a platform for information exchange on topics related to protecting the ecosystems of Lake Mead, Lake Mohave and their interrelated components. On a quarterly basis, members of local, state, and federal agencies have shared information on their respective efforts in water quality monitoring programs, habitat conservation programs, and ecological studies. Copies of past presentations are available on the LaMEM webpage (https://ndep.nv.gov/forum/eco_agendas.html). Key topics of interest have included discussions on water quality monitoring in the Lake Mead National Recreation Area, climate change modeling, quagga mussel monitoring, a Lake Mead evaporation study, revegetation at Las Vegas Wash, cyanotoxin monitoring, and the Glen Canyon high flow experiments.

Lower Colorado River Water Quality Partnership

Metropolitan, SNWA, and Central Arizona Project (CAP) formed the Lower Colorado River Water Quality Partnership in April 2011. The Partnership was formed with the understanding that many of the interests and views on issues associated with managing Colorado River water quality are mutual amongst the three agencies and can be addressed more effectively through coordinated and cooperative activities.

The Partnership continued to advocate for additional funding to expedite cleanup of the uranium mill tailings site. As discussed in the *Uranium Mill Tailings Removal near Moab, Utah* section, the project requires critical funding for current disposal cell expansion work and to return the cleanup operations to levels that would meet the 2025 target. **Appendix S** includes copies of additional letters sent by the Partnership agencies during the reporting period, as follows:

- In May 2013, the Partnership commented on the Remedial Investigation and Feasibility Study Work Plan for the perchlorate remediation in Henderson, NV.
- In May 2013, the Partnership also submitted a comment letter on the Draft Programmatic Environmental Impact Statement for the USDOE Uranium Leasing Program. The program would support mining activities in the upper Colorado River Basin within areas that may have the potential to impact Colorado River drinking water supplies.
- In March 2015, following review of the NPDES permits, the Partnership sent a letter to the wastewater dischargers in the Las Vegas valley emphasizing that optimized treatment and year-round phosphorus removal at the treatment plants are key to the long-term protection of downstream uses of the Colorado River in terms of phosphorus loading.
- In October 2015, following an accidental release of wastewater from the abandoned Gold King Mine in southwest Colorado in August 2015, the Partnership sent a letter to the U.S. Bureau of Reclamation (USBR) and U.S. Geological Survey requesting an improvement of the Lake Powell Water Quality Monitoring Program. The letters are related to key watershed management activities that are discussed in the following sections.

Nevada Environmental Response Trust

The Nevada Environmental Response Trust stakeholder group is discussed under the *Perchlorate Remediation in Henderson, Nevada* section of this chapter.

Topock Stakeholder Forums

The Topock stakeholder forums are discussed under the *Chromium-6 Remediation at PG&E's Topock Gas Compressor Station* section of this chapter.

Colorado River Basin Salinity Control Program

Program Description

About half the salinity in the Colorado River comes from natural sources; primarily saline sediment from prehistoric marine environments. The other half comes from human uses of water and activities near the River. The Colorado River Basin Salinity Control Program (Program) endeavors to reduce salinity by preventing salts from dissolving and mixing with the river's flow. For example, irrigation improvements and vegetation management reduce water available to transport salts vertically, laterally, and on the soil surface. Point sources, such as saline springs, are also controlled. A 1971 USEPA study analyzed salt loading in the river and concluded that approximately 47 percent of the salinity concentration at Hoover Dam is from natural causes, including contributions from saline springs, erosion of sediments, and groundwater discharge into the river [185]. Fifty-three percent of the salinity is from human activities, which influences the rate of natural salt movement from rock formations and soils to the river [185]. **Figure 6-1** demonstrates the salinity sources for human-caused salt loading and indicates that irrigation is the main salt load contributor.

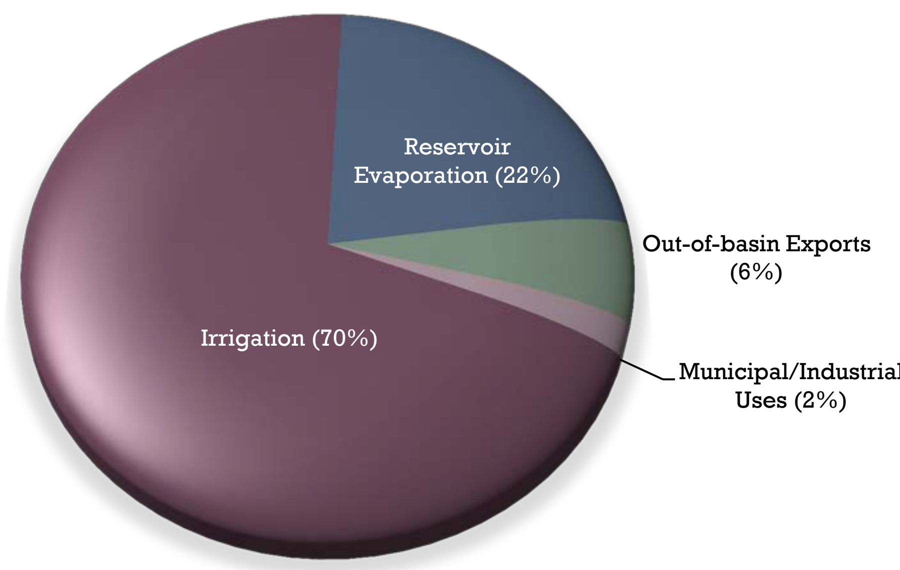


Figure 6-1. Colorado River Basin Human–Caused Salinity Sources

The enactment of the Federal Water Pollution Control Act Amendments in 1972 affected salinity control in that the legislation was interpreted by USEPA to require numerical standards for salinity in the Colorado River. The Basin states formed the Colorado River Basin Salinity Control Forum (Forum) in 1973 to develop these standards, including numeric salinity criteria and a basin-wide plan of implementation for salinity control, which USEPA subsequently approved. The Forum provides important interstate and interagency coordination and guidance for the Program and the combined efforts of the federal agencies and states. The Forum is comprised of representatives from each of the seven Basin States (Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California; **Figure 6-2**) appointed by the governor of the respective states. The Forum recommended average flow-weighted total dissolved solids (TDS) water quality standards, which include the following:

- 723 mg/L below Hoover Dam
- 747 mg/L below Parker Dam
- 879 mg/L at Imperial Dam

The Forum is required to review water quality standards and a Plan of Implementation every three years to maintain the flow-weighted average annual salinity at or below the 1972 level, while the states continue to develop their compact-apportioned water supply. The Plan of Implementation is not intended to address the salinity of the river caused by human activity prior to 1972 or salinity caused by natural variations in river flows. The most recent review was completed and adopted in October 2014 and is the thirteenth triennial review [185]. The analysis indicates a very low probability of exceedance of the numeric criteria with the Plan of Implementation in place and; therefore, recommends no change in the water quality criteria. As shown in **Figure 6-3**, salinity in the Colorado River generally increases from its headwaters to its terminus. Approximately 9 million tons of salt pass Hoover Dam annually. However, based on river flows and salt load concentrations, TDS levels do not exceed the Forum's water quality standards. Overall, historical data indicates that there has been a 100 mg/L long-term average reduction in salinity due to the Forum's salinity control measures.

Figure 6-2. Colorado River Basin Salinity Control Forum States [185]

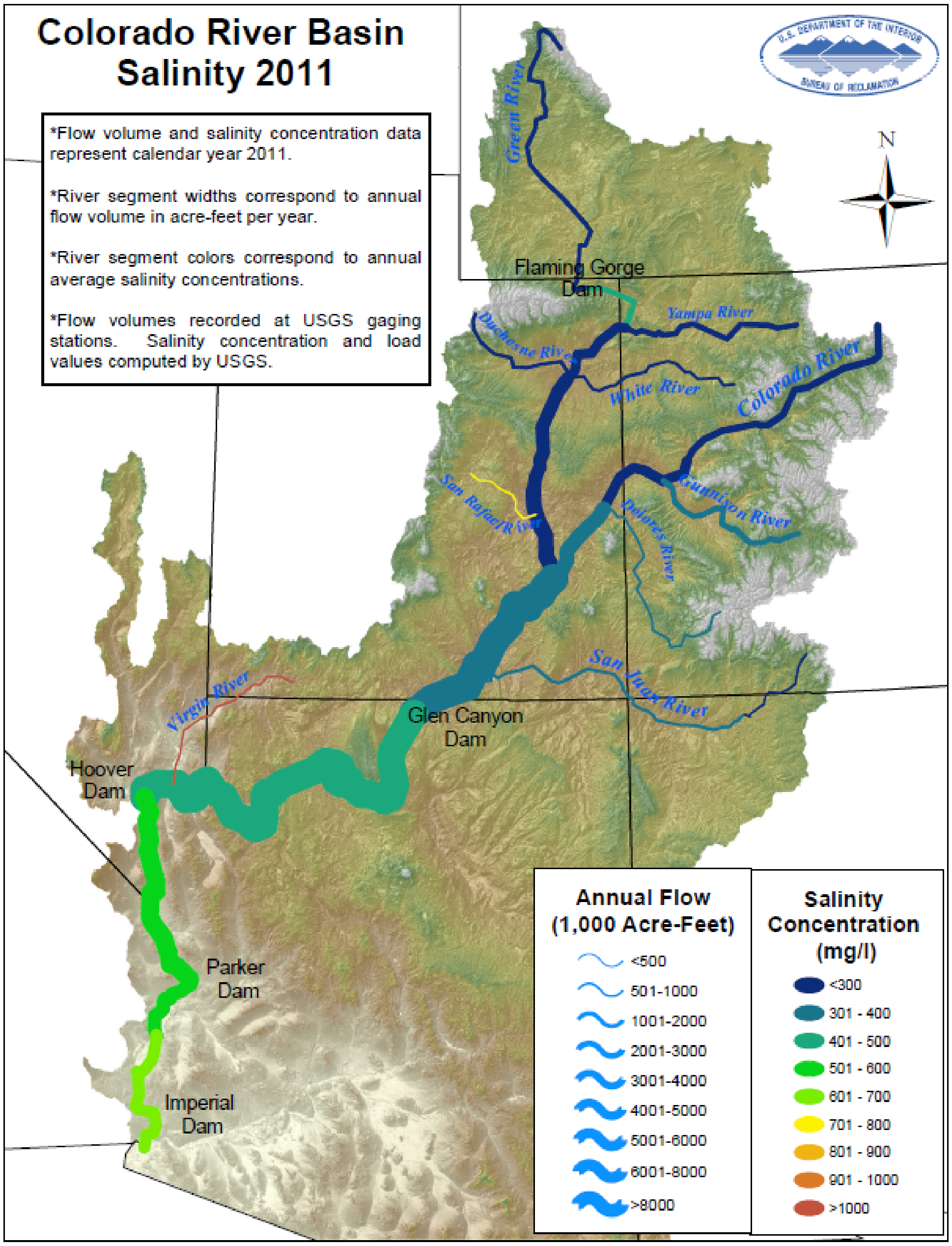


Figure 6-3. Flow and Salinity Concentrations across the Colorado River Basin [185]

The Forum adopted policies that promote the reduction of salt contributions to the Colorado River and minimize future increases in salt load caused by human activities. The Basin States issue National Pollutant Discharge Elimination System (NPDES) permits pursuant to these policies, which include the following:

- Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program (Adopted 1977)
- Policy for Use of Brackish and/or Saline Waters for Industrial Purposes (Adopted 1980)

- Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program for Intercepted Ground Water (Adopted 1982)
- Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program for Fish Hatcheries (Adopted 1988)

Reducing salinity in the Colorado River reduces economic damages, which are currently estimated at over $300 million per year [186]. The Plan of Implementation recognizes that additional salinity control further reduces economic damages in the lower Colorado River Basin, as well as providing additional benefits in the Upper Colorado River Basin. The salinity Program is projected to need an estimated total of 2.3 million tons of annual salinity control in order to maintain current salinity levels at Imperial Dam in 2035. Given financial constraints, the salinity Program aims to remove 1.68 million tons annually by 2035, which would reduce salinity by approximately 25 mg/L and 30 mg/L at Parker Dam and Imperial Dam, respectively [185]. To reach this objective, the program needs to implement 354,000 tons of new controls beyond the 1,326,000 tons of annual salinity controls already in place.

Approximately $40 million (70 percent federally funded) is spent annually on salinity control measures. Federal salinity control programs are funded through the U.S. Bureau of Reclamation (USBR) Basinwide Program; Natural Resources Conservation Services (NRCS) Environmental Quality Incentives Program (EQIP); and the U.S. Bureau of Land Management (BLM) Program. The remaining 30 percent is provided by the Basin States Program with Upper and Lower Basin funds, which derive their revenues from hydropower generation (85 percent from the Lower Basin, 15 percent from the Upper Basin).

The federal agencies work in close cooperation with the Forum to identify salinity control measures that can be implemented. Some of the salinity control projects include improved irrigation practices, rangeland management for non-point source control, and deep-well brine injection. As an example, USBR constructed the Paradox Valley Unit. Located in southwestern Colorado in the Paradox Valley, the project intercepts highly saline groundwater (brine) before it reaches the Delores River and disposes of it by deep well injection, about 14,000 feet below ground surface. The project prevents approximately 100,000 tons of salt from entering the Dolores River, a main stem of the Colorado River, which historically picks up 205,000 tons of salt annually through the Paradox Valley. In January 2013, the unit was taken offline following a M_L 4.4 earthquake near Paradox, Colorado caused by injection well operations. USBR resumed operations after incorporating operational changes to lessen pressure buildup and reduce the potential for future earthquakes. The deep-injection well is nearing the end of its useful life and USBR is currently evaluating construction of a second deep-injection well, creation of evaporation ponds, or other new technology alternatives. USBR anticipates completing the alternative impact analysis in 2019.

1999 Salinity Management Study

In June of 1999, Metropolitan and USBR completed a Salinity Management Study (1999 Study) with participation from Metropolitan's member and local agencies. The study goals were to assess regional problems and needs, evaluate salinity management strategies, and develop a salinity management policy and actions. The 1999 Study concluded that the region's groundwater basins were experiencing an adverse salt build-up that could potentially threaten supply reliability in the future and included a salinity economic damage model to estimate salinity impacts within Metropolitan's service areas. Following the 1999 Study, Southern California Salinity Coalition (SCSC) was formed in 2002 to coordinate salinity management strategies and programs with water and wastewater agencies throughout southern California.

In February 2012, Metropolitan entered into an agreement with USBR and the SCSC to review and update the 1999 Study. The objectives of the 1999 Study update are to 1) identify the current and expected challenges of salinity management in southern California and prioritize future actions, 2) update USBR's salinity economic impact model used for estimating salinity damages and for preparing the Forum's water quality standards triennial report, 3) update the regional salt balance to improve understanding of southern California salinity conditions and identify opportunities to promote effective regional salinity management, and 4) assess Metropolitan's future operational capability to deliver low salinity water supplies.

On June 1, 2012, SCSC convened a workshop to identify current salinity challenges and potential solutions to salinity management issues in southern California. The workshop results are being considered in the completion of the 1999 Study update. In September 2012, USBR hired a consultant to update the Salinity Economic Impact Model (SEIM) and the consultant completed a literature review of past model development. The consultant did not proceed with updating the SEIM and the contract was terminated in April 2015. Metropolitan worked with the Forum, SCSC, and USBR to expand the SEIM to account for damages in other reaches in the lower Colorado River. In January 2016, the Colorado River Basin Salinity Control Advisory Council approved funding for the model update to supplement USBR's resources. USBR plans to award a contract for updating the SEIM in 2017. Metropolitan and other stakeholders will continue to provide support to update the SEIM while completing the 1999 Study update.

Metropolitan Activities

Metropolitan staff serve on the Forum as representatives of California and also participate in the workgroup, which meets quarterly. The workgroup provides general staff and technical support to the Forum and makes recommendations in program related issues. These issues could include such things as review of numeric criteria, developing the Plan of Implementation, drafting the Forum's triennial review, oversight of the salinity model, and evaluating new science opportunities and potential new salinity control areas. During the reporting period, Metropolitan contributed approximately $2.7 million per year to the Lower Basin Development Fund, which is 35 percent of the total funds required for cost sharing from the Lower Basin States. Metropolitan does not pay directly to the Basin States Program, but rather the Basin States funds are collected based on a 2.5 mills per kilowatt-hour levy on California and Nevada purchases of hydropower generation from Hoover Power Plant. Along with federal appropriations, the funding is used for salinity control projects.

Currently, TDS is monitored monthly at all of Metropolitan's source waters and treatment plant effluents. In **Chapter 3**, **Figure 3-9** shows the historical TDS values in the CRA system during the reporting period. TDS in the Colorado River is relatively stable, with cycles fluctuating over multiple years. TDS during this CRWSS reporting period (2011–2015) averaged a low of 576 mg/L between January 2011 and September 2014 at Lake Havasu. Since September 2014, TDS levels at Lake Havasu have been on an upward trend and peaked at 650 mg/L in October 2015.

Since the mid-1990s, southern California water utilities have expressed strong concern about the high salt content in potable supplies, irrigation water, recycled wastewater, and groundwater resources. High salinity has an impact on various uses, including increasing the scaling potential on household appliances and plumbing fixtures and reducing agricultural crop yields. As a result, Metropolitan is committed to reducing salinity concentrations in southern California's water supplies through ongoing collaboration actions with the Forum and other pertinent agencies. Metropolitan will continue to work with partner agencies to complete the 1999 Study update and is currently in the process of completing a structural update of the SEIM to facilitate use of the model and streamline future model input and function updates.

Uranium Mill Tailings Removal near Moab, Utah

Project Description

A 16 million-ton pile of uranium mill tailings was left along the banks of the Colorado River near Moab, Utah. The tailings pile are remains from the decommissioned Atlas Uranium Mill, which operated between 1956 and 1984 to produce uranium concentrate for defense programs and fuel for nuclear power plants. Tailings are the remains of crushed processed uranium ore with low levels of radioactivity. During its operation, the mill produced approximately 1,400 tons of uranium concentrate per day.

The mill tailings were left behind in an unlined pond approximately 750 feet from the west bank of the Colorado River, which sits 94 feet above the river's floodplain. The location of the site is approximately 650 miles upstream of Metropolitan's Whitsett Intake at Lake Havasu. A portion of the pile lies within the 100-year floodplain of the Colorado River. Due to the proximity of the pile to the Colorado River, there is a potential for the tailings to enter the river as a result of a catastrophic flood event or other natural disaster. **Figure 6-4** is a downstream view of the mill tailings site in 1984 when operations at the Atlas Uranium Mill ceased.

Figure 6-4. Moab Uranium Mill Tailings Site in 1984 [187]

The Floyd D. Spence National Defense Authorization Act of 2001 transferred ownership and responsibility for the Moab site to the USDOE. In 2004, USDOE issued a Draft EIS identifying proposed alternatives for tailings disposal and groundwater remediation. Metropolitan submitted a comment letter on the Draft EIS in February 2005 urging for offsite removal of the tailings. Other states and agencies supported the option of offsite removal. In July 2005, USDOE issued its Final EIS with the preferred alternative of offsite disposal of the uranium mill tailings to Crescent Junction, Utah using rail transportation and active groundwater remediation. The Federal Record of Decision was issued in September 2005.

USDOE has conducted several onsite interim remedial efforts since 2000. Vertical drains were installed to remove contaminated pore water, which was then pumped to a 4-acre evaporation pond located on top of the tailings pile. Extraction wells, installed between the pile and the river, also pumped to the evaporation pond. An injection trench was installed to create a hydraulic barrier to mitigate movement of the contaminated plume towards the river and channel the plume to extraction wells. USDOE also installed monitoring wells to assess performance of the interim remediation efforts, including periodic monitoring of Colorado River water quality upstream and downstream of the site.

In 2008, USDOE realigned Moab Wash away from the tailings pile and widened the wash to increase the flow capacity and reduce its erosive velocities. As the tailings pile was located within the 100-year floodplain of Moab Wash, which flows into the Colorado River, relocating the wash away from the pile helps protect the Colorado River during a catastrophic flood event.

Secretary of Energy, Dr. Stephen Chu, announced in March 2008 that $108 million would be directed to the Moab Uranium Mill Tailings Remedial Action (UMTRA) project under the American Recovery and Reinvestment Act of 2009 (ARRA) to accelerate initial tailings removal. In April 2009, USDOE began tailings removal via rail to the Crescent Junction disposal site. The infusion of ARRA funds expedited the initial tailings cleanup allowing two trains to transport tailings, 5 days a week, to an engineered disposal cell at Crescent Junction. The rate of tailings removal has dropped since this initial period, as discussed later in this section. Through November 2016, over 8.4 million tons of the tailings pile has been removed and disposed of. **Figure 6-5** shows the Crescent Junction disposal cell in varying levels of completion. A final cover and an interim cover have been placed on the western portion of the cell (Phase 1) and tailings are being spread on the center portion of the cell (Phase 2). USDOE is currently working on the Phase 3 cell excavation and expects to complete excavation of 2 million cubic yards by September 2018, while continuing to remove and dispose of mill tailings.

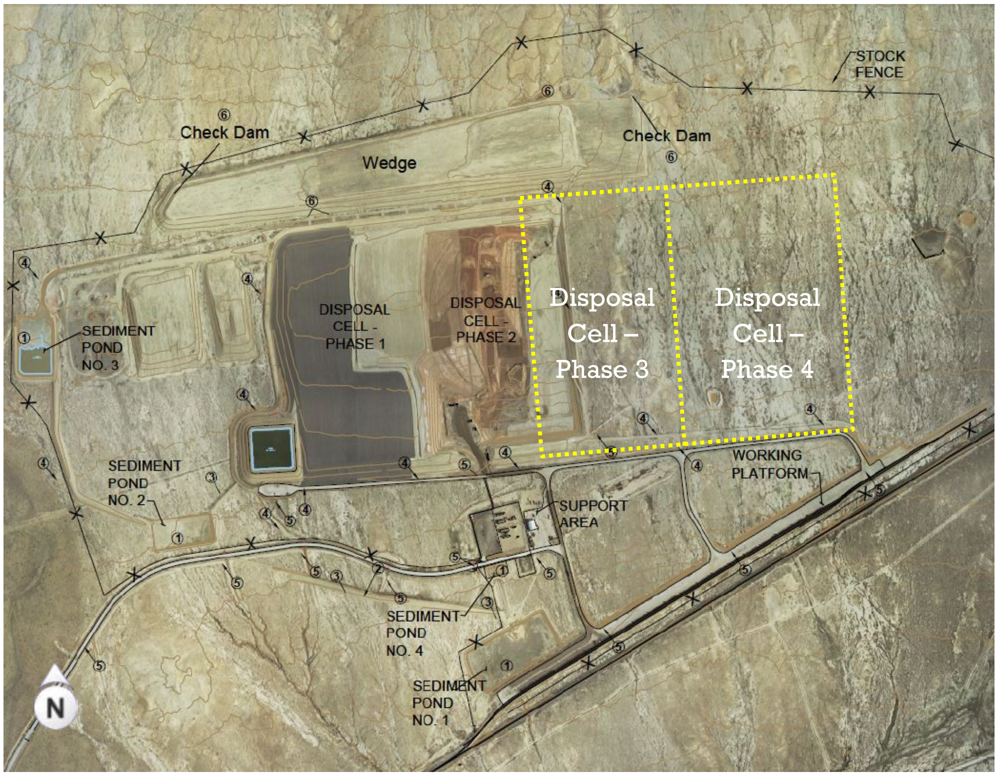


Figure 6-5. Crescent Junction Disposal Cell, April 2014 [188]

On November 18, 2014, a significant rockslide occurred 800 feet above a rail bench used for loading containers onto railcars for transport to the Crescent Junction disposal site [189]. As shown in **Figure 6-6** an estimated 4,500 cubic yards of rock impacted operations at the UMTRA site. USDOE resumed mill tailings removal at a reduced capacity in January 2015 after a two-month interruption, and resumed full-scale operations in October 2015 after implementing safety measures including a hillside monitoring program and transportation plan.

Figure 6-6. Rockslide at UMTRA Site (November 2014) [187]

Since ARRA funds were fully expended in July 2011, budget constraints have challenged USDOE with maintaining project progress on tailings removal while still being able to respond to critical project needs, such as implementing site safety measures and shifting resources to necessary equipment repairs and disposal cell expansion. The project has historically received $35–38 million per year and based on USDOE's annual budget, tailings removal has reduced from approximately 2 million tons annually (with ARRA funds) to between 600,000 and 900,000 tons annually. This reduction results from previously utilizing two trainloads per day, 5 days per week to currently, since May 2016, utilizing a single trainload per day, 2 days a week. It is estimated that 45 million annually would be needed to meet USDOE's targeted completion date for full removal of the tailings pile by 2025. The total cost of the remediation efforts is anticipated to be over $1 billion.

Metropolitan Activities

Metropolitan continues to advocate for expeditious removal of the tailings pile. Moving the pile offsite will prevent a catastrophic flood event from washing the mill tailings directly into the Colorado River, and will prevent radioactive constituents from entering Metropolitan's source waters. The presence of the uranium mill tailings pile adjacent to the Colorado River impacts the public's confidence in the safety and reliability of the river as a source of drinking water supplies. As discussed in the *Colorado River Stakeholder Partnerships* section, over the years, Metropolitan has sent letters (**Appendix S**) to the Secretary of Energy and Congressional delegates advocating for increased funding to maintain effective and timely cleanup of the UMTRA site to ensure long-term protection of the Colorado River.

As discussed in the CRWSS 2010 Update, in 2011, the Partnership sent a letter to the Secretary of Energy, Dr. Stephen Chu, to advocate for additional funding to expedite cleanup of the uranium mill tailings site near Moab, Utah. During this reporting period, the Partnership continued to advocate for additional funding to expedite cleanup of the uranium mill tailings site. The reduction of available funds beginning in July 2011 has slowed down tailings removal. In February 2013, the Partnership sent a letter to the Secretary of Energy, Dr. Stephen Chu, urging the administration to increase funding for USDOE to expedite removal of the tailings pile. In January 2015, the Partnership sent a letter to Secretary of Energy, Ernest J. Moniz, advocating for increased funding to meet USDOE's targeted completion date of 2025. Funding increased from a baseline of $31 million to $35.7 million in Fiscal Year 2015 and $38.6 million in Fiscal Year 2016. Metropolitan and CAP sent a letter in May 2016 to Secretary Moniz expressing concern over the nearly $4 million in proposed budget cuts for Fiscal Year 2017, when additional funds are needed for the current disposal cell expansion work and to return the cleanup operations to levels that would meet the 2025 target.

On April 9, 2012, the Moab Federal Project Director, Mr. Don Metzler, provided an update to Metropolitan's Board on the UMTRA project. USDOE continues to regularly inform Metropolitan of the UMTRA project remediation progress and project challenges.

Metropolitan will continue to monitor USDOE tailings cleanup progress and engage in efforts to support expedient remediation of the site. Metropolitan also continues to monitor uranium levels in Colorado River water. Uranium concentrations at Whitsett Intake have remained stable and ranged between 2 and 2.9 pCi/L from 2011 through 2015. This is well below California's MCL for uranium, which is 20 pCi/L.

Energy Exploration and Development

Project Description

Background

An increasing demand for energy is driving various energy development activities in the Colorado River basin. A 2010 USGS Study identified significant oil and gas development areas in the Upper Colorado River Basin, shown in **Figure 6-7**, where 60 percent of the lands are federally owned [190]. In 2016, USGS completed an assessment of undiscovered oil and gas resources within the Unita-Piceance Province, shown in green in **Figure 6-7**. The 2016 USGS Study found that this area has an estimated 74 million barrels of shale oil, 66.3 trillion cubic feet of gas, and 45 million barrels of natural gas liquids that can be recovered from the Mancos Shale in the basin [191]. In addition to oil and gas reserves, the Colorado River basin is also rich in tar sands, coal, and uranium deposits. Mining of these resources is supported by the General Mining Act of 1872, which opens federal land to mining claims if it has not been designated for specific uses (e.g., national parks, wilderness areas).

The development of these energy resources make the Colorado River vulnerable to non-point source pollution, which could result from surface disturbance during construction of production facilities, underground mining and extraction, and wastewater discharge. In recent years, federal and state agencies have proposed various legislation to regulate the surge in energy development interests and address environmental impacts.

Hydraulic Fracturing

Hydraulic fracturing involves the extraction of oil and gas from underground rock formation by injecting chemical fluids. Although hydraulic fracturing has been used for over 60 years, cost-effective improvements in extraction technology have increased its use in the last ten years. Within the Colorado River Basin, hydraulic fracturing has been used primarily in Colorado, Utah, and Wyoming. However, estimating the extent of hydraulic fracturing activities is difficult due to lack of disclosure requirements.

In March 2015, the U.S. Bureau of Land Management released a Final Rule to Support Safe, Responsible Hydraulic Fracturing Activities on Public and Tribal Lands. The BLM Rule would regulate over 100,000 oil and gas wells on federally managed lands, of which over 90 percent use hydraulic fracturing, and require industry to disclose chemicals used in hydraulic fracturing through the website FracFocus. The BLM Rule was to take effect on June 24, 2015, but was challenged by multiple states including Colorado, Utah, and Wyoming. On June 21, 2016, the U.S. District Court for the District of Wyoming invalidated the BLM Rule, finding that BLM lacked the authority to regulate hydraulic fracturing on public lands and that the Safe Drinking Water Act removes all federal authority over hydraulic fracturing [192].

In June 2015, USEPA completed the draft Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources. The draft study found that approximately 6,800 sources of drinking water for public water systems nationally are located within a mile of at least one hydraulically fractured well. The draft study also identified potential risks to drinking water resources including spills of hydraulic fracturing fluids and produced water, fracturing directly into underground drinking water resources, below ground migration of liquids and gases, inadequate treatment and discharge of wastewater. The draft study did not find evidence that these risks have led to widespread, systemic impacts on drinking water resources and indicated that this could be due to inaccessibility of information on hydraulic fracturing activities and potential impacts [193]. USEPA continues to invest in understanding hydraulic fracturing and its potential impact on drinking water, which will include further studies following an August 11, 2016 USEPA Science Advisory Board review of the draft Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources [194].

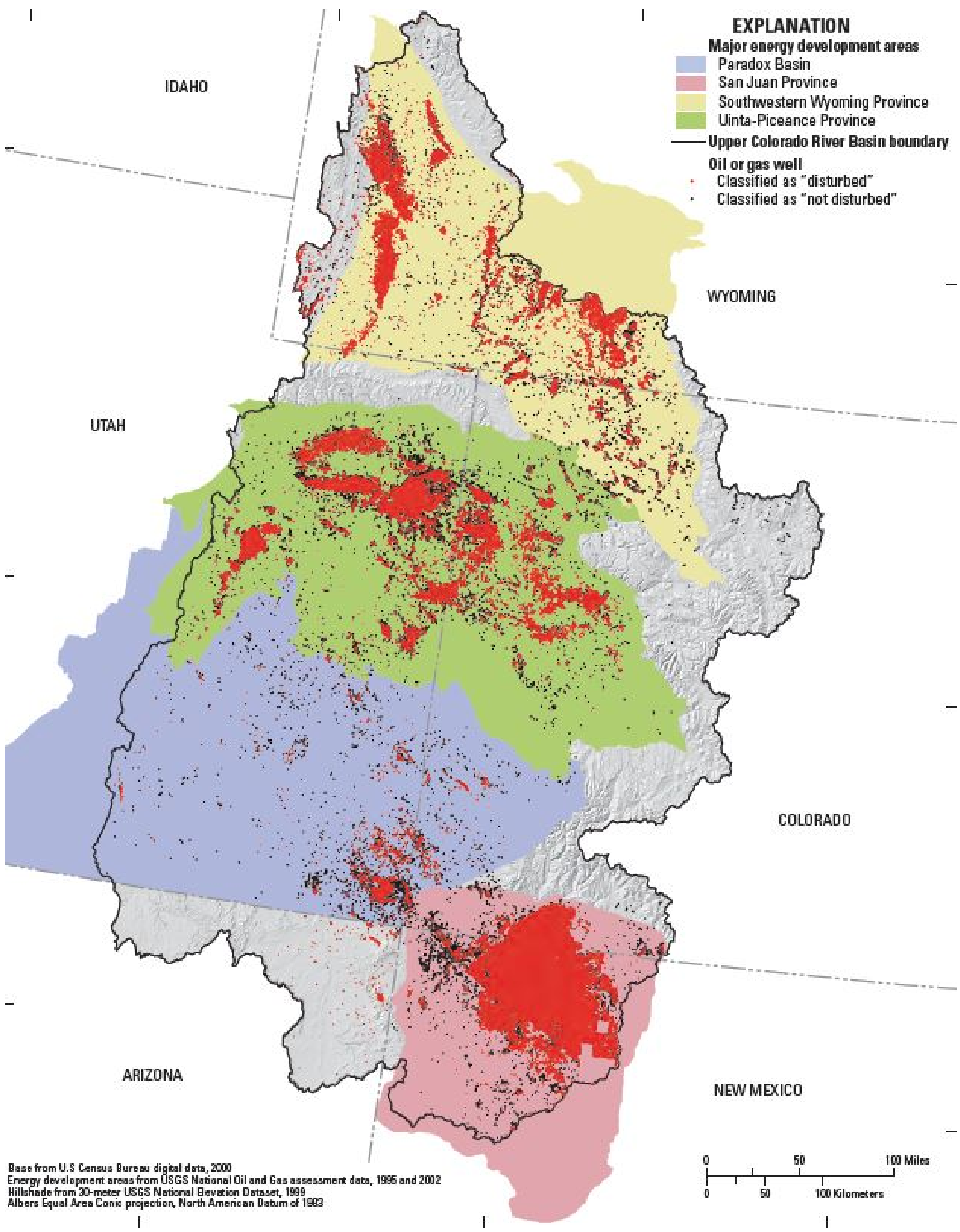


Figure 6-7. Energy Development Areas in Upper Colorado River Basin [190]

Uranium Exploration Near Grand Canyon

Previous CRWSS updates have discussed potential contamination threats resulting from a renewed interest in nuclear energy, which sparked thousands of new uranium mining claims throughout the western United States. Mining claims within a few miles of Grand Canyon National Park and the Colorado River have been of particular attention. Mining is prohibited in other areas within this region such as within Grand Canyon National Park or adjacent to the park within tribal lands or dedicated national monuments.

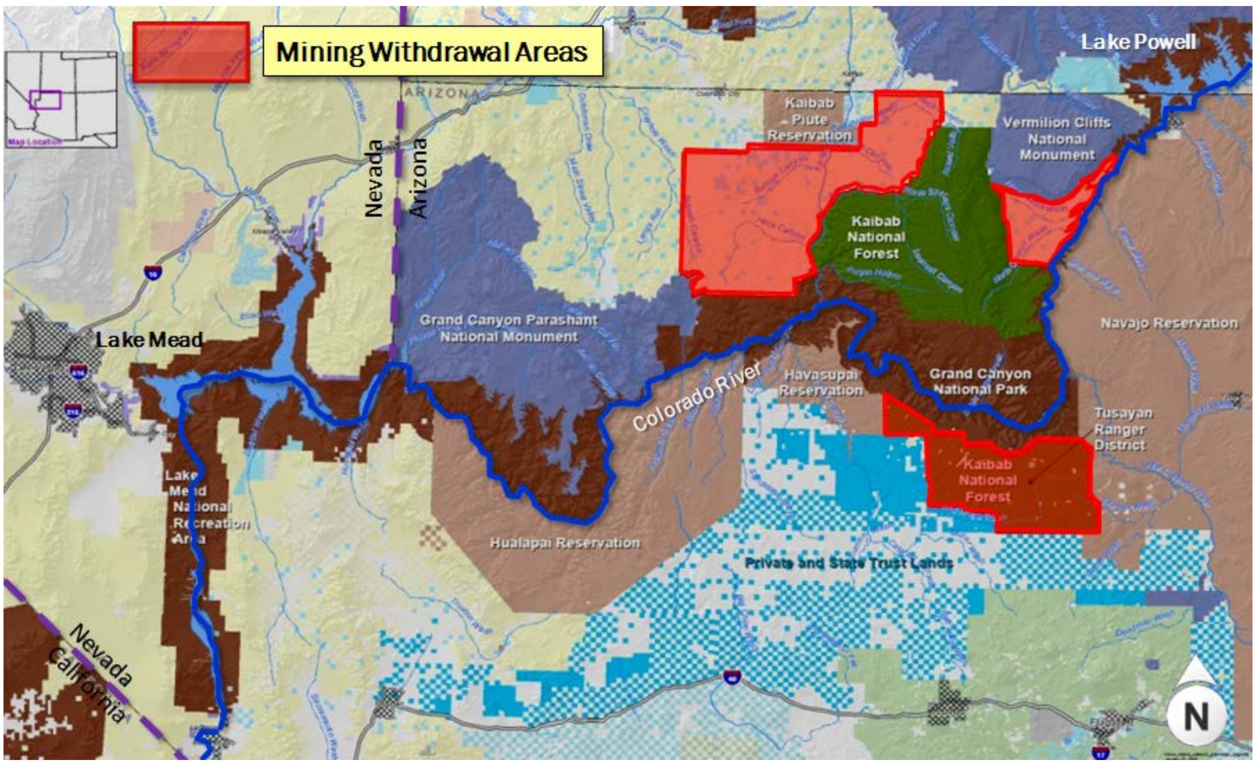


Figure 6-8. Grand Canyon Area Lands Seeking Mining Withdrawal [195]

In July 2009, Secretary of the Interior Ken Salazar announced a two-year hold on new mining claims on nearly 1 million acres adjacent to Grand Canyon National Park (areas shown in **Figure 6-8)** to allow necessary studies and environmental analysis to be conducted. In January 2012, Secretary Salazar formally signed a 20-year moratorium on new uranium and other hard rock mining claims. The moratorium has been challenged by a number of industry groups and was most recently upheld by a U.S. District Court in September 2014. Local conservation groups continue to defend the moratorium and are seeking additional protection of lands with mines that have been inactive for long periods of time, but may resume operations.

In addition to these federal actions, Arizona Congressman Raul Grijalva (D-AZ) introduced into legislation the Grand Canyon Watersheds Protection Act in 2009 and the Grand Canyon Watersheds Protection Act of 2013. This legislation was not enacted, but would have permanently removed areas adjacent to Grand Canyon National Park from new mining claims.

Abandoned Mines

In August 2015, an accidental release of wastewater from an abandoned mine in southwest Colorado (**Figure 6-9**) demonstrated the potential threat that mining activities can have on public health and the environment. USEPA was conducting an investigation of the Gold King Mine to assess ongoing water releases from the mine, treat the mine water, and assess the feasibility of further mine remediation. USEPA's excavation operations resulted in the accidental release of three million gallons of metals-contaminated water into the Animas River, shown in **Figure 6-10**, which flows to Lake Powell and the Colorado River through the San Juan River as shown in **Figure 6-11**. The spill did not result in any direct impacts to lower Colorado River drinking water users due to its upstream location and resulting dilution.

However, the spill did affect water uses for tribes and communities in close proximity to the spill. New Mexico Environment Department implemented a temporary ban on the use of private domestic wells and stopped supplies from the Animas and San Juan Rivers to the San Juan County drinking water system. The city of Durango also temporarily stopped pumping raw water for their drinking water treatment system. During a short duration, metal concentrations in the San Juan River exceeded Navajo Nation's screening levels for safe agriculture and irrigation, which impacted Navajo Nation farmers and ranchers.

USEPA continues to collect and assess water quality from Animas and San Juan Rivers daily and is also monitoring metal deposits in sediments and their release during high water events. In March 2016, the San Juan Basin Health Department issued a statement indicating that it is unlikely that heavy metals remaining in soils will make their way into crops at levels that would impact human or livestock health [196]. Overall, USEPA also does not anticipate adverse health effects from exposure to metals in surface water and is working with Colorado, New Mexico, the Navajo Nation, and the U.S. Fish and Wildlife to continue to investigate long-term impacts on wildlife and fish. As of August 2016, USEPA has spent more than $29 million to address the Gold King Mine incident [197].

Figure 6-9. Gold King Mine Spill, August 5, 2015 [198]

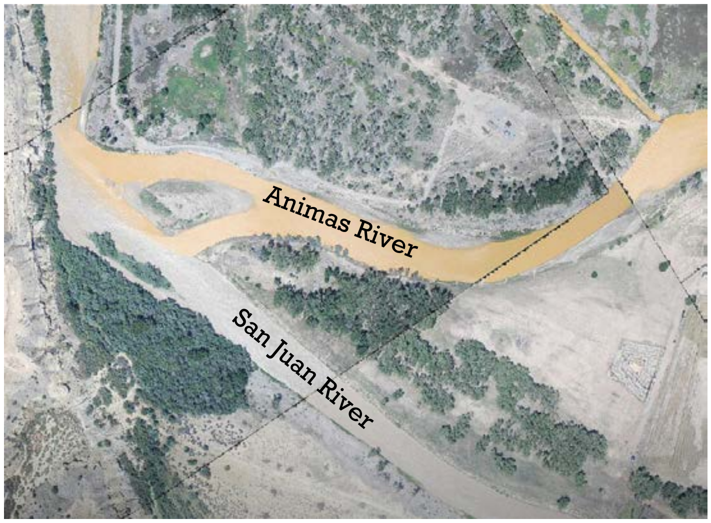


Figure 6-10. Confluence of Animas and San Juan River near Farmington, New Mexico, August 8, 2015 [198]

Figure 6-11. Gold King Mine Spill in Silverton, Colorado August 2015

Although abandoned mines can be a threat to public health, safety and the environment, a comprehensive inventory of abandoned mines does not exist [199]. Four federal agencies fund the cleanup and reclamation of abandoned mines, which include USEPA, BLM, U.S. Department of Agriculture's (USDA) Forest Service, and the Office of Surface Mining Reclamation and Enforcements. BLM estimates that the majority of abandoned mines on federally-managed lands are in the Colorado River Basin states – Arizona, Colorado, Nevada, New Mexico, and Utah.

Abandoned mines can impact water quality through the formation of drainage water including acid, alkaline, and metal mine drainage. Abandoned mine drainage forms from the chemical reaction of surface water and shallow groundwater with mining rocks that can leach metals and alkaline materials or react with sulfur-bearing minerals to form acidic drainage [200]. The drainage may be highly toxic when mixed with groundwater, surface water, and soil. Since there is no comprehensive inventory of abandoned mines, the amount of released mine drainage cannot be estimated.

While cleanup efforts of abandoned mines are ongoing, federal agencies continue to approve mining of new or abandoned mines. An assessment completed by the U.S. Government Accountability Office (GAO) found that between Fiscal Years 2010 and 2014, BLM and USDA had approved 68 mine plans of operation encompassing nearly 36,000 acres in the western United States [201].

Metropolitan Activities

Metropolitan routinely monitors for uranium in its source waters and is not aware of any exceedances of regulated levels of uranium as a result of mining operations. However, Metropolitan recognizes that uranium mining in areas near the Colorado River can have impacts on the public's confidence in the safety and reliability of this water supply due to the potential for uranium mining operations to impact drinking water quality.

As discussed in the CRWSS 2010 Update, Metropolitan, in conjunction with Partnership agencies sent letters in March 2008 and June 2009 to former Secretaries of the Interior Dirk Kempthorne and Ken Salazar, respectively, to highlight concerns on the issue of uranium mining, and to request that the Department of the Interior carefully evaluate the implications on Colorado River water quality and include broad stakeholder review of environmental impact analyses prior to any authorizations of exploration or mining. In 2011, the Partnership agencies also sent a comment letter on BLM's draft EIS for the proposed Northern Arizona Proposed Withdrawal project, which continued to advocate for close federal oversight over mining claims to ensure Colorado River water quality protection.

As discussed earlier, in May 2013, the Partnership agencies submitted a comment letter on the Draft Programmatic Environmental Impact Statement for the USDOE Uranium Leasing Program (**Appendix S**). USDOE's Uranium Leasing Program would support mining activity in the upper Colorado River Basin within areas that may have the potential to impact Colorado River drinking water supplies. Metropolitan's comment letter recommended that USDOE's Uranium Leasing Program require a comprehensive water quality monitoring program, and work with USBR to correct inaccuracies regarding the Paradox Valley Unit project, evaluate and mitigate potential impacts of large-scale exploration and mining activities on salinity loading to the Colorado River, consider removing select lease tracts with greatest potential to affect water quality from the leasing program, and include an evaluation of worst-case scenarios in subsequent environmental reviews. In May 2014, USDOE issued its Record of Decision for the Uranium Leasing Program and announced that it would continue to manage the Program for 10 years.

Following the Gold King Mine spill, the Partnership agencies sent a letter to USBR and USGS in October 2015 requesting an improvement of the Lake Powell Water Quality Monitoring Program (**Appendix S)**. Although the Gold King Mine spill did not have a direct impact to the Partnership agencies due to its upstream location and resulting dilution, the incident prompted the Partnership to increase collaboration on water quality monitoring in Lake Powell. The USBR established a workgroup, including the Partnership and USGS, to enhance Lake Powell's monitoring program to better manage and respond to upstream water quality issues.

In March 2015, Metropolitan responded to the Grand Canyon Trust's letter regarding the issue of inactive mines in northern Arizona, within the watershed tributary to the Grand Canyon and Colorado River (**Appendix S**). Metropolitan acknowledged the concerns and noted previous communications to the Secretary of Interior emphasizing the need to ensure protection of the Colorado River and its tributaries.

Metropolitan and the Partnership will continue to track uranium exploration and other energy development activities throughout the Colorado River Basin to ensure measures are taken to protect the water quality of the Colorado River.

Perchlorate Remediation in Henderson, Nevada

Project Description

Background

Perchlorate was first detected in Colorado River water in June 1997 and was traced back to Las Vegas Wash. The source of contamination was found to be emanating from a Henderson, Nevada chemical manufacturing facility previously owned by Kerr-McGee Corporation, and transferred to Tronox, Inc. in 2005. Currently, the site is owned by Nevada Environmental Response Trust (NERT), as further discussed in this section. Beginning in 1945, perchlorate was produced at the Kerr-McGee/Tronox facility for military and aerospace use. Perchlorate-containing waste was disposed of in unlined pits. Over time, perchlorate spread into the relatively shallow aquifer beneath the site.

Another large perchlorate groundwater plume is also present in the Henderson area from the former Pacific Electrochemical Production Company (Pepcon) site, later known as the American Pacific Corporation (AMPAC), and is now owned by Endeavour, LLC (Endeavour). In 1958, this plant began producing chemicals, including ammonium perchlorate and other oxidizers, until 1988 when an explosion destroyed the plant. **Figure 6-12** illustrates the approximate delineation of the Tronox and Endeavour perchlorate plumes in proximity to the Las Vegas Wash, Las Vegas Bay, and Lake Mead.

Figure 6-12. Tronox and Endeavour Perchlorate Plumes

Over the years, both perchlorate sites in Henderson, Nevada have been under various ownerships as shown in **Table 6-2**. This section references multiple ownership names corresponding to the historical site ownership and remedial responsibilities during the respective operating periods.

Table 6-2. Henderson Perchlorate Site Ownership

Current Site Ownership	Previous Site Ownership
Nevada Environmental Response Trust (NERT)	Tronox LLC (Tronox) Kerr-McGee Chemical LLC (Kerr-McGee)
Endeavour LLC (Endeavour)	American Pacific Corporation (AMPAC) Pacific Electrochemical Production Company of Nevada (PEPCON)

Tronox/NERT Remediation

Perchlorate contaminated groundwater from the Tronox/NERT plume flows north, approximately 3 miles from the Tronox/NERT site, to the Las Vegas Wash. Since perchlorate contamination was discovered in the Las Vegas Wash in 1997, significant control strategies to intercept and treat perchlorate have been implemented. Prior to controls, the Tronox/NERT plume released approximately 900 lbs/day, on average, to the Las Vegas Wash. Since early 2007, perchlorate loading as measured in the Las Vegas Wash has typically been between 50 and

Tronox/NERT FBR System

100 lbs/day **(Figure 6-13**). This has led to a concurrent reduction of perchlorate levels at Metropolitan's Whitsett Intake at Lake Havasu from 0.009 mg/L in 1998 to typically less than 0.002 mg/L today. **Figure 3-7** in **Chapter 3** illustrates the recent decline in perchlorate concentrations at Whitsett Intake.

Several remedial efforts have been made at the Tronox/NERT site to address perchlorate contamination under the direction of the Nevada Division of Environmental Protection (NDEP). In 1998, Tronox constructed an 11-acre evaporation pond to retain perchlorate-contaminated groundwater. A deep slurry wall was also installed to slow the transport of the plume migrating to the Las Vegas Wash. Tronox began operation of an ion exchange system near the Las Vegas Wash (referred to as the seep area) in 1999 and at the Athens Road well field site in 2002. In 2004, due to economic reasons and operational difficulties experienced with the ion exchange systems, Tronox switched treatment methods to an ex-situ biological treatment system using fluidized bed reactors (FBRs). An FBR consists of a reactor vessel where bacterial biomass is immobilized and can grow on a hydraulically fluidized bed of granular activated carbon. The perchlorate concentration in the influent to the FBR system is typically between 250 and 300 mg/L and the discharge to Las Vegas Wash is typically below 0.004 mg/L. Through June 2016, remedial efforts at the Tronox/NERT site have prevented an estimated 4,630 tons of perchlorate from entering the Colorado River system. This has resulted in a reduction of over 90 percent of the perchlorate entering the Colorado River. **Figure 6-13** illustrates the decline of perchlorate loading into Las Vegas Wash since it was first discovered in 1997.

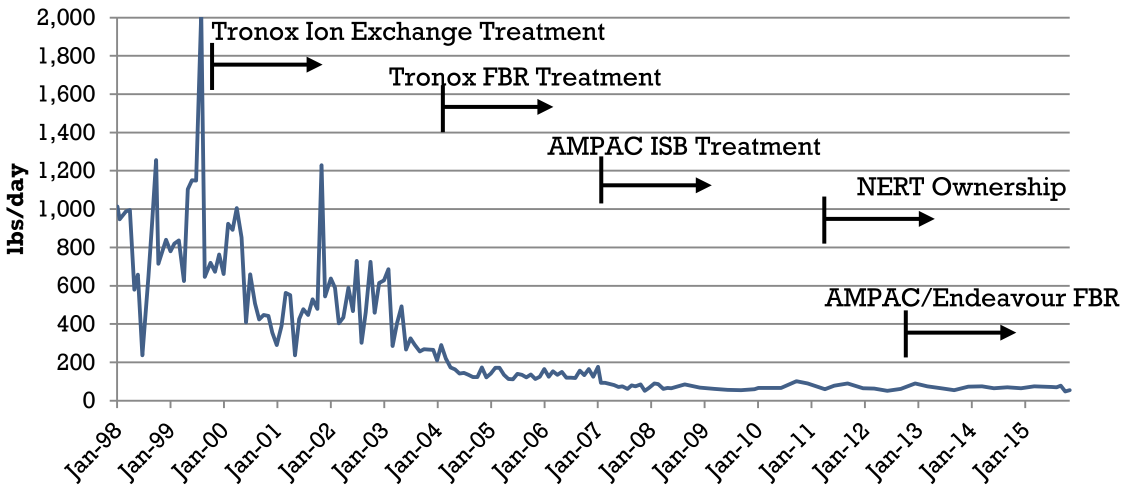


Figure 6-13. Perchlorate Load Reduction into Las Vegas Wash

In January 2009, Tronox filed for Chapter 11 bankruptcy protection through the United States Bankruptcy Court, Southern District of New York. Tronox cited significant environmental liabilities taken on from Kerr-McGee as a primary cause of their financial liabilities. The bankruptcy settlement resulted in the formation of the Nevada Environmental Response Trust (NERT), which has been given ownership and responsibility for site cleanup as of February 14, 2011, with NDEP providing regulatory project oversight. NERT received $81 million through the bankruptcy settlement. In April 2014, Tronox reached a $5.15 billion settlement with its predecessors, which awarded approximately $1.1 billion, directed to NERT, to clean up the former Tronox site. The settlement, which represents one of the largest environmental recoveries in history, went into effect in January 2015 and helps to ensure adequate funds are available for site cleanup and protection of the downstream Colorado River. During the reporting period, NERT completed several improvements to optimize the current treatment system including refurbishment of the FBRs and critical repairs to process equipment (e.g., flow meters, well pumps, air compressor system, sludge transfer pump). NERT also began operating additional extraction wells to maximize groundwater extraction and completed improvements to convert the GW-11 pond to an equalization basin upstream of the FBRs.

NERT is currently conducting remedial investigations for long-term soil and groundwater cleanup, while NDEP is initiating a regional investigation of downstream perchlorate contaminated areas to further reduce loading into Las Vegas Wash. Current efforts involve a soils investigation of former perchlorate production buildings at the site to identify perchlorate origin sources and a groundwater and surface water investigation near the Las Vegas Wash. In addition, NERT has commenced field studies of various remedial technologies, which include soil flushing and bioremediation, to assist with determining the final remedy. NERT anticipates completing the remedial investigations in 2020.

NERT anticipates finalizing a feasibility study report in 2021, containing an evaluation of multiple remedial alternatives, for NDEP to prepare a Record of Decision in 2022. Construction of the final remedy is expected to begin in 2022 with full cleanup anticipated to take several decades. NERT and NDEP hold quarterly meetings with Metropolitan, SNWA, and CAP to ensure the Colorado River stakeholders are informed on remedial progress and budgetary issues.

AMPAC/Endeavour Remediation

Between 1997 and 2004, over 100 monitoring wells were installed by PEPCON/AMPAC. Various treatment systems were investigated for the site. In 2002 and 2003, a pilot test for in-situ bioremediation (ISB) technology was conducted and found acceptable for full-scale. ISB is a biological process using naturally-occurring microorganisms to treat soil and groundwater contamination. For the system, contaminated groundwater was extracted, nutrients were added to enhance bioremediation (along with an electron donor and other constituents as required), and the conditioned water was then reinjected into the aquifer near Las Vegas Wash.

In June 2006, an interim ISB system began operation with four extraction wells. The interim system showed success, which resulted in full-scale operations since December 2006. The ISB system extracted groundwater from the Athens Road area as well as an area referred to as Athens Pen, an area approximately 1,200 feet north of Athens Road. The system consisted of nine extraction wells, an ISB water processing plant, and six reinjection wells.

After startup of the full-scale system, AMPAC continued to experience biofouling at its injection well site, which limited the flow capacity of the remedial system. AMPAC shut down the ISB system in June 2012 and, in September 2012, started FBR treatment (similar to the Tronox FBR system) to increase perchlorate destruction rates. In 2012, AMPAC also expanded its extraction system to include five deep extraction wells in the Auto Mall area, which allowed for treatment of higher perchlorate loads closer to the source area. The full-scale FBR system removes approximately 1,000 lbs/day of perchlorate compared to the ISB system, which only removed between 30 and 50 lbs/day.

Effective December 14, 2015, Endeavour LLC (Endeavour) assumed full responsibility for conducting and completing the perchlorate remediation activities.

Metropolitan Activities

Metropolitan continues to actively engage with NDEP regarding the perchlorate cleanup efforts in Henderson, Nevada. NERT and NDEP hold quarterly meetings with Metropolitan, SNWA, and CAP to ensure the Colorado River stakeholders are informed of remedial progress and NERT budgetary issues. Metropolitan also participates in site visits to review the current remediation performance and discuss planned remedial project efforts.

Tronox/NERT Site Visit, October 2014

Metropolitan reviews all pertinent project documents to provide input on the development of the long-term remedial plan. In May 2013, Metropolitan, through the Partnership, submitted a comment letter on the 2012 *Remedial Investigation and Feasibility Study (RI/FS) Work Plan for the Nevada Environmental Response Trust Site* (**Appendix P**). In 2013, Metropolitan, on behalf of NERT and stakeholders, also commissioned a third-party expert review of the RI/FS Work Plan to assist with assessment of perchlorate conditions at the site, and to evaluate and identify remediation alternatives. Metropolitan also review pertinent documents on Endeavour's remediation efforts.

Metropolitan collects quarterly perchlorate samples at various sites within the Colorado River and within Metropolitan's service area. Monthly samples are collected at the Whitsett Intake at Lake Havasu. Samples at this location are analyzed through a low-level method (USEPA Method 332; MRL 0.0001 mg/L) to better represent the effects of the Henderson remediation efforts in lowering perchlorate levels within the lower Colorado River system. Metropolitan also analyzes split samples with NDEP for the Las Vegas Wash Northshore Road bridge monitoring location.

Metropolitan has also been engaged in perchlorate regulatory issues. A perchlorate MCL of 0.006 mg/L was established in California by DDW in October 2007. This value was equivalent to that previously set by Office of Environmental Health Hazard Assessment (OEHHA) in 2004. OEHAA issued a revised PHG of 0.001 mg/L in February 2015. Metropolitan coordinated discussions with external agencies including the Association of California Water Agencies (ACWA) and American Water Works Association (AWWA), and provided comments during the PHG revision process.

On the federal side, in February 2011, USEPA announced its decision to regulate perchlorate under the Safe Drinking Water Act no later than February 2013. The Natural Resources Defense Council entered into a lawsuit with USEPA in February 2016 claiming USEPA failed to meet the deadlines for promulgating perchlorate regulations. In October 2016, USEPA filed a settlement agreement with NRDC agreeing to issue a proposed perchlorate rule by October 31, 2018, and a final rule by December 19, 2019. Metropolitan has supported AWWA's position during USEPA's regulatory determination process to seek full review of the model and methodologies being used to derive a perchlorate MCL, and will continue to be engaged with USEPA and other stakeholders as a draft MCL is developed.

Wastewater Management in the Las Vegas Valley

Project Description

Over the past few decades, the cities of Las Vegas and Henderson and Clark County Water Reclamation District have been responsible for wastewater treatment in the Las Vegas Valley. In 2011, the City of North Las Vegas' wastewater treatment plant came online. This plant treats approximately 25 MGD of wastewater previously treated by the City of Las Vegas' wastewater treatment plant. In recent years, these agencies have typically discharged approximately 160 MGD of tertiary treated wastewater effluent into Las Vegas Wash, which flows into Las Vegas Bay and Lake Mead.

As reported in the 2005 and CRWSS 2010 Updates, the Clean Water Coalition (CWC), a joint powers authority of the four wastewater agencies, was formed in 2002. The CWC was formed to investigate and implement an alternative means of discharging wastewater into Lake Mead and the Colorado River system. Several options were considered for this alternative discharge project, referred to as the Systems Conveyance and Operations Program, or SCOP, with the preferred alternative to discharge effluent through an outfall diffuser deep within Boulder Basin of Lake Mead. However, in 2009, a number of changed conditions affecting the Las Vegas Valley led to the reevaluation of the need for SCOP. Some of these changed conditions included lower population growth projections, national economic downturn, financing issues, and optimized treatment at the wastewater treatment plants with respect to phosphorus removal. As such, CWC officially terminated SCOP in September 2011 and shortly thereafter, the agency was dissolved.

Following a massive algae bloom in Boulder Basin in 2001, the dischargers voluntarily began year-round phosphorus removal at their wastewater treatment plants (Note: Nevada's total maximum daily load, or TMDL, for phosphorus into Las Vegas Wash limits the plants to 334 lbs/day of phosphorus discharged during the algae growing season, defined as March 1 through October 31). In 2005, the dischargers also began optimizing their treatment to remove a greater amount of phosphorus from their plants. Historically, the plants collectively have discharged over 500 lbs/day phosphorus into Las Vegas Wash. This was lowered to below 334 lbs/day following adoption of the TMDL in 1994, and then voluntarily applied year-round by the dischargers since 2002. Following optimization in 2005, the wastewater treatment plants are currently discharging approximately 200 lbs/day of phosphorus. **Figure 6-14** illustrates the declining phosphorus loading into Las Vegas Wash since 1990 despite increases in population growth.

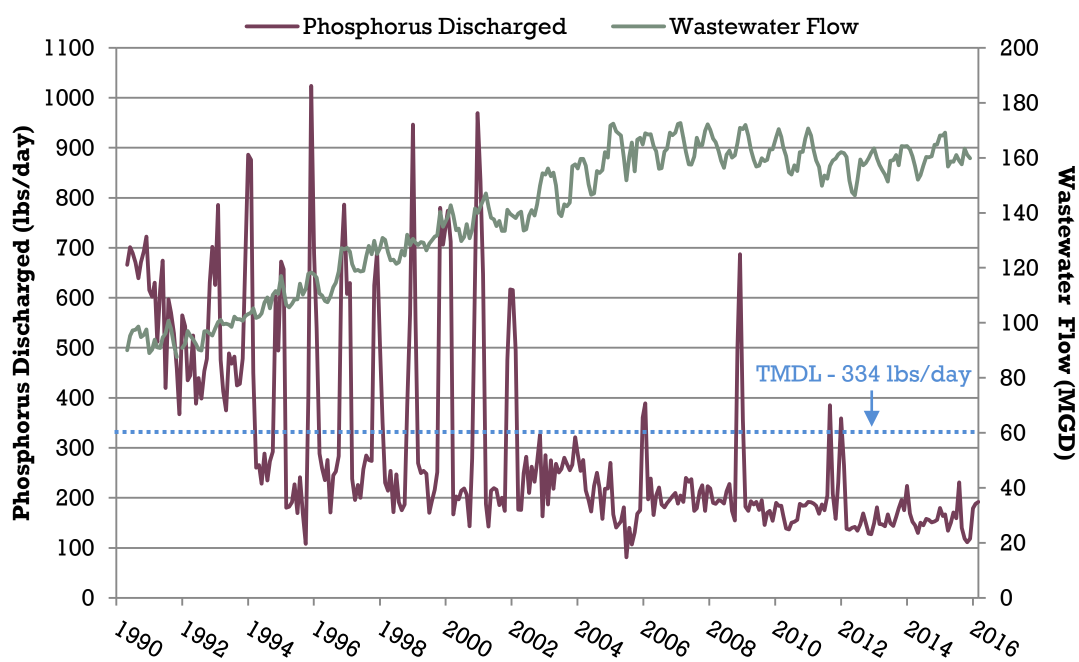


Figure 6-14. Declining Phosphorus Loading into Las Vegas Wash

The four wastewater agencies renewed their NPDES Permits in April 2015 (previous permits were issued in 2011). Fact Sheets from the NPDES Permits for each of the dischargers are included in **Appendix T** for reference. The permit renewals continue to include provisions to protect the ecological systems and beneficial uses of the Las Vegas Wash, Boulder Basin of Lake Mead, and the Colorado River system downstream of Hoover Dam.

As indicated in the NPDES Permit Fact Sheets (**Appendix T**), the following treatment processes are included for each of the facilities discharging to Las Vegas Wash:

- City of Las Vegas, Water Pollution Control Facilities: Train 1- primary sedimentation, trickling filters and secondary sedimentation followed by nitrification (activated sludge) for the conversion of ammonia to nitrate, chemical addition and filtration for phosphorus removal, chlorination and dechlorination; Train 2 – primary sedimentation, BOD and biological nutrient removal using the Bardenpho process, secondary sedimentation, chemical addition and filtration for additional phosphorus removal, chlorination, and dechlorination
- City of Henderson, Kurt R. Segler Water Reclamation Facility: preliminary treatment, activated sludge, biological nutrient removal cells to achieve phosphorus removal and nitrogen reduction, solids contact clarifiers for secondary phosphorus removal, sand filtration, and ultraviolet or hypochlorination disinfection
- Clark County, Flamingo Water Resource Center: preliminary treatment, primary sedimentation, advanced activated sludge followed by biological nutrient removal in the activated sludge process, secondary clarification, filtration and ultraviolet disinfection. Filtration is completed at two facilities (Outfall 001 and Outfall 002); Outfall 001 also includes a 30 MGD membrane and ozone facility.
- City North Las Vegas, North Las Vegas Water Reclamation Facility: preliminary treatment, membrane bioreactor secondary treatment, disinfection, and solids handling.

Table 6-3 identifies the design and long-term average discharges for the wastewater treatment plants discharging into Las Vegas Wash based on the 2015 NPDES permits, and summarizes some recent treatment process improvements achieved by the plants since the CRWSS 2010 Update.

Table 6-3. Recent Improvements at Wastewater Treatment Plants in Las Vegas Area

Las Vegas Discharger	Design Discharge	Long-term Average Discharge	Process Improvements
City of Las Vegas[1] (Water Pollution Control Facility)	91 MGD	46.7 MGD	Converted the nitrification facility to provide biological nutrient removal, nitrification, and denitrification. Constructed a sludge blending pump station and installed a digester gas purification system.
City of Henderson[2] (Kurt R. Segler Water Reclamation Facility)	40 MGD	12.8 MGD	Opened the new 8 MGD membrane bioreactor Southwest Water Reclamation Facility and earmarked $40.5 million for plant rehabilitation over 5 years.
Clark County Water Reclamation District (Flamingo Water Resource Center – Outfall 001 East Campus and Outfall 002 West Campus)	150 MGD	89.4 MGD	Brought a 30 MGD membrane and ozone treatment facility online at one of two filtration facilities. Rehabilitated 55 MGD of dual media filters and awarded a contract to build 65 MGD of new dual media filters and replace aging UV disinfection equipment.

Las Vegas Discharger	Design Discharge	Long-term Average Discharge	Process Improvements
City North Las Vegas[3] (North Las Vegas Water Reclamation Facility)	25 MGD	16.9 MGD	Stabilized operation of the new membrane bioreactor plant and began construction of a pipeline to carry highly treated effluent directly to the Las Vegas Wash.

1 Durango Hills Water Resource Center design discharge is 10 MGD and long-term average discharge is 2.97 MGD. Durango Hills primarily uses wastewater for irrigation but may discharge to Las Vegas Wash during non-irrigation season.

2 Southwest Water Reclamation Facility design discharge is 8 MGD and there have been no discharges to Las Vegas Wash. Southwest Water Reclamation Facility supplies reclaimed water to customers for irrigation but can discharge to Las Vegas Wash in an emergency.

3 City of North Las Vegas supplies reclaimed water for irrigation of a golf course at Nellis Air Force Base and the remainder of the plant effluent is discharged to Las Vegas Wash.

Metropolitan Activities

Since SCOP was terminated in 2011, Metropolitan has continued to collaborate with Las Vegas wastewater dischargers through various stakeholder forums including the Ecosystem Monitoring Workgroup, established in early 2012 to coordinate and discuss water quality issues pertinent to Lake Mead and other mutual interests for the Colorado River system. Metropolitan believes the implementation of year-round phosphorus removal and optimization of the wastewater treatment systems represent good practice with respect to drinking water source protection and must continue. The lower discharge levels and year-round removal are not regulatory requirements, but practices that the dischargers have voluntarily taken on to address water quality issues for Las Vegas Wash and Lake Mead, which in turn provides protection of downstream uses. In a November 2014 letter to the Partnership agencies (Metropolitan, SNWA, and CAP) the wastewater dischargers expressed their commitment to continuing year-round phosphorus removal, process improvements, and capital investments to maintain phosphorus at concentrations below levels of concern (**Appendix T**). In a March 2015 response letter, the Partnership emphasized that optimized treatment and year-round phosphorus removal at the treatment plants are key to the long-term protection of downstream uses of the Colorado River in terms of phosphorus loading **Appendix T**.

Metropolitan will continue to track performance of the wastewater treatment plants with respect to phosphorus discharges and expects future water quality issues to be successfully addressed through collaborative processes between the dischargers, SNWA, and Metropolitan, or through broader stakeholder forums such as the Lake Mead Water Quality Forum. The 5-year NPDES Permit cycle also offers Metropolitan and other interested parties additional opportunities to provide formal input and address any future concerns.

Las Vegas Wash Stabilization Program

Program Description

Background

For over 35 years, the Las Vegas Wash (Wash), which drains the increasingly urbanized Las Vegas Valley into Lake Mead and Colorado River, has sustained significant erosion. Before the Las Vegas Valley developed, the Las Vegas Wash was primarily a dry desert wash channel that would only flow during rainstorms. However, due to the growth in the Las Vegas Valley, the Wash began conveying increased amounts of treated effluent, groundwater, urban runoff, and storm flows. As a result of these increased flows, the erosion has deepened the Wash, diminished established wetlands, and transported sediment to Lake Mead. A depiction of the erosion issue is shown in **Figure 6-15** and **Figure 6-16** [202].

Figure 6-15. Las Vegas Wash downstream of Northshore Bridge, 1978 [202]

Figure 6-16. Las Vegas Wash downstream of Northshore Bridge, 2005 [202]

As discussed in the *Perchlorate Remediation in Henderson, Nevada* section, perchlorate-contaminated groundwater plumes from chemical manufacturing facilities in the Henderson area have seeped into the Wash and perchlorate is held in deep gravels and sediments. Some of the perchlorate mass is controlled by geologic formations that are actively eroding. Further down-cutting in the Wash has the potential to mobilize perchlorate downstream.

Erosion and Perchlorate Control

In 1998 the Las Vegas Wash Coordination Committee (LVWCC), comprised of 29 members from federal, state, and local agencies and private interests, was formed with the intent of addressing issues related to the Wash. In 2000, the LVWCC, overseen by SNWA, approved a Comprehensive Adaptive Management Plan, which recommended stabilization of the Wash as one of the highest recommended priority efforts. In 2002, a cooperative agreement was signed between major stakeholders and in an amended agreement, in 2012, SNWA was designated as the lead agency to coordinate and manage the Las Vegas Wash Stabilization Program.

The purpose of the Las Vegas Wash Stabilization Program is to reduce erosion in the Wash by slowing the stream flow, while providing favorable conditions for restoring habitat along the Wash. The program proposes construction of 21 erosion control structures along the Wash as shown in **Figure 6-18**. Since 1999, 19 structures have been built; during the reporting period, 8 weir structures were completed including Homestead, Lower Narrows, DU Wetlands No. 1, Duck Creek Confluence, Upper Narrows, Archery, Silver Bowl, and Three Kids Weirs. The recently constructed Three Kids Weir (**Figure 6-17**) is one of the largest weirs along the Las Vegas Wash and spans 450 feet across the wash with an elevation drop of 17 feet. The Three Kids Weir replaced the temporary Demonstration Weir, constructed by Lake Las Vegas in 1999, which was the first rock riprap erosion control structure on the Las Vegas Wash as previous weirs were constructed of finished concrete.

The overall cost for completing the program is estimated at $168 million. The Wash receives funding from local sales tax revenues, capital grants from the Southern Nevada Public Lands Management Act, and from other local agencies through in-kind construction activities or direct funding to SNWA.

Figure 6-17. Three Kids Weir, July 2015
[203]

In 2002, NDEP had placed the lower reach of the Wash on its 303(d) list of impaired waters due to potential impacts to aquatic life resulting from total suspended solids (TSS). However, the program has resulted in successful erosion control, stabilization, and enhancement efforts, which have significantly decreased TSS concentrations. NDEP delisted the Las Vegas Wash in 2004 after data demonstrated compliance with the TSS water quality standards of 135 mg/L [204].

The Las Vegas Wash Stabilization Program has involved construction of weirs downstream of where the NERT perchlorate plume enters the Wash. The NERT plume enters the Wash downstream of the Pabco Weir. Completion of these erosion control structures was critical to minimize the potential for future mobilization of subsurface perchlorate-laden geologic formations. Construction of the weirs, downstream of the NERT plume, previously involved dewatering and temporarily discharging groundwater that had higher levels of perchlorate than what was historically contained in Wash surface flows. Dewatering discharges were modeled to assess impacts at both the SNWA and Metropolitan intakes to determine the optimal dewatering discharge and operating period to minimize any downstream impacts. The modeling results indicated negligible impacts to downstream water quality.

NDEP issued an NPDES permit to regulate perchlorate discharges during construction dewatering; actual discharges were well below permitted levels. SNWA actively monitored perchlorate levels at numerous locations including the Wash, SNWA intakes, Lake Mead, and Hoover Dam during and after dewatering activities. No downstream impacts from the dewatering activities have been identified.

In April 2016, NDEP issued a Finding and Order requiring NERT to provide an Engineering Evaluation/Cost Analysis (EE/CA) that evaluates the cost, feasibility, schedule and permitting requirements for transferring and treating groundwater extracted during SNWA's construction dewatering for the Historic Lateral and Sunrise Weirs. The Historic Lateral and Sunrise Weirs are located downstream of the NERT perchlorate plume and groundwater extracted during construction dewatering is estimated to contain 3 tons of perchlorate. These are the final two weirs influenced by the NERT plume. NDEP and NERT are currently coordinating installation of a perchlorate treatment system (likely ion exchange) to manage and treat groundwater extracted during construction of the weirs, which is expected to begin in June 2017.

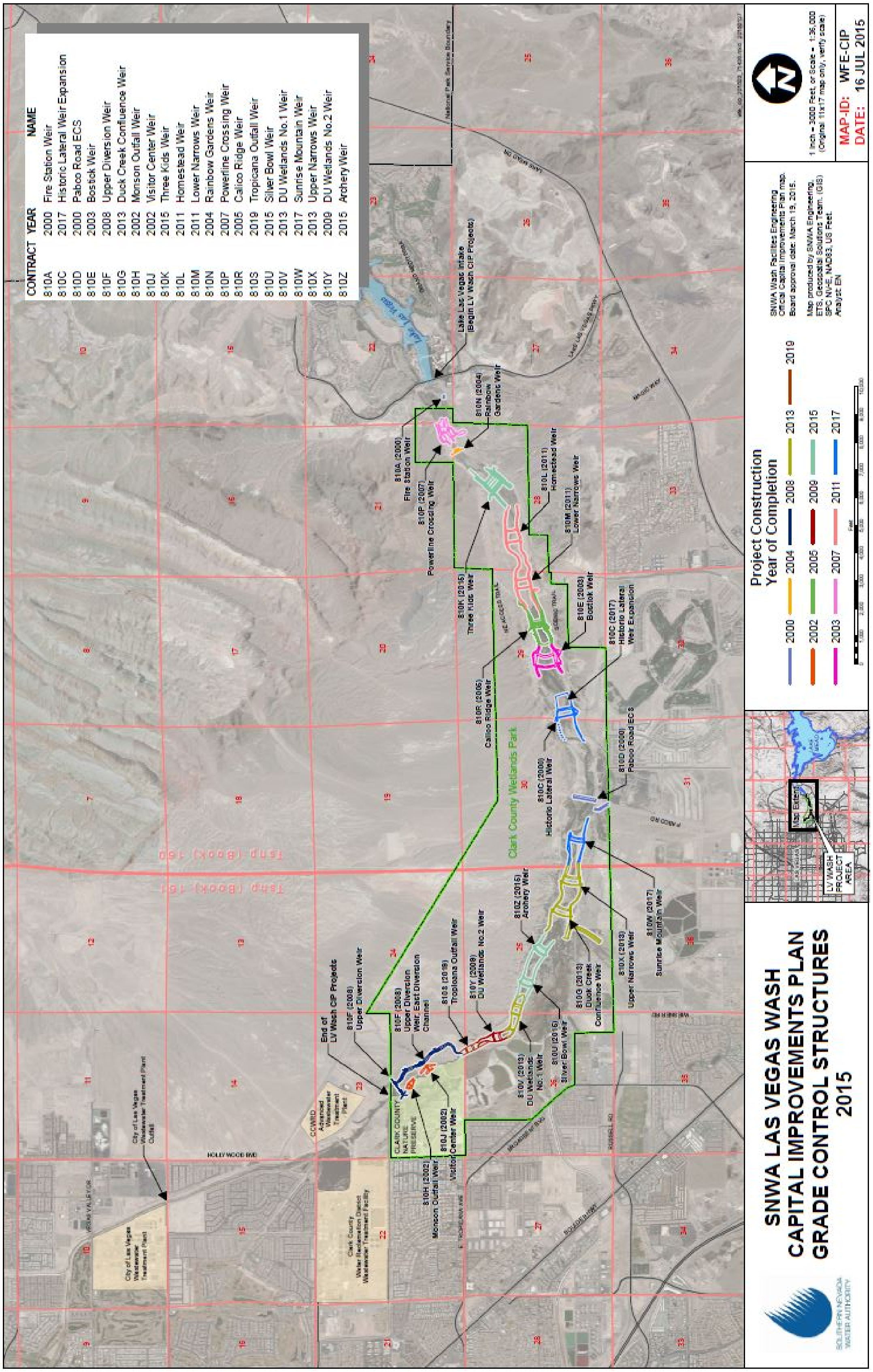


Figure 6-18. Las Vegas Wash Stabilization Program [212]

Metropolitan Activities

In 2009, SNWA informed Metropolitan of plans to construct six of the erosion control structures in areas affected by perchlorate contamination and presented modeling results of dewatering scenarios and potential impacts to water quality at Whitsett Intake. Metropolitan reviewed the monitoring and modeling information provided by SNWA and conducted an independent assessment of the potential impacts on the Colorado River from construction dewatering discharges into the Wash. Metropolitan concurred with SNWA's modeling results and recommendations.

SNWA continues to closely coordinate construction activities with Metropolitan, provides regular reports on perchlorate concentrations and loadings during dewatering, provides copies of quarterly reports, which are submitted to NDEP, and includes Metropolitan on visits to the weir sites. In September 2016, Metropolitan reviewed and commented on documentation provided by NDEP and NERT regarding the proposed treatment system for the groundwater extracted during dewatering for the weir construction. Overall, Metropolitan strongly supports the Las Vegas Wash Stabilization Program, which is improving water quality in Lake Mead and controlling long-term perchlorate loading.

As discussed in Chapter 3, Metropolitan conducts quarterly monitoring for perchlorate at multiple locations along the Colorado River and monthly monitoring at Whitsett Intake. Monitoring results at the Whitsett Intake (shown in **Figure 3-7**) indicate that perchlorate concentrations have trended downward and have been below 0.002 mg/L in recent years. Monitoring results have not demonstrated any downstream effect from the dewatering activities.

Chromium-6 Remediation at PG&E's Topock Gas Compressor Station

Project Description

Background

The Pacific Gas and Electric (PG&E) Topock Compressor Station is located in eastern San Bernardino County approximately 15 miles southeast of Needles, California. The facility, which began operations in 1951, compresses natural gas for transmission through pipelines to northern and central California. Before being transported, the compressed gas is cooled in cooling towers. Until approximately 1985, chromium-containing compounds were used to reduce corrosion and inhibit scale build-up in the cooling system. In 1985, PG&E replaced the chromium-6 based cooling water treatment products with non-hazardous phosphate-based products.

From 1951 to 1964, untreated blow-down wastewater from the cooling towers was discharged to Bat Cave Wash, a normally dry stream that leads to the Colorado River, located adjacent to the station. As a result, a groundwater plume of chromium-6 was found at the PG&E Topock site. In 1964, PG&E began treating the wastewater to convert chromium-6 to chromium-3, which is less toxic and less mobile in groundwater. At about this time, PG&E also constructed a percolation bed in the wash to impound the discharged wastewater and allow it to percolate into the ground and/or evaporate. In 1970, discharges to Bat Cave Wash ceased and treated wastewater was discharged to an injection well located on PG&E property. In 1973, PG&E discontinued the use of the injection well, and wastewater was discharged exclusively to a set of four single-lined evaporation ponds. In 1989, the single-lined ponds were replaced with four new double-lined ponds.

Regulatory Cleanup Process

The Resource Conservation and Recovery Act (RCRA) of 1980 and the Hazardous and Solid Waste Amendments of 1984, collectively known as RCRA, established the Corrective Action Process being followed for remediation. In February 1996, PG&E and the California Department of Toxic Substances Control (DTSC) entered into a Corrective Action Consent Agreement based on the RCRA Corrective Action Process. The cleanup activity is also subject to federal oversight and must follow the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA), which was created to fund cleanup of hazardous sites in 1980. In 2005, PG&E entered into a Consent Agreement with the U.S. Department of the Interior (DOI).

The Corrective Action Process for both RCRA and CERCLA have similar milestones as shown in **Figure 6-19**. In addition, the RCRA Corrective Action activities must comply with the California Environmental Quality Act (CEQA). The environmental investigation has been coordinated between DTSC and DOI; and in 2009, a Final RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report was completed. The RFI/RI provided a hydrogeologic characterization and results of groundwater, surface water, and river sediment investigations. In 2009, PG&E also completed a Corrective Measures Study/Feasibility Study (CMS/FS) to identify and evaluate remedial alternatives and to provide the basis for the selection of a recommended alternative. In accordance with CERCLA, DOI finalized the Groundwater Record of Decision in December 2010, which presented the remedial action. In conjunction with DOI, DTSC finalized the Notice of Remedy Selection in January 2011. In January 2011, as part of CEQA, an Environmental Impact Report was certified to determine any significant impacts resulting from the proposed remedial action.

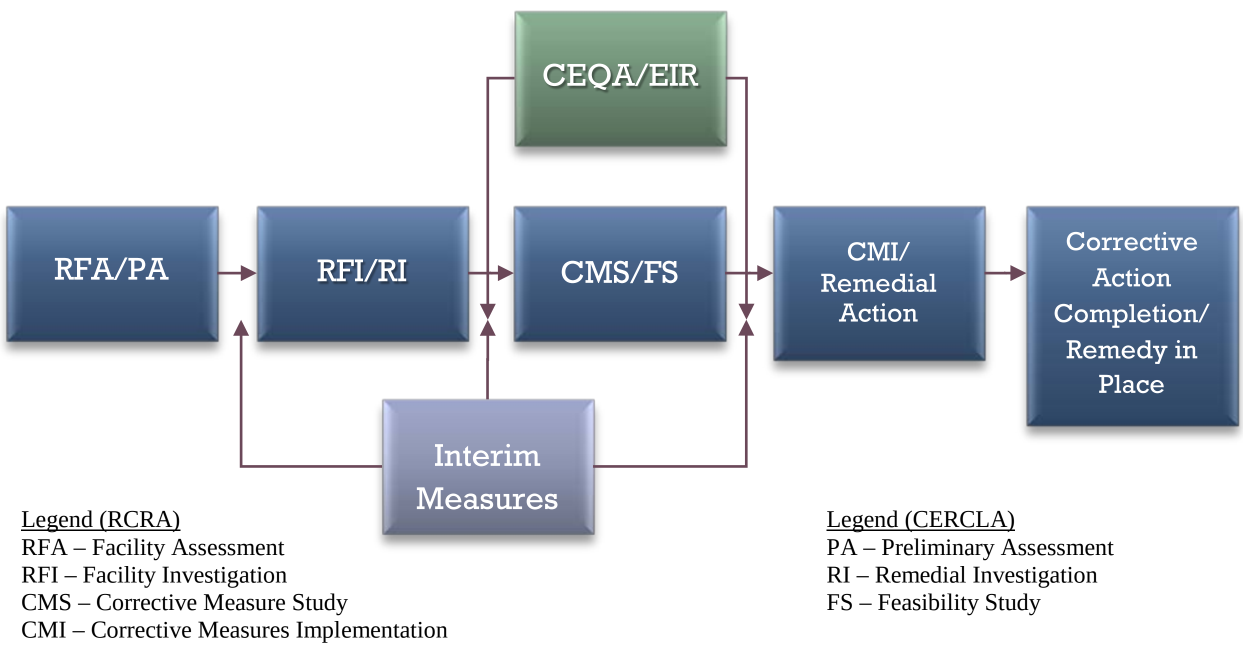


Figure 6-19. Topock Compressor Site Regulatory Cleanup Process

In January 2011, DTSC directed PG&E to proceed with preparing a Corrective Measures Implementation/Remedial Action Work Plan. The Revised Groundwater Corrective Measures Implementation/Remedial Design Work Plan, completed in November 2011, presents the framework and schedule for the implementation of the selected Final Remedy. In addition, PG&E prepared the final design based on the selected Final Remedy, which involves the installation of an in-situ bioremediation treatment system described later in this section. In November 2015, PG&E submitted the *Basis of Design/ Final (100%) Design Report for the Final Groundwater Remedy* to DTSC and DOI. In April 2015, DTSC determined that a Subsequent Groundwater Environmental Impact Report would have to be prepared to evaluate potential environmental impacts based on new design details, such as the installation of the freshwater wells, in the Final Design.

Water Quality Monitoring

PG&E began groundwater and surface water monitoring in 1997 as part of RFI/RI and manages an ongoing Groundwater Monitoring Program. The current Groundwater Monitoring Program includes more than 100 monitoring wells, which are sampled regularly for chromium-6, total chromium, and other water quality constituents. Based on this monitoring work, PG&E has delineated the chromium-6 plume shown in **Figure 6-20**.

The monitoring well in closest proximity to the Colorado River is MW-34-100, a deep well located approximately 60 feet west of the Colorado River and north of the railroad tracks. An analysis of the MW-34-100 sampling provides an indication of the potential chromium-6 migration impacts on the river and reveals that the maximum concentration level of chromium-6 observed in the well was 0.976 mg/L in June 2006 (**Figure 6-21**). Chromium-6 levels, shown in **Figure 6-21,** correlate with fluctuating river levels as influenced from Davis Dam releases. USBR releases higher flows in spring/early summer and reduces flow in November/December resulting in the higher chromium-6 concentrations. The data collected for MW-34-100 also demonstrates the performance and effectiveness of the interim measures, described in the following section. Overall, the level of chromium-6 has decreased after interim treatment measures were implemented in 2005 and the plume has reduced in size, thus reducing the risk of potential contamination to the Colorado River.

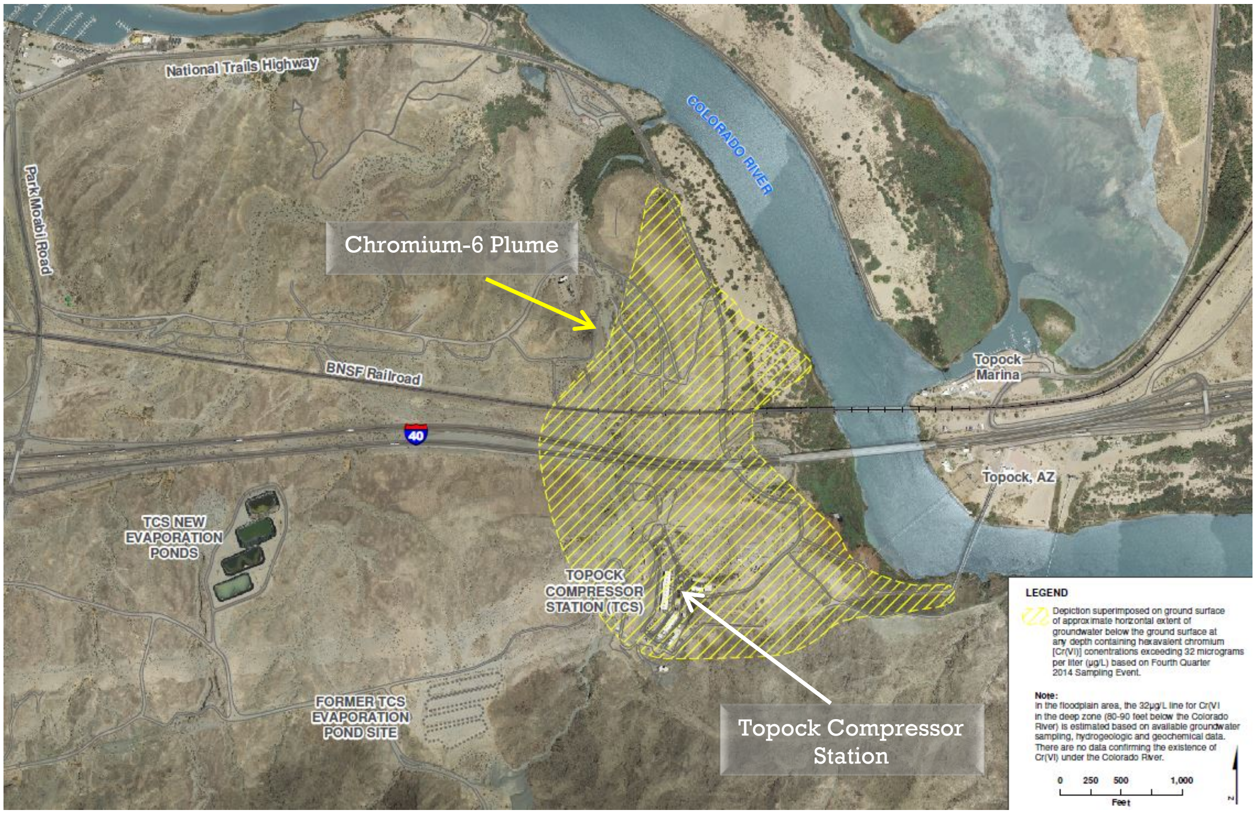


Figure 6-20. Chromium-6 Groundwater Plume [205]

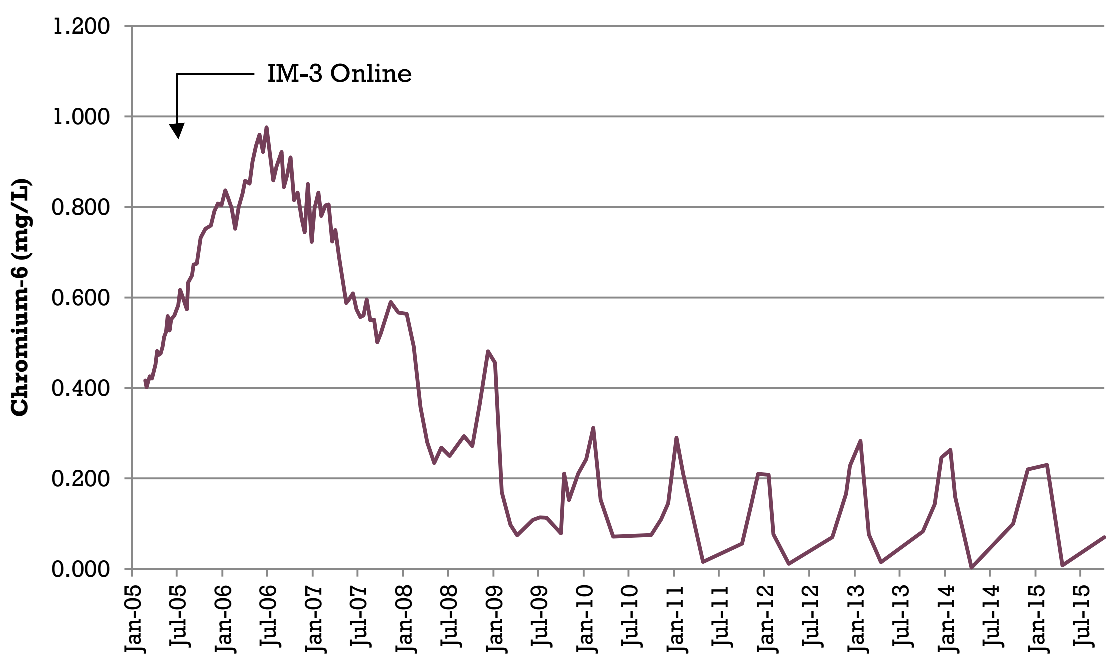


Figure 6-21. Chromium-6 Groundwater Monitoring Results at Topock Site MW-34-100 (2011–2015)

Interim Measures

DTSC was prompted to initiate immediate remediation at the site when a 0.111 mg/L concentration of chromium-6 was detected at monitoring well MW-80 in January 2004, which is located approximately 65 feet from the Colorado River. In March 2004, PG&E implemented Interim Measure 2 (IM-2) a groundwater extraction and treatment system to control flow of groundwater away from the Colorado River for protection of public health and the environment. In 2005, Interim Measure 3 (IM-3), which includes a treatment plant and conveyance system, was implemented to remove groundwater at higher rates than was possible with IM-2 and thus increasing the hydrologic gradient away from the river. The IM-3 process consists of groundwater extraction, treatment, and reinjection of the treated water into the groundwater aquifer upstream of the plume. The general layout of the IM-3 facilities is shown in **Figure 6-22**.

Since the beginning of the Interim Measures in 2004, approximately 25 percent of the chromium-6 plume mass has been removed. The chromium-6 removal rate has declined over the years from 1,200 lbs/year removed in 2005 to less than 400 lbs/year removed in 2015. In July 2015, PG&E identified the potential for increasing chromium-6 removal by shifting pumping operations from well PE-1, which has a chromium-6 concentration of approximately 0.004 mg/L to well TW-3D, which has a chromium-6 concentration of approximately 0.8 mg/L [205]. PG&E continues to evaluate options for optimizing the interim treatment measures and will be applying the experience gained from the IM-3 operations to the final groundwater remedy. IM-3 will be decommissioned during start-up construction of the final groundwater remedy.

Final Groundwater Remedy

As per the *Notice for Groundwater Selection* dated January 31, 2011, the selected remedy involves installation of injection and extraction wells along the National Trails Highway to create a treatment zone by continuously mixing the contaminated plume groundwater with nutrient-added water to promote the reduction of chromium-6 to chromium-3. Chromium-3 is insoluble and would precipitate out of the water and attach to the soil substrate. In addition, extraction wells near the Colorado River would act as a barrier to prevent contamination from reaching the river. Additional injection wells located around the plume would inject fresh water and groundwater, removed from locations near the river, to push the plume towards the treatment zone. Project construction is estimated for completion in 2022, after which the operations and monitoring phase is anticipated to take approximately 30 years or more.

Figure 6-23 demonstrates the approximate location of the proposed In-Situ Reactive Zone (IRZ) wells along National Trails Highway, the extraction wells proposed along the riverbank and in the East Ravine area, and the proposed injection wells located in the upgradient area east of the IRZ wells.

Soils Cleanup

DTSC and DOI are also overseeing the soil cleanup of the Topock Project Site per the RCRA and CERCLA processes. On August 24, 2015, DTSC certified the Soil Investigation Project Final EIR and Soil RFI/RI Work Plan for a soils investigation. DOI also approved the Soil RFI/RI Work Plan on August 24, 2015. The soils investigation field work was completed between November 2015 and March 2016. Approximately 1,000 soil samples were collected from 319 locations. In September 2016, PG&E submitted a plan identifying additional data collection required for addressing data gaps. The additional soils investigation and soils risk evaluation will be used in preparing the final RFI/RI Report, which is anticipated in 2018.

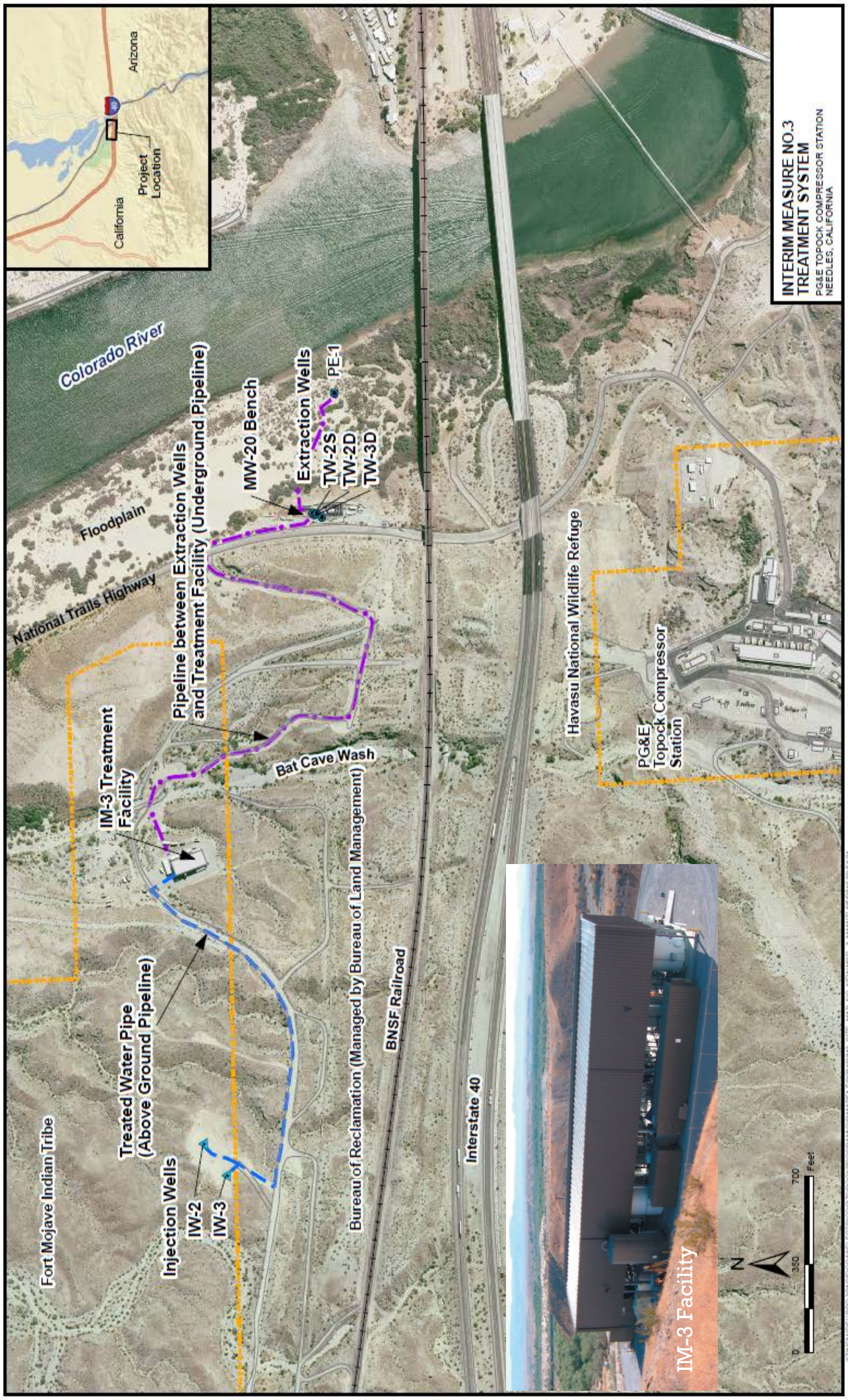


Figure 6-22. Interim Measure No. 3 Treatment at Topock Site

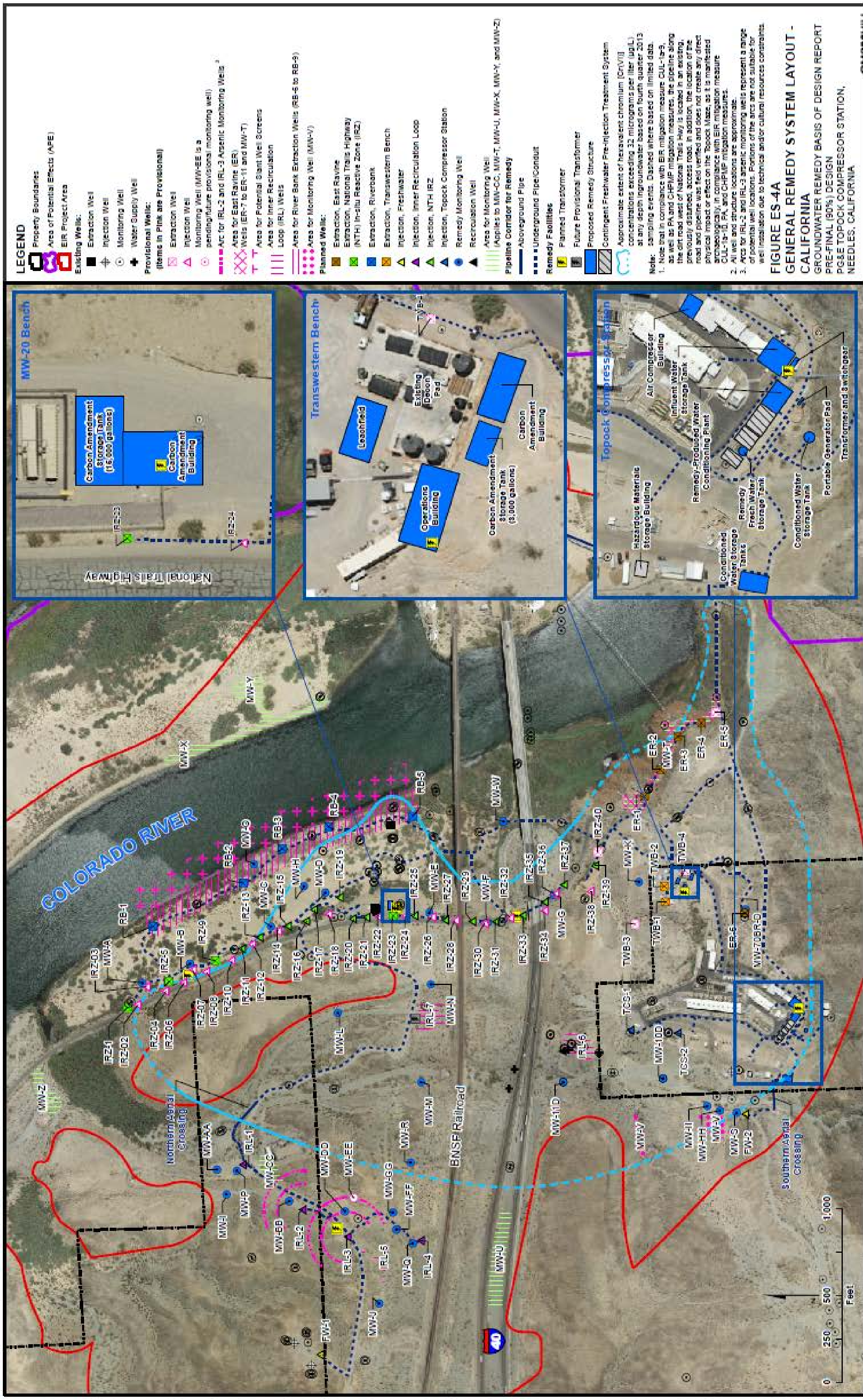


Figure 6-23. Topock Final Groundwater Remedy Layout

Groundwater Subsequent EIR

In May 2015, DTSC issued a Notice of Preparation for a Subsequent Environmental Impact Report (SEIR) based on the determination that the Final Design for the chromium-6 groundwater remedy included substantial changes that were not addressed in the previous Groundwater FEIR, which was certified on January 30, 2011. The SEIR will only consider new Final Design details, which include the freshwater supply and treatment system, construction and soils staging, increase in soil disturbance, new wells, infrastructure footprint, and the Interim Measures decommissioning. The SEIR will consider new environmental information gathered from cultural and environmental surveys conducted as part of the soils investigation. DTSC anticipates releasing the draft SEIR in January 2017 for public review. The Final Design would be approved when the SEIR is certified.

Metropolitan Activities

In 2000, a Consultative Workgroup (CWG), comprised of various stakeholders, state, and federal regulatory agencies, was formed to provide consultation and recommendations on the remediation project. The CWG consists of a multitude of agencies such as the BLM, US Geological Survey, Regional Water Quality Control Board, DOI, Bureau of Indian Affairs, U.S. Fish and Wildlife Service, USBR, ADEQ, Indian tribes, Colorado River Board, and Metropolitan among others. Metropolitan has participated as an active member of the CWG since August 2003.

In addition to the CWG, a Topock Leadership Partnership (TLP) was convened following the Topock Breakthrough Summit in 2008. Metropolitan also participates in the TLP and the Clearinghouse Task Force (CTF), a subgroup of the TLP, which consists of leadership from regulatory agencies, stakeholders, and Indian tribes. The CTF meets monthly to develop tools and implement ideas to improve communications and enhance stakeholder understanding of the technical and regulatory processes of the project. The TLP meets as needed to discuss the project at a high level and allow for leadership input and communication transparency.

Metropolitan began monitoring the Colorado River in 2003, and sampled locations as shown in **Figure 3-4** in **Chapter 3**. Three sampling stations are located upstream of the Topock Compressor Station, and three sampling stations downstream of the site. As shown in **Table 3-10** in **Chapter 3**, chromium-6 levels have been primarily ND (< 0.03 mg/L) with minimal low level detections downstream of the PG&E Topock Gas Compressor site.

Since becoming involved in August 2003, Metropolitan has reviewed numerous work plans and technical data and has provided letters and technical memorandums to review and comment on the progress of the cleanup effort. **Appendix U** provides copies of the key correspondence submitted during the reporting period. Overall, Metropolitan supports the remediation plan that both DTSC and DOI have selected and will continue participating in the stakeholder process to assist with keeping the project moving forward, which will ensure long-term protection of the Colorado River.

Lake Mathews Watershed Planning and Management

Project Description

Background

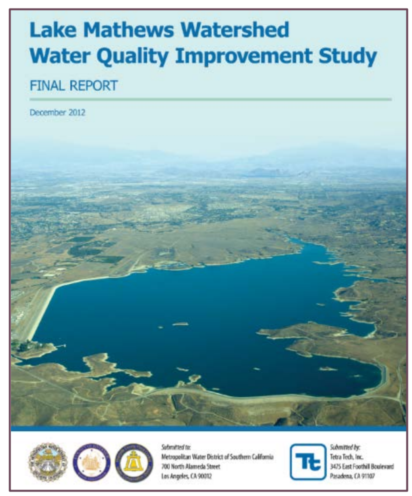
The Lake Mathews Drainage Water Quality Management Plan (DWQMP) was completed in the early 1990s through a partnership between Metropolitan, County of Riverside, and Riverside County Flood Control and Water Conservation District (RCFCWCD). An Environmental Impact Report for the DWQMP was also prepared and adopted at that time by the Riverside County Board of Supervisors. The DWQMP was developed to protect the quality of water in Lake Mathews by taking a regional approach to managing runoff in the watershed. The plan investigated the effects that existing and future development may have on Lake Mathews water quality and recommended steps that could be taken to reduce the contaminants that enter the lake associated with stormwater, or as a result of accidental spills in the watershed.

Under the DWQMP, runoff pollution would be managed and mitigated by the implementation of Best Management Practices (BMPs) throughout the watershed, including several regional stormwater treatment facilities (detention basin, sediment basins, wetlands, diversion ponds, etc.). As specified in the DWQMP, these facilities would be implemented in phases as the watershed develops. Some of the plan's recommended facilities have since been built, such as the Cajalco Creek Dam/Detention Basin (**Figure 6-24**) and several sediment basins. The Cajalco Creek Dam and Detention Basin was constructed in 2001 to help reduce contaminants flowing into Lake Mathews from Cajalco Creek. The project consists of a dam across Cajalco Creek, a single sedimentation basin upstream of the dam, and four sedimentation basins downstream of the dam. The dam provides the capability to detain waters flowing in Cajalco Creek to allow sediment to settle prior to releasing the water to Lake Mathews. The upstream sedimentation basin traps additional contaminants from the creek water. The four sedimentation basins, which are located on the south side of Lake Mathews, trap sediments and contaminants in tributaries that flow directly into the lake.

In 2006, Metropolitan collaborated with RCFCWCD to complete the Gavilan Hills-Smith Road Debris Basin. This debris basin is within a subwatershed with significant erosion potential and therefore, will greatly reduce sediment loads, along with other pollutants, transported downstream to the Cajalco Creek Detention Basin.

Figure 6-24. Cajalco Creek Dam and Detention Basin

Lake Mathews Watershed Study



As the DWQMP was completed nearly two decades ago, many of the stormwater treatment facilities recommended in the plan are not feasible and/or would not be the appropriate watershed management solutions in today's environment based on current water quality and environmental regulations, advances in stormwater management technologies, and available land in the watershed.

Metropolitan, in conjunction with RCFCWCD and County of Riverside, initiated a watershed study in 2008 to assess the current and future threat of runoff pollution into the lake and identify solutions to protect the use of Lake Mathews as a drinking water supply source. Metropolitan and its project partners constructed a dynamic model for the Lake Mathews watershed to examine the effects of development and various stormwater treatment options or BMPs and to address runoff pollutant loading into the lake. The Lake Mathews Watershed Water Quality Improvement Study was completed in December 2012. The study evaluated constituents such as total nitrogen, total phosphorus, sediment, and fecal coliform.

The study also included modeling of various future development scenarios and evaluated DWQMP BMP water quality management strategies and low-impact development (LID) requirements. **Table 6-4** summarizes a pared down list of scenarios including full implementation of LID and DWQMP BMPs, Cajalco Creek Wetlands #2, Lake Mathews Estates Water Quality Pond, and Alexander Street Water Quality Wetlands (all centralized BMPs identified in the DWQMP). The performance of each scenario in **Table 6-4** is ranked as high, medium, or low against the various targets including general evaluation criteria, cost and cost-effectiveness, provision of multiple benefits, and environmental effectiveness. **Table 6-5** compares the selected scenarios against meeting water quality objectives including sediment, nitrogen, and bacteria targets. Based on regulatory requirements for LID BMPs, the study found that implementation of both DWQMP and LID BMPs may overcompensate for expected development and suggested that implementation of the Lake Mathews Estates Water Quality Pond provides the most cost-effective alternative for continuing to ensure long-term protection of Lake Mathews.

The watershed study results can be used to help manage existing uses and guide future development and stormwater management practices in the watershed. The results also assist Metropolitan and partnering agencies in reviewing development proposals and other projects within the watershed to ensure protection of Lake Mathews. This watershed-wide assessment and model provides an effective planning tool that evaluates the impacts of watershed development on Metropolitan's source water quality.

The model used for the study has been supported by USEPA and utilized within several other southern California watersheds for performing technical water quality assessments and supporting regulatory development and compliance. An enhanced monitoring program may be needed to calibrate the watershed model, assess conditions, and evaluate effectiveness of the management actions. More reliable flow measurements at the flume meter downstream of the CCDDB and at key upstream locations will also better calibrate the watershed model. The model will be refined as additional data is collected for calibrating the model in the future.

Lake Mathews Watershed Development

As development in the Lake Mathews watershed increases in the future, along with changes to existing land uses, there is a potential for increasing pollutant loading into the lake. Previous water quality monitoring events have indicated elevated levels of some constituents of drinking water concern within the watershed. Metropolitan's construction of the Cajalco Creek Dam and Detention Basin in 2001 was a key element of the DWQMP and has been effective in removing sediment and attached pollutants from entering Lake Mathews. However, other upstream watershed controls are needed to minimize the pollutant load into the detention basin and ensure protection of lake water quality.

One of the larger development projects in the Lake Mathews Watershed is the Boulder Springs-Dailey Ranch development, which is located north and south of Cajalco Creek, approximately four miles east of Lake Mathews. The County of Riverside has required the project to implement DWQMP BMPs or functionally equivalent features to ensure that the project will not adversely impact water quality in Lake Mathews.

To address anticipated growth and mobility needs, the County of Riverside Transportation Department is proposing to widen and realign Cajalco Road, which traverses the Lake Mathews Watershed south of Lake Mathews and travels east-west in the vicinity of the Colorado River Aqueduct and other Metropolitan facilities. The County is currently evaluating various proposed alignment alternatives shown in **Figure 6-25,** which will be refined based on public and agency input and minimizing environmental impacts.

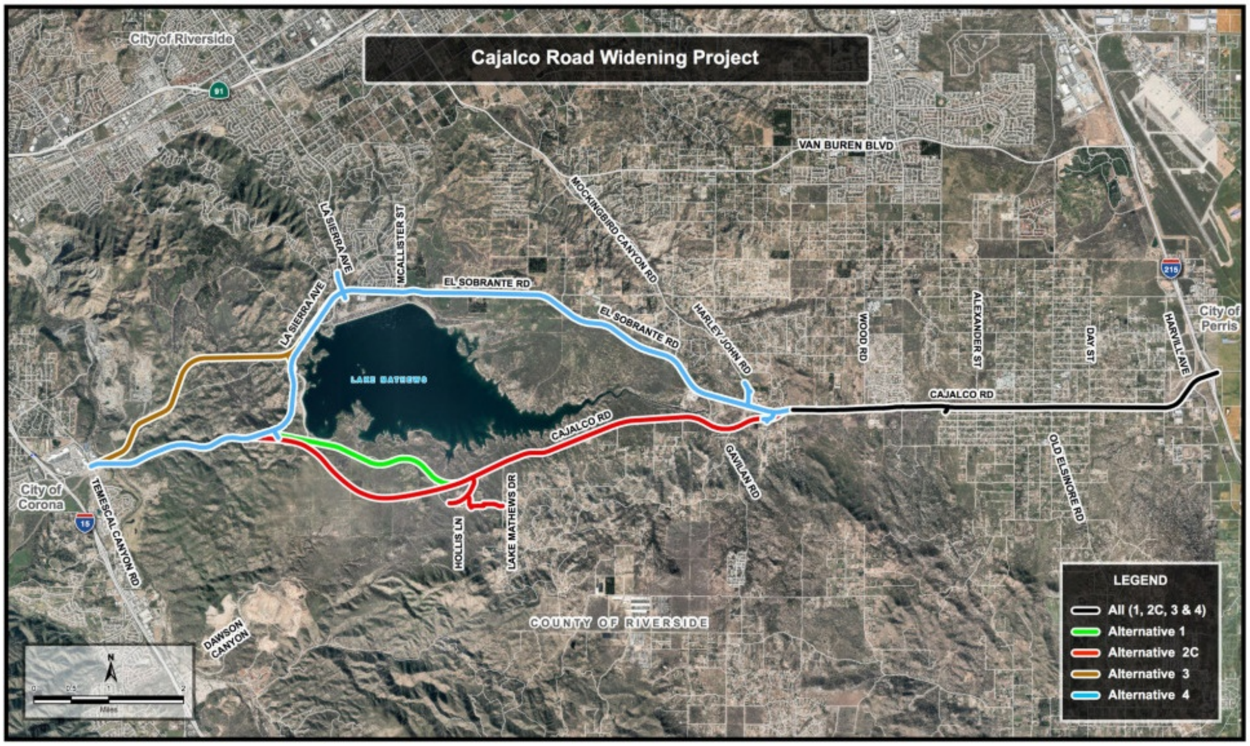


Figure 6-25. Cajalco Road Widening Project Alternatives [206]

Metropolitan Activities

During the reporting period, Metropolitan was involved with reviewing proposed developments to evaluate potential water quality impacts to Lake Mathews. Metropolitan coordinated closely with the RCFCWCD and the County of Riverside to provide input during the planning and approval process for the Boulder Springs-Dailey Ranch development. The developer used the Lake Mathews Watershed Study model developed in 2012 to evaluate various BMP scenarios and proposed to substitute DWQMP facilities with an instream wetland restoration and infiltration project that would mitigate adverse effects from the development projects. As the developer proceeds with the project, Metropolitan will continue to work closely with the RCFCWCD and County of Riverside to review additional information needed to fully demonstrate the effectiveness of the substitute DWQMP facilities including conceptual design and performance criteria, an operations and maintenance plan, and a water quality monitoring plan. **Appendix V** provides a copy of Metropolitan's 2015 comment letter to RCFCWCD and County of Riverside regarding the Boulder Spring-Dailey Ranch Development.

Metropolitan was also involved with reviewing the Cajalco Road Widening and Realignment Alternative Project and provided input to the County on the impacts to Metropolitan's facilities within the proposed project's road alternatives. **Appendix V** provides a copy of the recent correspondence regarding Metropolitan's review of potential impacts to Metropolitan's operational facilities. Metropolitan continues to coordinate with DWQMP affected parties to address potential impacts to Lake Mathews water quality.

Metropolitan continues to collect samples at detention basins following significant storm events such as at the end of 2010, discussed in the CRWSS 2010 Update; there were no significant rain events during the reporting period. Further discussion of these monitoring events is contained in **Chapter 4**.

Table 6-4. Lake Mathews Watershed Study Decision Framework [207]

Criteria	Future 4c (Cajalco Creek Wetland #2)*	Future 4e (Lake Mathews Estates Water Quality Pond)*	Future 4j (Alexander Street Water Quality Wetlands East and West)*	Future 4*
General Criteria				
Likelihood of future development	●	◑	◑	◑
Potential for development sponsor	◑	◑	●	◑
Potential to treat areas without LID	◑	●	◑	●
Public ownership	◑	◑	◑	◑
Permitting feasibility	○	◑	◑	◑
Cost & Cost-Effectiveness				
Estimated capital cost and maintenance	●	●	◑	○
Cost-effectiveness	●	●	◑	○
Opportunity for shared public/private responsibility	◑	●	●	◑
Potential for multiple funding streams	◑	●	◑	◑
Multiple Benefits				
Habitat enhancement	●	●	●	●
Community and aesthetic enhancement	◑	●	●	●
Water resources	○	●	○	◑
Environmental Effectiveness				
Pollutant removal effectiveness	◑	●	◑	●
Protection of Cajalco Creek	◑	○	●	●

*high (●), medium (◑), low (○)

Table 6-5. Evaluation of Lake Mathews Watershed Study Scenarios against Water Quality Objectives [207]

Water Quality Objectives	Future 4c (Cajalco Creek Wetland #2)*	Future 4e (Lake Mathews Estates Water Quality Pond)*	Future 4j (Alexander Street Water Quality Wetlands (East and West))*	Future 4*
Sediment				
Meets load reduction target	◑	●	◑	●
Nitrogen				
Meets load reduction target	●	●	●	●
Phosphorus				
Meets load reduction target	◑	●	◑	●
Bacteria				
Meets load reduction target	◑	●	◑	●
Overall Effectiveness				
Meets load reduction targets	◑	●	◑	●

*Meets or exceeds load reduction target (●), somewhat close to meeting target (◑), substantially short of meeting target (○)

Recommendations for Key Watershed Management Activities

Continue to support the efforts of CCRSCo (also identified in Chapter 4)
Metropolitan will continue to participate in and support CCRSCo's efforts to protect the water quality of the Colorado River, including working with USBR on the spill notification process and supporting CCRSCo's development of a watershed plan with funding from a USBR WaterSMART grant to enhance watershed planning efforts for the lower Colorado River.

Continue to participate in Lake Mead Water Quality Forum's Ecosystem Monitoring Workgroup
Metropolitan will continue to participate in the Ecosystem Monitoring Workgroup, formed to enhance multi-agency cooperation on ecosystem monitoring for Lake Mead and Colorado River watersheds.

Participate with the Lower Colorado River Water Quality Partnership
Metropolitan will continue to actively participate with SNWA and CAP to monitor Colorado River water quality issues of mutual interest and develop strategies and management actions to ensure source water protection.

Participate in the Colorado River Basin Salinity Control Program and related efforts addressing salinity management in Metropolitan supplies
Metropolitan will continue to serve on the Colorado River Basin Salinity Control Forum, as representatives of California, and participate in the Forum Workgroup to support funding and implementation of salinity control projects, and completion of the triennial review.

Complete the Salinity Management Plan Study Update
Metropolitan will collaborate with USBR, SCSC, and the Forum to complete the Salinity Management Plan Study Update, which will include an update of the economic impact model used by the Forum to assess Colorado River salinity impacts.

Support expeditious removal of the uranium mill tailings pile near Moab, Utah
Metropolitan will continue to support the efforts of USDOE in cleanup of the mill tailings site, advocating for continued and increased federal funding for expeditious removal of the tailings pile to ensure protection of downstream drinking water uses.

Participate in the Lake Powell Water Quality Monitoring Workgroup
Metropolitan will continue to participate in monthly workgroup meetings, led by USBR to review and discuss Lake Powell water quality data.

Track uranium exploration and other energy development activities
Metropolitan will continue to track uranium exploration and other energy development activities throughout the Colorado River Basin to ensure measures are taken to protect the water quality of the Colorado River.

Continue to track and engage with stakeholders on perchlorate remediation efforts in Henderson, Nevada
Metropolitan will continue to coordinate with NDEP, NERT, and other key Colorado River stakeholders to monitor and provide input on the remedial investigation and efforts related to the Tronox/NERT and Endeavour perchlorate plumes.

Continue to track performance of Las Vegas Valley wastewater treatment plants
Metropolitan will continue to coordinate with Las Vegas area wastewater dischargers, review and

comment, as necessary, on NPDES permit renewals, and track phosphorus discharges from the wastewater treatment plants to ensure protection of downstream drinking water uses.

Continue to track NDEP's progress on development of a Nutrient Criteria Strategy for the State of Nevada

Metropolitan will track Nevada's Nutrient Criteria Strategy, an effort being pursued by NDEP in cooperation with USEPA Region IX with the end goal of improving Nevada's existing nutrient criteria as discussed in **Chapter 3**.

Continue to participate in advisory groups for chromium-6 remediation at the Topock Gas Compressor Station (also identified in Chapter 4)

Metropolitan will continue to coordinate with the lead regulatory agencies and PG&E and actively participate in various workgroups to support efforts to remediate the chromium-6 groundwater plume adjacent to the Colorado River near Needles, California. In addition, Metropolitan will review the Subsequent EIR, groundwater model improvements, and decommissioning of IM-3 facilities during construction, anticipated in 2019, to ensure protection of Colorado River water quality.

Continue to coordinate with Riverside County Flood Control and Water Conservation District on development reviews (also identified in Chapter 4)

Metropolitan will coordinate closely with RCFCWCD on development proposals that could impact water quality within the Lake Mathews Watershed including the Boulder Springs-Dailey Ranch development project. As appropriate, Metropolitan would recommend the application of the Lake Mathews watershed model to evaluate the effectiveness of proposed stormwater treatment options in protecting Lake Mathews' water quality.

Continue to track progress of the Cajalco Road Widening project and evaluate potential impacts to Lake Mathews (also identified in Chapter 4)

Metropolitan will continue to track the status of the Cajalco Road Widening and Safety Enhancement project, evaluate potential impacts to Lake Mathews based on the proposed alignments and provide input into the environmental review process.

Comment on regulatory development for perchlorate and chromium-6

Metropolitan will track the federal regulatory processes for perchlorate and chromium-6 and the California regulatory progress on the perchlorate MCL, which is currently under review; coordinate with regulators, trade organizations, and other water utilities; and comment as appropriate in the drinking water standard setting process.

7 Findings and Recommendations

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Chapter 7 Findings and Recommendations

This CRWSS 2015 Update presents an evaluation of the watershed area that impacts Colorado River water, as it flows to southern California and at Metropolitan's source water reservoirs. The update reviews each of the watershed and regional areas (Upper Colorado River, Lake Mead, Lake Havasu and Lake Mohave, Colorado River Aqueduct, Lake Mathews, Diamond Valley Lake, and Lake Skinner) during the reporting period, 2011–2015. Discussions for the Upper Colorado River and Lake Mead watersheds are limited to the identification of key watershed management activities that Metropolitan has engaged in to protect source water quality. The update primarily focuses on the watersheds near Metropolitan's intake (i.e., below the Hoover Dam) and the downstream Colorado River Aqueduct (CRA) system, as these watersheds will potentially have the greatest impact on water quality at Metropolitan's water treatment plants. The near-intake zone concept, an accepted practice by State Water Resources Control Board's Division of Drinking Water (DDW), was defined as the watersheds for Lake Mohave and Lake Havasu downstream to Metropolitan's terminal reservoirs.

The 2015 CRWSS presents comprehensive information (i.e., in-depth discussions, data tables and analyses, figures, and reference maps) that is organized in the following chapters.

Chapter 1	Overview of major reservoirs along the Colorado River and Metropolitan's service area, study purpose and conduct, and summary of previous watershed sanitary survey updates.
Chapter 2	Overview of the physical and hydrologic characteristics of the watersheds that comprise the study area.
Chapter 3	Description of Metropolitan's monitoring programs, summary of raw water quality data, and an evaluation of selected key constituents.
Chapter 4	Vulnerability assessment of Metropolitan's Colorado River system watershed areas for the nine potentially contaminating sources (PCSs) selected for the 2015 update.
Chapter 5	Updates to current and anticipated drinking water regulations and Metropolitan's water treatment plants' capability compliance with these regulations.
Chapter 6	Key watershed management efforts for the Colorado River watershed study area and Metropolitan's activities and involvement.
Chapter 7	Summary of principal findings and a comprehensive list of recommendations.

The principal findings of the CRWSS 2015 Update from Chapters 3, 4, 5, and 6 are presented in the following four sections: (1) summary of source water quality review, (2) summary of watershed potential contaminant sources (PCSs), (3) summary of water treatment plant regulatory compliance, and (4) summary of key watershed management activities. A list of recommendations is also provided to strengthen and guide future source water protection efforts.

Summary of Source Water Quality Review

The CRWSS 2015 Update involves a compilation of source water quality monitoring data between 2011 and 2015. Water quality monitoring programs were developed in compliance with California Surface Water Treatment Rule (SWTR)—Title 22, Article 7, Section 64665 of California Code of Regulations (California Title 22). The following constituents of concern were selected for evaluation in the CRWSS 2015 Update: various inorganic compounds (i.e., aluminum, boron, chromium-6, perchlorate, total dissolved solids [TDS], nutrients [total phosphorus and nitrate]), radionuclides (i.e., uranium, radium, gross alpha and gross beta emitters, strontium-90, and tritium), turbidity, organic compounds (i.e., total organic carbon [TOC], *N*-nitrosodimethylamine [NDMA], pharmaceuticals and personal care products [PPCPs]), and microbiological constituents (i.e., coliforms and pathogens).

Metropolitan maintains a proactive monitoring program, which extends beyond that required by the regulations for source water quality. Monitoring is often conducted more frequently than required. In addition, Metropolitan monitors several constituents of interest, which are not currently regulated due to source water concerns.

A summary is provided below on the findings for each of the constituents or class of constituents (inorganic, radionuclides, turbidity, organic, and microbiological), referred to as constituents of interest in this report. Source water data is monitored at Whitsett Intake on Lake Havasu, San Jacinto Tunnel West Portal, Lake Mathews, Lake Skinner, Diamond Valley Lake, and influents to Metropolitan's water treatment plants. Some constituents may be monitored in reaches between Hoover Dam and Whitsett Intake due to specific source water concerns.

Inorganic Compounds

Inorganic compounds are naturally occurring mineral elements that are typically dissolved into groundwater and surface water flows from erosion of rock and soil formations containing the minerals. However, some of the inorganic compounds that were selected as constituents of interest were introduced by human activities and at elevated levels may be a source water quality concern.

Aluminum

Aluminum was selected for evaluation as it is on U.S. Environmental Protection Agency's (USEPA's) Drinking Water Contaminant Candidate List (CCL) and Metropolitan's water treatment plants use aluminum sulfate (alum) for coagulation, which may contribute to aluminum in the finished water effluent. Aluminum has a primary standard of 1 mg/L and a secondary aesthetics-based standard of 0.2 mg/L. Concentrations in Colorado River source waters are typically low with levels well below the secondary standard. However, in the spring rainy season, heavy precipitation produces runoff, which may introduce sediments containing aluminum into the source waters. This results in a temporary increase in aluminum levels, which return to normal after storm flows subside.

Boron

Boron was selected for evaluation as it is on USEPA's CCL list and based on Metropolitan's member agencies' concerns. Boron is an unregulated chemical with a DDW notification level of 1 mg/L. Concentrations were found to be stable and well below the DDW notification level.

Chromium-6

Chromium-6 was selected for evaluation as it is a regulated constituent, has contaminated groundwater near the Colorado River, and based on member agencies' concerns. Metropolitan became aware of a groundwater plume of chromium-6 near the Pacific Gas and Electric (PG&E) Topock Gas Compressor Station in 2003. California adopted a drinking water standard for chromium-6 of 0.01 mg/L effective on July 1, 2014. USEPA is currently conducting human health assessments for chromium-6 and will determine whether to regulate chromium-6 in drinking water beyond the current regulations for total chromium. Median source water concentrations were low (less than 0.0001 mg/L) along the CRA and terminal reservoirs. Immediately, downstream of the PG&E Topock Gas Compressor site, chromium-6 levels have been low, with a maximum detection level of 0.00006 mg/L at the sampling point above the railroad bridge.

Perchlorate

Perchlorate was selected for evaluation as it is a regulated constituent and was detected in the Colorado River in 1997, resulting from a groundwater plume that flowed into Lake Mead via Las Vegas Wash in Henderson, Nevada. Perchlorate has a California maximum contaminant level (MCL) of 0.006 mg/L. On February 1, 2015, OEHHA published the updated perchlorate PHG of 0.001 mg/L. Over the reporting period, the median concentration for all source water monitoring sites was low with a maximum value of 0.0016 mg/L below Davis Dam in September 2013, at Whitsett Intake in March 2015, and at the San Jacinto Tunnel West Portal in April 2015. Perchlorate levels at Whitsett Intake have been typically less than 0.002 mg/L since 2006. Since perchlorate was first discovered, source water sampling at Las Vegas Wash shows a 90 percent decrease in perchlorate loading over time as a result of the groundwater remediation efforts.

TDS

TDS was selected for evaluation as it is an important constituent to Metropolitan and its member agencies and affects a variety of sectors. High salinity water increases scaling potential, can reduce agricultural crop yields, limit groundwater recharge efforts, and can reduce the marketability and usability of reclaimed water. TDS and sulfate have a secondary MCL and are regulated based on aesthetics, rather than a health hazard, at a range of concentrations. Water with TDS lower than the recommended level (500 mg/L) is considered desirable for a high degree of customer acceptance; concentrations ranging to the upper contaminant level (1,000 mg/L) are acceptable if it is neither reasonable nor feasible to provide more suitable waters. TDS ranging to the short-term contaminant level (1,500 mg/L) is acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources.

The Colorado River Basin Salinity Control Forum has recommended numeric standards for TDS of 723 mg/L below Hoover Dam, 747 mg/L below Parker Dam, and 879 mg/L at Imperial Dam. Metropolitan has a Salinity Management Policy with a goal of achieving a running annual average (RAA) of 500 mg/L TDS for treated waters, which is typically accomplished by blending higher TDS Colorado River water with State Water Project (SWP) water. Overall, TDS in the Colorado River has cycled up and down over multiple years depending on hydrology in the Colorado River Basin, and showed a slight declining trend during the reporting period. Median TDS concentrations along the CRA were above the recommended level of 500 mg/L. Since sulfate is the primary component of TDS in Colorado River water, sulfate trends are similar to TDS trends; median sulfate levels along the CRA were below the recommended sulfate level of 250 mg/L. Metropolitan's current strategy of blending Colorado River water with SWP water has proven to be effective when sufficient SWP supplies are available. Due to low SWP allocation and drought conditions during the reporting period, the maximum TDS levels in source waters exceeded the target goal of 500 mg/L, with the exception of Diamond Valley Lake, which was not filled with Colorado River water due to quagga mussel concerns.

Nutrients

Total phosphorus was selected for evaluation as it is the primary limiting nutrient for algal growth in Colorado River water. Nitrate was also evaluated due to potential impacts of septic systems along the lower Colorado River. Nutrients are naturally occurring in aquatic ecosystems, but when present in excess may result in taste and odor production, nuisance algal blooms, excessive macrophyte (aquatic plant) growth, toxin production, increased TOC levels, and shortened filter runs at treatment plants. Total phosphorus is the limiting nutrient controlling cyanobacteria and algal growth in the Colorado River system. Therefore, Metropolitan has an active interest in levels of phosphorus loading from the wastewater treatment plants in the Las Vegas Valley. Total phosphorus has no primary or secondary MCL. The Nevada Administrative Code has established a 0.05 mg/L beneficial use standard and 0.02 mg/L anti-degradation standard for the Colorado River below Hoover Dam. Nitrate has a primary MCL of 10 mg/L (as nitrogen). Total phosphorus in the Colorado River is relatively stable around 0.010 mg/L, but with periodic spikes during storm events. For nitrate, median source water concentrations were low (less than 0.5 mg/L as nitrogen) at the sampled locations.

Radionuclides

Radionuclides can come from natural or man-made elements that can give off radiation as they decay from unstable forms of atoms into more stable atoms. Radionuclides were evaluated because the Colorado River is vulnerable to contamination from upstream sources related to the uranium mill tailings pile near Moab, Utah. The radionuclides evaluated in the CRWSS 2015 Update are uranium, radium, gross alpha and gross beta emitters, strontium-90, and tritium. The following results for radionuclides were observed during the reporting period:

- Gross alpha levels in the source waters were consistently below the MCL of 15 pCi/L. Gross alpha activity (minus the uranium activity) has an MCL of 15 pCi/L.
- Uranium levels in the source waters were consistently below the California MCL of 20 pCi/L. The USEPA MCL for uranium is 0.03 mg/L (27 pCi/L).
- The combined radium was less than the state detection limit for purposes of reporting (DLR) of 0.5 pCi/L and the individual quarterly results of radium-226 and radium-228 were less than 1 pCi/L for all the monitoring locations. The USEPA and California MCLs for radium are set as the sum of radium-226 and radium-228 at 5 pCi/L.
- Gross beta activities in the source waters and treated waters were well below the screening level of 50 pCi/L. Exceeding the screening level of 50 pCi/L for gross beta would trigger a requirement for further testing to characterize the water.
- Strontium-90 activities were below the California DLR of 2 pCi/L. Strontium-90 has an MCL of 8 pCi/L.
- Tritium activities were below the California DLR of 1,000 pCi/L. Tritium has an MCL of 20,000 pCi/L.

Turbidity

Turbidity was evaluated because it is a regulated constituent used to evaluate the efficiency and effectiveness of water treatment processes and is a general indicator of water quality. Some sources of turbidity include erosion and sediment transport during storm events, waste discharges, and runoff from watersheds. Turbidity requirements are regulated under California's Surface Water Treatment Regulations (Chapter 17, California Title 22) and the Federal Interim Enhanced Surface Water Treatment Rule (IESWTR). With the exception of one month, when turbidity spiked to 6.8 NTU at Lake Skinner, source water turbidity data from 2011–2015 were less than 4 NTU for all monitoring locations.

Organic Compounds

Organic compounds can be either naturally occurring compounds, such as TOC, or synthetic chemical compounds, such as volatile organic compounds (VOCs) that contain carbon. Select organic compounds were evaluated due to potential source water quality concerns.

TOC

TOC was evaluated since it is a DBP precursor regulated under the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rules and is known to be present in Colorado River water. Decayed plant material and organics from wastewater are potential sources of TOC and can be contributed from the general watershed, urban and agricultural runoff, and wastewater. The D/DBP Rules have enhanced coagulation requirements for finished water and compliance is now determined on a locational basis rather than on a distribution system-wide basis. Median TOC levels within the CRA system ranged between 2.56 and 3.00 mg/L. The highest measurement of TOC in the source water sampling was 4.30 mg/L measured at San Jacinto Tunnel West Portal in August 2014, likely caused by significant runoff in upstream watersheds.

NDMA

NDMA was evaluated as it is a potential carcinogen that may be regulated by USEPA and DDW in the foreseeable future. Wastewater treatment plant effluent and agricultural runoff can contribute organic material into source waters, which react to form NDMA at water treatment plants. USEPA placed NDMA in the Unregulated Contaminant Monitoring Regulation 2 (UCMR 2) and on the Contaminant Candidate List 3 (CCL3) and draft CCL4. DDW has not established an MCL for NDMA, but has a notification level of 100 ng/L and recommends that occurrences of NDMA in treated water supplies at concentrations greater than 100 ng/L be included in the utility's annual Consumer Confidence Report. In December 2006, the Office of Environmental Health Hazard Assessment (OEHHA) set a public health goal of 3 ng/L for NDMA. Metropolitan ceased monitoring its source waters (at treatment plant influents) in 2011 since all plant influent samples were non-detect, indicating that NDMA is primarily formed as a disinfection byproduct and is not present in the source water.

PPCPs

PPCPs were evaluated as the occurrence and fate of PPCPs has emerged as an issue for source water quality and as a subject of public concern. PPCPs are comprised of several chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, and cosmetics. Some PPCPs, together with other organic wastewater contaminants (OWCs) such as pesticides and polycyclic aromatic hydrocarbons (PAHs), are known or suspected to be endocrine disrupting compounds. Currently, there are no regulatory requirements for PPCPs. Metropolitan's PPCP monitoring program found PPCPs and OWCs at low ng/L levels in source water samples; much lower than applicable MCLs and orders of magnitude lower than therapeutic doses, which are in milligrams per dose. Though these levels of PPCPs and OWCs may affect the aquatic environment and wildlife, the impact on human health is widely considered insignificant [28] [29].

Microbiological Constituents

Coliforms

Coliforms were evaluated because they are indicative of the general microbial quality of water. Principal sources of potential fecal contamination include runoff (i.e., stormwater, urban, and agricultural), body contact recreation, wastewater discharges, and migratory bird deposits. In March 2008, California Title 22 required monthly reporting to DDW of total coliform and fecal coliform or *E. coli* levels in the raw water entering the treatment plants. Metropolitan initially monitored all three constituents but discontinued fecal coliform monitoring in 2010. The primary indicator of the microbial quality of water is *E. coli* for Metropolitan's source waters; total coliform levels may provide general trending of the microbial quality of water. The median *E. coli* levels were low (< 10 CFU per 100 mL) for Metropolitan's source waters. The median total coliform levels were slightly higher than levels reported in the CRWSS 2010 Update. This may be partially due to the switch in analytical method in 2006 from multiple-tube-fermentation (MTF) to membrane filtration using MI medium (MF-MI). In the summers of 2013, 2014, and 2015, monthly total coliform levels were observed to be lower at Diemer and Weymouth plants possibly due to chlorination for quagga mussel control at Lake Mathews.

Pathogens

Cryptosporidium and *Giardia* were selected for evaluation since the original CRWSS. *Giardia* and viruses are regulated under the SWTR, which requires a minimum of 3-log and 4-log reduction at water treatment plants, respectively. *Cryptosporidium* is regulated under the IESWTR, requiring 2-log reduction, and under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), with a potential requirement for additional treatment determined by its source water concentration. Metropolitan's pathogen monitoring program includes monthly monitoring of water treatment plant influents for *Giardia* and *Cryptosporidium*. Between 2011 and 2015, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples. *Giardia* was detected once, at a concentration of 1 cyst per 10 L, in the Weymouth plant influent sample collected in September 2011. Beginning in April 2015, monthly monitoring of treatment plant influents was mandated and reported under the LT2ESWTR Round 2 monitoring. The Round 2 monitoring will continue through March 2017. As required by LT2ESTWR, *Cryptosporidium* concentrations, turbidity, and *E. coli* concentrations were monitored. In 2015, *Cryptosporidium* oocysts were not detected in any of the treatment plant influents receiving Colorado River water.

Summary of Watershed Potential Contaminant Sources

The CRWSS 2015 Update includes an evaluation of various point and non-point contaminant sources, referred to as PCSs, for five watershed areas – Lake Mohave and Lake Havasu watersheds, Colorado River Aqueduct, Lake Mathews watershed, Lake Skinner watershed, and Diamond Valley Lake watershed. The PCSs include 1) *Erosion, Urban and Stormwater Runoff*, 2) *Recreation*, 3) *Municipal and Industrial Dischargers*, 4) *Spills*, 5) *Landfills*, 6) *Leaking Underground Storage Tanks*, 7) *Septic Systems*, 8) *Agriculture,* and 9) *Fires*. Although the focus of the PCS discussion is on the 5-year reporting period (2011–2015), updates through the writing of this report summarizing discussions regarding regulatory oversight of PCSs and key studies that are relevant to the contaminant source are included for completeness.

Of the nine PCSs identified, the *Spills* and *Erosion, Urban and Stormwater Runoff* PCSs have potential to affect all watershed areas as shown in **Table 7-1**. However, the greatest potential threat to source water quality would result from the *Erosion, Urban and Stormwater Runoff*, *Recreation*, and *Municipal and Industrial Discharges* PCSs. These PCSs are of particular concern because of their ability to directly contribute pollutants to source waters based on their occurrence in the watershed or in consideration of high urban growth and development anticipated in some watersheds.

Table 7-1. Summary of PCSs and Geographical Regions Reviewed

Watershed	Erosion, Urban and Stormwater Runoff	Recreation	Municipal and Industrial Discharges	Spills	Landfills	Leaking Underground Storage Tanks	Septic Systems	Agriculture	Fires
Lake Mohave and Lake Havasu	✓	✓	✓	✓	✓	✓	✓	✓	✓
Along CRA	✓		✓	✓	✓	✓		✓	
Lake Mathews	✓	✓		✓	✓	✓	✓	✓	✓
Lake Skinner	✓	✓		✓		✓	✓	✓	✓
Diamond Valley Lake	✓	✓		✓					✓

A discussion is provided below to highlight the major PCSs for each watershed.

Lake Mohave and Lake Havasu Watersheds

Lake Mohave is a long and narrow reservoir formed by Davis Dam on the Colorado River, which defines the border between Nevada and Arizona. The lake is a 1,818,000 acre-feet capacity reservoir and lies near Laughlin, Nevada and Bullhead City, Arizona. The lake and adjacent lands forming its shoreline are part of the Lake Mead National Recreation Area administered by the National Park Service. Lake Havasu is a 648,000 acre-feet capacity reservoir behind Parker Dam on the Colorado River, on the border between California and Arizona.

The Lake Mohave and Lake Havasu watersheds include the Colorado River from Hoover Dam to Parker Dam through the tri-state region of Arizona, Nevada, and California. The watersheds drain multiple alluvial valleys, but do not have a major tributary upstream of Metropolitan's Whitsett Intake.

The Bill Williams River, which enters Lake Havasu between Whitsett Intake and Parker Dam, can potentially impact Metropolitan's intake water quality during very large storm events. The majority of the land use in the watershed is rangeland.

The Colorado River through the Lake Mohave and Lake Havasu watersheds is susceptible to PCSs related to recreational activities. In this desert reach, the Colorado River attracts both local and vacationing users to boating, camping, hiking, and other recreational activities. To ensure protection of Colorado River water quality, federal agencies such as National Park Service, U.S. Coast Guard, and Bureau of Land Management provide oversight and regulations to manage recreational uses. Metropolitan reviews water quality data, published by multiple agencies, to monitor the impacts of the ongoing recreational activities.

Metropolitan includes its Colorado River monitoring data on Southern Nevada Water Authority's (SNWA)'s Lower Colorado River Water Quality Database. This online regional database allows member-only access and contains data from multiple federal, state, and local agencies that monitor Colorado River water quality. The database also allows stakeholders, including Metropolitan, to track historical water quality changes at key locations along the lower Colorado River. Several studies conducted by multiple agencies are also ongoing to assess water quality issues relevant to the lower Colorado River. The Lake Mead Ecosystem Monitoring Workgroup provides a forum for discussing and sharing various water quality studies.

The general watershed area has minimal development and municipalities have populations less than 100,000. The existing development is concentrated in close proximity to the Colorado River and most of the cities rely on septic systems for wastewater treatment. The groundwater, which can contain high nitrate levels due to septic tanks, has the potential to degrade the river water quality. In recent years, Lake Havasu City and Bullhead City have constructed sewer collection systems and reduced the number of septic systems by more than 75 percent in their respective cities.

Metropolitan also stays informed and participates in ongoing monitoring and clean-up efforts for areas of concern. This includes reviewing groundwater monitoring data for the Needles Sanitary Landfill, tracking progress on initial efforts to clean up a chromium-6 groundwater plume at the McCulloch site, and actively participating in the PG&E Topock Gas Compressor Station chromium-6 remediation process. A long-term remedial alternative has been selected for the Topock site and PG&E completed design in 2015. Construction is expected to start in 2017 after completion of a subsequent environmental review, and would be completed in 2022.

Metropolitan also tracks spills and is included in the Lower Colorado River Geographic Response to receive spill notifications as an affected downstream water utility. USBR has been designated as the lead response agency and is coordinating with CCRSCo members to ensure an effective notification process with all members.

Colorado River Aqueduct

The CRA spans 242 miles of desert and mountain ranges between Metropolitan's Whitsett Intake on Lake Havasu and Lake Mathews in Riverside County, California. The CRA system includes the San Diego Canal, which delivers water to San Diego County from a junction structure located approximately 25 miles east of the CRA terminus at Lake Mathews. Although the aqueduct and its associated facilities were designed to keep most local runoff out, a few areas of the aqueduct may receive drainage, especially during flood events. Public access to open-channel sections of the CRA system is not allowed and frequent and routine ground and aerial surveillance help protect the system from unauthorized entry.

This region, which includes a long reach of the CRA and San Diego Canal, consists of open barren lands and is primarily susceptible to potential spills from transportation vessels or contaminated runoff from concentrated animal feeding operations (CAFOs). Spills on vehicle and railroad crossings over the CRA would directly flow into the aqueduct and impact water quality. Metropolitan stays informed on reported spill activity. In addition, the prevalence of dairies along the San Diego Canal could have a potential impact on CRA water quality. Metropolitan will continue to stay informed on related regulatory efforts.

Since LACSD is no longer pursuing the Eagle Mountain Landfill, the Eagle Mountain Pumped Storage project is the only project of interest that is proposed in the Eagle Mountain area of the CRA. Metropolitan will continue to track progress for this project to ensure protection of the CRA. Metropolitan also began preliminary work with DWR on a Perris Dam active seepage recovery project, which would recover dam seepage water and discharge it to the CRA. Future CRWSS updates would include discussion of this project if it moves forward.

Lake Mathews Watershed

Lake Mathews is the terminal reservoir for the CRA and is located in western Riverside County approximately 10 miles southwest of the city of Riverside. The lake is surrounded by the 5,100-acre Lake Mathews Multiple Species Reserve. Lake Mathews has a capacity of 182,000 acre-feet and receives a limited amount of local runoff water in addition to Colorado River water. The watershed is drained primarily by Cajalco Creek, which is intermittent, flowing only during storm events or in the presence of agricultural runoff.

Lake Mathews watershed includes large community developments in the unincorporated areas of Corona, Woodcrest, Lake Elsinore, and Riverside. Lake Mathews does not offer recreational opportunities; hence, the primary potential impact to source water quality is related to the development growth in the watershed area. Over half of the watershed is developed with residential, commercial, or industrial improvements while the remaining watershed primarily encompasses open space and agricultural land uses.

Significant efforts have been undertaken to ensure the protection of Lake Mathews' water quality. Previous efforts include the development of the Drainage Water Quality Management Plan (DWQMP), which provided recommendations for large scale best management practices (BMPs) located along Cajalco Creek and other watershed tributary drainages. Regional BMPs, such as flood control and sedimentation facilities, have been constructed by, or with support from, Metropolitan. In addition, Metropolitan provides ongoing services to support the Lake Mathews Multiple Species Habitat Conservation Plan in protecting the Multiple Species Reserve buffer that surrounds Lake Mathews.

Riverside County continues to implement their 2010 MS4 Permit, which mandates low impact development (LID) BMPs and requires significant development projects to complete water quality management plans (WQMPs) to identify applicable BMPs. Metropolitan, in cooperation with Riverside County Flood Control and Water Conservation District and the County of Riverside, completed the Lake Mathews Watershed Study in 2012 and developed a watershed model to evaluate the effects of development and various BMPs on runoff pollutant loading into the lake.

During the reporting period, Riverside County also adopted General Plan documents containing policies to protect Lake Mathews. Based on the Riverside County General Plan, development in the watershed will continue to increase. A proposed transportation project within the watershed is Riverside County's Cajalco Road Widening project, which will improve Cajalco Road between Interstate 215 and Temescal Canyon, south of Lake Mathews. Also, a proposed large housing development in the watershed is the Boulder Springs-Dailey Ranch development project, located east of Lake Mathews and along Cajalco Road. Metropolitan will work with project stakeholders to ensure that water quality impacts are minimized through stormwater management practices and other development requirements.

Diamond Valley Lake Watershed

Diamond Valley Lake is located near Hemet with an 810,000-acre-foot capacity. The lake can be filled with SWP or Colorado River water through the inlet/outlet tower or with SWP water through the secondary inlet. Since the discovery of quagga mussels in Colorado River water in 2007, only SWP water has been used to fill Diamond Valley Lake. Diamond Valley Lake's contributing watershed area is limited to the ephemeral drainage areas from the hills surrounding the reservoir. Approximately half of the watershed consists of vacant land and the other half is the lake itself, which offers recreational uses.

The watershed is unique in that Metropolitan owns and manages the watershed area surrounding the lake. The surrounding property does not have urban development, but the lake is open to public use for fishing, boating, hiking, and other non-body contact recreational uses. Metropolitan leases areas around the lake for marina operations and related recreational facilities. Since the lake is primarily susceptible to PCSs from these recreational activities, Metropolitan has developed Boating Rules and Regulations for Diamond Valley Lake.

Metropolitan has developed a Recreational Activity Plan (RAP), which has been approved by DDW, to promote and operate recreational facilities within the Diamond Valley Lake area while protecting water quality. This includes the 6-mile long North Hills Trail (for hiking and equestrian use), which is primarily outside the watershed, but connects two 5-acre trailheads at the northwest and northeast ends of the lake. The watershed's aesthetic and recreational opportunities have appealed to developers interested in expanding recreational uses. During the reporting period, Metropolitan extended the boat launch ramp, which was exposed under low lake levels due to drought conditions. Metropolitan also began efforts to upgrade the marina restroom facilities. Metropolitan will continue to be involved with recreational planning efforts to minimize the potential for water quality impacts and will amend the RAP as necessary.

Lake Skinner Watershed

Lake Skinner is located in Riverside County near Temecula and serves as a regulatory storage reservoir for the Robert A. Skinner Water Treatment Plant (Skinner). The lake has a storage capacity of 44,000 acre-feet and the major sources of water for the reservoir are the Colorado River and the

California State Water Project (SWP). Lake Skinner receives very little local runoff compared to the amount of water imported to the lake.

The watershed is primarily drained by Tucalota Creek, Rawson Canyon Creek, and Middle Creek, which are ephemeral streams, flowing only after prolonged or heavy rains. A majority of the watershed is vacant land, designated for open space and recreation including the Southwestern Riverside County Multi-Species Reserve (Reserve) and Lake Skinner Recreation Area. Residential land use accounts for approximately a third of the watershed and the majority of residences are ranches or hobby farms, defined as properties with ten horses or less.

Metropolitan allows multiple recreational opportunities in the Lake Skinner area including boating, trails, and park space. Water quality impacts to the lake are minimized through boating guidelines and agreements with Riverside County Regional Park and Open Space District for oversight of the recreational elements. An equestrian trail exists along the perimeter of the Lake Skinner Recreational Area and within the watershed. Trail use has been minimal during the CRWSS 2015 Update period and riding is not permitted during the rainy season. The approximate 13,700-acre Reserve occupies a portion of the watershed and provides a buffer for development. Metropolitan coordinates with the Reserve on vegetation management practices to ensure water quality protection.

Outside of the lake area, the majority of the watershed is vacant land and the primary threat to water quality is due to the horse corrals on private properties. Although there are a number of equestrian and bovine related businesses in the Lake Skinner watershed, there are a greater number of hobby farms. Many of these properties and horse corrals do not have adequate BMPs in place to ensure protection of downstream water quality. Local resource conservation districts do not specifically outreach to individual property owners but do provide educational outreach covering best management practices for the general ranch community within the Lake Skinner watershed at local events.

Although development has slowed down in recent years, future build out could impact water quality within the Lake Skinner watershed. Metropolitan will continue to evaluate watershed conditions and work with local agencies and other stakeholders to develop and implement water quality improvement and protection plans to minimize impacts from existing properties and future development growth in the area.

Summary of Water Treatment Plant Evaluations

Metropolitan owns and operates three water treatment plants (Robert B. Diemer, Robert A. Skinner, and F.E. Weymouth) that treat varying blends of Colorado River water and SWP water. The water treatment plants are subject to compliance with state and federal drinking water regulations. **Chapter 5** of this CRWSS 2015 Update presents a detailed overview of existing drinking water regulations and regulatory changes since the previous update in 2010.

Metropolitan complied with all existing primary drinking water regulations including those revised or added since the CRWSS 2010 Update. These drinking water regulations include the National Primary Drinking Water Regulations; Phases I, II, and V Standards; Total Coliform Rule; Surface Water Treatment Rule (SWTR); Lead and Copper Rule; Stage 1 D/DBP Rule; Interim Enhanced Surface Water Treatment Rule (IESWTR); Radionuclides Rule; Filter Backwash Recycling Rule; Arsenic Rule; Long Term 2 Enhanced SWTR; and Stage 2 D/DBP Rule.

As the primacy agency, California is required to adopt USEPA's MCLs under each rule by reference or make them more stringent. Primacy agencies can also add their own MCLs for constituents deemed to pose a threat to public health but do not yet have federal MCLs; therefore, California Title 22 includes more regulated constituents. None of the regulated primary constituents were detected at any level of concern in the effluent from the three water treatment plants.

A summary of Metropolitan's compliance with current and anticipated drinking water regulations is presented below.

Compliance with Existing Drinking Water Regulations

The following drinking water regulations were promulgated prior to the review period for this CRWSS update. New regulations that became effective during the current review period are discussed under Compliance with New Drinking Water Regulations below.

National Primary Drinking Water Standards

USEPA regulated 22 constituents in 1976 under the National Interim Primary Drinking Water Regulations (NPDWR), the first set of standards after the creation of the Safe Drinking Water Act. Newer, more stringent regulations between 1986 and 2013 have superseded the NPDWR and added more MCLs for a total of 91 regulated constituents collectively referred to as primary standards. Primary standards are health-related, legally enforceable standards that apply to public water systems. For the period under review, there were two detected constituents in Metropolitan's water treatment plant effluents with unchanged standards from the original list of 22 regulated constituents – fluoride and nitrate. Fluoride occurs naturally in raw water supplies, but it is also added to treated water. Nitrate occurs naturally in groundwater and surface waters can also have nitrate associated with the use of fertilizers or from animal and human waste. Other detected constituents on the list of primary standards are addressed below under their respective newer rules.

The federal MCL for fluoride is 4 mg/L. California's MCL for fluoride is 2.0 mg/L. In April 2015, DHHS recommended that water systems adjust their fluoride content to 0.7 mg/L, as opposed to temperature-dependent optimal levels ranging from 0.7 mg/L to 1.2 mg/L based on scientific evidence provided by CDC. The 0.7 mg/L optimal level aims to provide the benefits of fluoridation while minimizing effects of dental fluorosis (teeth discoloration) in children. DDW is consulting with public water systems to amend individual permits to reference CDC's recommended optimal level of 0.7 mg/L, which corresponds with the existing control range of 0.6 mg/L to 1.2 mg/L; 80 percent or more of daily fluoride samples collected in a month must fall within this range. Fluoride concentration in each water treatment plant's effluent is maintained within the optimal range, with a maximum of 1.0 mg/L in the period covered by this report.

Both the federal and California MCL for nitrate is 10 mg/L (as nitrogen). Metropolitan collects monthly water samples at the treatment plant effluents for nitrate (as nitrogen). Nitrate (as nitrogen) concentrations for this reporting period ranged from < 0.4 to 0.6 mg/L at each water treatment plant.

Aluminum, regulated as a primary standard in California and used in the treatment process as a coagulant, was also detected in the water treatment plant effluents. California's MCL for aluminum is 1 mg/L. USEPA has a secondary MCL of 0.2 mg/L, but no primary MCL. Compliance is based on running annual average (RAA). For individual samples collected monthly at each water treatment plant effluent, aluminum concentrations ranged from < 0.050 to 0.340 mg/L at each water treatment plant.

Secondary Standards

National Secondary Drinking Water Regulations (NSDWR) regulate contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. USEPA recommends secondary standards to water systems, but does not require systems to comply. The secondary drinking water regulations are intended as guidelines for the states; however, DDW enforces secondary MCLs. All constituents complied with their respective secondary MCLs as RAA except at the Skinner plant and Weymouth plant where the threshold odor number (TON) was higher than the recommended secondary MCL of 3 TON.

Aluminum, which has a secondary MCL of 0.2 mg/L, ranged from < 0.050–0.340 mg/L at the effluents of the treatment plants with the highest single treatment plant RAA of 0.167 mg/L at Diemer plant. Specific conductance and total dissolved solids (TDS) vary from year to year, mostly because of the blending of CRW and SWP water, but they are always below the upper limits of their respective consumer acceptance range of 1,600 µS/cm and 1,000 mg/L. Treated water specific conductance ranged from 370–1,080 µS/cm and TDS ranged from 214–668 mg/L. The availability of SWP supplies has decreased in recent years due to drought conditions and Delta pumping restrictions. Under low SWP allocations, Metropolitan has increased its reliance on higher salinity CRW to meet water demands. As a result, the plant effluent TDS at the Diemer, Skinner, and Weymouth plants has increased, primarily exceeding 500 mg/L since April 2013 and reflecting CRW salinity levels under no blend conditions.

A secondary MCL requires the water to be noncorrosive. At the treatment plant effluents, the saturation index is always maintained in the positive range, as a distribution system corrosion control measure, with a target finished water pH $\geq$ 8.0. Saturation index ranged from 0.05 to 0.94.

In addition to TON, Metropolitan voluntarily conducts weekly aesthetic evaluations of both odor and flavor using the flavor profile analysis (FPA) method. FPA is employs a panel of highly trained sensory assessors. The Skinner plant effluent exceeded the recommended secondary MCL of 3 TON in April 2008 and quarterly samples were collected until the 1st quarter of 2012 when the running annual average (RAA) for TON was at or below 3 TON. An intensive investigation was conducted to determine the source and cause for increased TON, but no sources were found and the event dissipated naturally. In April 2013, the Weymouth plant effluent exceeded the recommended secondary MCL of 3 TON and quarterly samples were collected until the 2nd quarter of 2014 when the RAA for TON was at or below 3 TON. There were no significant treatment or water quality changes during this period and no specific cause was identified for the increase in TON. During this period, the FPA did not indicate any odor events. In addition, the elevated TON did not extend to Skinner's or Weymouth's distribution system, and there were no consumer complaints. Annual sampling resumed in April 2015 and the TON was below 3 TON at Diemer, Skinner, and Weymouth treatment plants.

Phase I, II, and V Standards

A combined total of 57 constituents are regulated under Phase I, II, and V Standards. Three constituents, barium, fluoride and nitrate, were detected at maximum levels of 0.139 mg/L, 1.0 mg/L, and 0.6 mg/L, respectively, which is well below their respective MCLs of 1 mg/L, 2 mg/L, and 10 mg/L.

Total Coliform Rule

Under the Total Coliform Rule, no more than 5.0 percent of the samples collected from the distribution system during the month can be positive for total coliform bacteria. During the period under review, twenty positive total coliform samples were collected from the distribution system with the highest monthly total coliform positive of 0.5 percent occurring in 2012. In 2012 total coliform positive samples occurred in the distribution system in January, April, and May at one out of 674, one out of 656, and four out of 741, respectively. The positive total coliform samples were traced to the Willits Pressure Control Structure, which was disinfected. On any occasion when a routine total coliform sample tests positive, three repeat samples from the same location are collected and tested for coliforms. The process is repeated until all repeat samples are total coliform negative. With the exception of discovering the source of contamination for the 2012 positive total coliform samples, the reason for other positive coliform bacteria results was not apparent. There was no total coliform MCL violation.

Surface Water Treatment Rule

Constituents under the SWTR that apply to the water treatment plants are *Giardia*, turbidity, *Legionella*, viruses, and disinfectant residual. Compliance under the SWTR is based on treatment techniques (TTs) instead of MCLs. The Diemer, Weymouth, and Skinner plants comply with the TT requirements of the SWTR and always achieve the turbidity requirements and the CT (disinfectant concentration multiplied by contact time) requirements for 3-log (99.9%) reduction for *Giardia* and 4-log (99.99%) reduction for viruses. USEPA indicates that if *Giardia* and viruses are removed or inactivated according to the TTs in the SWTR, *Legionella* will be controlled; therefore, no limit is set for *Legionella*. The SWTR also requires that disinfectant residual entering the distribution system must not fall below 0.2 mg/L for more than 4 hours during any 24-hour period. Metropolitan's target for chlorine residual entering the distribution system from the treatment plants is 2.5 mg/L and it did not fall below 0.2 mg/L at any time in any of the plant effluents during this CRWSS review period. Metropolitan complies with turbidity requirements, which were made more stringent under the IESWTR as discussed under *Interim Enhanced Surface Water Treatment Rule* in **Chapter 5**.

Metropolitan showed that total coliform enumeration is a poor indicator for pathogens in Metropolitan's water supply sources. DDW agreed that source water weekly *E. coli* median levels that do not exceed 100 MPN per 100 mL would support the 3-log reduction for *Giardia* and 4-log reduction for viruses.

Lead and Copper Rule

Sampling under Lead and Copper Rule is conducted at taps in homes and other buildings; therefore, Lead and Copper Rule does not directly apply to water treatment plant effluents. However, corrosivity of water leaving the treatment plants could impact the level of lead and copper in the distribution system and customer taps. A plant effluent target pH $\geq$ 8.0 is maintained at each of the three water treatment plants to achieve a positive saturation index as a corrosion control measure in the distribution system and the plumbing system of homes and buildings served. Neither lead nor copper was detected at the effluent of the Diemer, Skinner, or Weymouth plants.

Stage 1 and Stage 2 Disinfectants/Disinfection Byproducts Rules

In December 1998, USEPA promulgated the Stage 1 D/DBP Rule, which became effective in February 1999 and required large systems to be in compliance by January 2002. DDW adopted the Stage 1 D/DBP Rule in April 2005 and it became effective on June 17, 2006. Stage 1 D/DBP Rule consists of maximum residual disinfectant levels (MRDLs) for disinfectants, TTs to control DBP precursors, and MCLs for DBPs. Chlorine, chloramines, and chlorine dioxide are covered under the rule as alternative disinfectants for the control of DBP formation. The MCLs for DBPs resulting from chlorination are 0.080 mg/L for total trihalomethanes (TTHMs) and 0.060 mg/L for the five regulated haloacetic acids (HAA5). Metropolitan uses chloramines as its secondary disinfectant. Metropolitan has complied with Stage 1 D/DBP Rule since its inception in 2002.

USEPA finalized the Stage 2 D/DBP Rule in January 2006 and DDW adopted the Stage 2 D/DBP Rule, effective June 21, 2012. Under Stage 2 D/DBP Rule, compliance with the MCLs is based on the average of four individual quarterly DBP measurements collected at a given location, referred to as locational running annual average (LRAA). Metropolitan completed and submitted the Initial Distribution System Evaluation (IDSE) Report to DDW on September 27, 2006. The Disinfectant/Disinfection Byproducts Compliance Plan was last updated on December 20, 2013. The plan requires monitoring at 50 locations for Stage 1 and Stage 2 D/DBP Rules; the locations covered by each of Metropolitan's treatment plants were approved by DDW in 2009. Metropolitan had already been monitoring the 50 locations under Stage 1 D/DBP Rule, prior to Stage 2 compliance beginning in April 2012 and results have shown that Metropolitan complies with the LRAA of TTHM (0.080 mg/L) and HAA5 (0.060 mg/L) for each monitoring location under Stage 2 D/DBP Rule. The highest TTHM LRAA at the core locations for the Diemer, Skinner, and Weymouth plants were 0.052 mg/L, 0.024 mg/L, and 0.061 mg/L, respectively. The highest HAA5 LRAA at the core locations for the Diemer, Skinner, and Weymouth plants were 0.027 mg/L, 0.007 mg/L, and 0.034 mg/L, respectively. To further ensure compliance with the Stage 2 D/DBP Rule, Metropolitan implemented ozone disinfection at the Skinner plant in October 2010 and Diemer plant in July 2015, and is in the process of constructing ozone facilities at the Weymouth plant.

Metropolitan began using chlorine to control the proliferation of quagga mussels in the CRA, the Lake Skinner outlet conduit, and at the Lake Mathews headworks or outlet tower in July 2007. Since 2007, Metropolitan has used the Step 2 method for compliance due to the effects of chlorinated CRW. During the reporting period, the Step 2 method was used at Diemer, Skinner, and Weymouth plants until the 3rd quarter of 2011 for Skinner plant and the 2nd quarter of 2015 for Diemer plant, following ozone treatment. With ozone treatment, Diemer and Skinner plants use the 40/30 Alternative Compliance Criteria, which does not require achievement of specified TOC removals when TOC RAA < 4.0 mg/L, alkalinity > 60 mg/L, TTHM RAA ≤ 0.040 mg/L and HAA5 LRAA ≤ 0.030 mg/L.

Bromate formation is associated with ozone treatment because ozone reacts with bromide to form bromate. During the reporting period, the bromate level ranged ND–0.012 mg/L with the highest RAA of 0.0065 mg/L for Skinner plant. The detection limit for purpose of reporting is 0.001 mg/L while the MCL is 0.010 mg/L as a RAA. Monitoring for Diemer plant began in July 2015 when ozone went online, and bromate levels have not been detectable (< 0.001 mg/L).

Interim Enhanced Surface Water Treatment Rule

The IESWTR grants 2.0-log *Cryptosporidium* removal credit for systems with conventional or direct filtration water treatment plants provided turbidity requirements are met under the combined filter effluent (CFE) requirements of the IESWTR (≤ 0.3 NTU in 95 percent of samples based on 15-minute sampling intervals and never to exceed 1 NTU). The plants achieved 100-percent compliance with the IESWTR requirements based on 5-minute sampling intervals. The maximum 95th percentile CFE turbidity of 0.10 NTU occurred at the Skinner plant in July 2015.

Radionuclides Rule

Gross alpha, gross beta, and uranium have MCLs of 15 pCi/L, 4 mrem/yr, and 20 pCi/L, respectively. Detected radionuclides at the Diemer, Skinner, and Weymouth plants are well below their respective MCLs. Gross alpha has a detection limit of 3 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from < 3 to 5.0 pCi/L. Gross beta has a detection limit of 4 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from < 4–6.5 pCi/L. Uranium has a detection limit of 1 pCi/L; detection during quarterly monitoring at the three treatment plants in 2011 and 2014 ranged from 1.2–2.8 pCi/L.

Filter Backwash Rule

The FBRR requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes be returned to a location such that all processes of a system's conventional or direct filtration including coagulation, flocculation, sedimentation (conventional filtration only), and filtration are employed.

Weymouth, Diemer, and Skinner plants have WWRPs that treat filter backwash water, sludge thickener supernatant, and liquids from dewatering processes and return the reclaimed water to the plant influent prior to any treatment in compliance with the FBRR. In addition, DDW established goals that no more than 10 percent of the total plant flow should come from washwater return and that the WWRP effluent turbidity should be less than 2.0 NTU. Metropolitan strives to achieve these goals at its treatment plants. For the December 2015 FBRR form submitted to DDW, the average recycled water turbidities were 0.41 NTU, 0.54 NTU, and 0.73 NTU at the Diemer, Skinner, and Weymouth plants, respectively. The average recycled water flows were 1.2 percent, 13.4 percent, and 2.3 percent at the Diemer, Skinner, and Weymouth plants, respectively.

Arsenic Rule

The federal arsenic MCL, originally set at 0.050 mg/L under NPDWR, was revised to 0.010 mg/L effective January 23, 2006; DDW adopted the federal MCL effective November 28, 2008. For this reporting period, the maximum arsenic concentration at each of the Diemer and Weymouth plant effluents was 0.003 mg/L, which is well below the MCL. Arsenic was not detected in the Skinner plant effluent at the DLR value of 0.002 mg/L.

Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rules

USEPA finalized the LT1ESWTR in January 2002, applicable to public water system serving fewer than 10,000 persons, and the LT2ESWTR in January 2006. DDW adopted both the LT1ESWTR and the

LT2ESWTR, effective on July 1, 2013. One of the major provisions of the LT2ESWTR was required source water monitoring for *Cryptosporidium*, *E. coli*, and turbidity.

For Schedule 1 systems, such as Metropolitan, the start of the two-year monitoring period for the LT2ESWTR was October 2006. Metropolitan completed Round 1 monitoring under the LT2ESWTR in 2008. Pathogen monitoring at the plant influents between 2006 and 2008 indicated that the Diemer, Skinner, and Weymouth plants fall into Bin 1 classification as *Cryptosporidium* was not detected in any samples over the 24-month period. Therefore, the plants do not require additional actions under the LT2ESWTR. The LT2ESWTR Round 2 monitoring began in April 2015 for the treatment plants. During the period covered by this report, *Cryptosporidium* oocysts were not detected in any of the 60 treatment plant influent samples. During the period from April 2015 to December 2015, monthly monitoring of treatment plant influents was mandated and reported under the LT2ESWTR Round 2 monitoring. The Round 2 monitoring will continue through March 2017. As required by the LT2ESTWR, *Cryptosporidium* concentrations, turbidity, and *E. coli* concentrations are being monitored.

Perchlorate

California's MCL for perchlorate is 0.006 mg/L, effective October 2007. USEPA has no MCL for perchlorate at this time. Prior to the MCL development, perchlorate was detected at 0.004 mg/L and 0.005 mg/L at the Diemer and Skinner plants, respectively, during California UCMR monitoring in 2004. This is attributed to contamination of CRW via Las Vegas Wash at that time. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants at the DLR of 0.004 mg/L during this reporting period.

Compliance with New Drinking Water Regulations

A number of MCLs, public health goals (PHGs), notification levels (NLs), and other requirements have been revised or added since the CRWSS 2010 Update was completed. They are summarized below along with Metropolitan's compliance with the new regulations.

Chromium-6

On July 27, 2011, OEHHA established the PHG for chromium-6 at 0.00002 mg/L. As of July 1, 2014, the California MCL for chromium-6 is 0.010 mg/L. Chromium-6 levels at the plant effluents were between 0.00004 mg/L and 0.00016 mg/L. The elevated chromium-6 at the Diemer, Skinner, and Weymouth plants was most likely caused by blending of other source waters, most notably from pump-in programs along the California SWP system.

Long Term 2 Enhanced Surface Water Treatment Rule

Compliance with the LT2ESWTR is discussed above under Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rule.

Stage 2 Disinfectants and Disinfection Byproducts Rule

Compliance with the Stage 1 and Stage 2 D/DBP Rule is discussed above under Stage 2 Disinfectants and Disinfection Byproducts Rule.

New Public Health Goals

Five PHGs (perchlorate, chlorobenzene, endothall, hexachlorocyclopentadiene, silvex, and trichlorofluoromethane) were revised and one new PHG (chromium-6) was added during this review period. No new or revised PHG during this CRWSS update period has any impact on the operations at the Diemer, Skinner, and Weymouth plants.

On April 24, 2014, OEHHA finalized the revised PHGs as 0.070 mg/L for chlorobenzene, 0.094 mg/L for endothall, 0.002 mg/L for hexachlorocyclopentadiene, 0.003 ng/L for silvex, and 1.3 mg/L for trichlorofluoromethane. On February 1, 2015, OEHHA published the updated perchlorate PHG of 0.001 mg/L based on new research that focused on the effects of perchlorate on infants. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected (ND; < 0.0001 mg/L) in the plant effluents at the Diemer, Skinner, or Weymouth plants during this reporting period based on the USEPA Method 332.

New Notification Levels

During this report period, there were no NLs that have been revised or added. NLs are established either in response to actual contamination of drinking water supplies or in anticipation of possible contamination. Chemicals for which notification levels are established may eventually be regulated by MCLs. There was no actual contamination, or threat of contamination, to Colorado River water by any chemical that has a notification level during this reporting period.

Compliance with Anticipated Drinking Water Regulations

The safety of drinking water supplies is an ongoing priority for public health regulatory officials. As such, federal and state regulatory agencies continue to revise existing regulations and propose new regulations as potential contaminants are identified. Metropolitan continues to evaluate compliance with these anticipated regulations and does not foresee any significant impacts.

Fluoride

On April 27, 2015, the U.S. Department of Health and Human Services (DHHS) announced a final recommendation of 0.7 mg/L to replace the current recommended range of 0.7 to 1.2 mg/L of fluoride in treated drinking water. This updated recommendation is based on USEPA and DHHS scientific assessments to balance the benefits of preventing tooth decay while limiting any unwanted health effects. These scientific assessments will also guide USEPA in making a determination of whether to lower the maximum amount of fluoride allowed in drinking water, which is set to prevent adverse health effects. USEPA is currently reviewing both the primary and secondary standards for fluoride but has not established a timeline for releasing the final recommended fluoride level for drinking water. As the primacy agency, DDW will adopt any new fluoride MCL set by USEPA or set a more stringent fluoride MCL. Metropolitan will make necessary adjustments at each of the water treatment plants to feed fluoride at the level recommended in the future. No impact is expected.

NDMA

Neither USEPA nor DDW has established an MCL for *N*-nitrosodimethylamine (NDMA) at this time. In 2002, DDW set NDMA notification and response levels of 10 ng/L and 300 ng/L as RAA. OEHHA set a PHG of 3 ng/L for NDMA in December 2006. USEPA added NDMA to UCMR 2 in 2007 and included it on the CCL3 in 2009 and the draft CCL4 in 2015. Metropolitan began voluntarily sampling NDMA on a quarterly basis in 2005 and completed a special monitoring under UCMR 2 in 2008. Since 2014, Metropolitan has conducted voluntary NDMA monitoring at treatment plant effluents and representative distribution system locations twice per year. During this reporting period, NDMA did not exceed 10 ng/L as RAA at any monitoring location.

Under voluntary monitoring, the Diemer plant effluent had an NDMA peak concentration of < 2 ng/L and Diemer's distribution system had NDMA concentrations ranging from < 2 to 5.5 ng/L. The Skinner plant effluent had an NDMA peak concentration of 6.5 ng/L and Skinner's distribution system had NDMA concentrations ranging from 2 to 11 ng/L. The Weymouth plant effluent had an NDMA peak concentration of 2.5 ng/L and Weymouth's distribution system had NDMA concentrations ranging from < 2 to 6.7 ng/L. Metropolitan's compliance strategy will be based on the future MCL.

Perchlorate

California's MCL for perchlorate is 0.006 mg/L, effective October 2007. USEPA has no MCL for perchlorate at this time. A revised perchlorate MCL may be established in the future in response to the January 7, 2011, revised draft perchlorate PHG of 0.001 mg/L by OEHHA. Perchlorate was detected at 0.004 mg/L and 0.005 mg/L at the Diemer and Skinner plants, respectively, during California UCMR monitoring in 2004. This is attributed to contamination of CRW via Las Vegas Wash at that time. Remediation efforts in the Las Vegas area have resulted in no detection of perchlorate in any of the treatment plant influents since 2004; therefore, perchlorate was not detected in the plant effluents at the Diemer, Skinner, or Weymouth plants at the DLR of 0.004 mg/L during this reporting period.

PPCPs

As discussed under the *Summary of Source Water Quality Review* above, Metropolitan's PPCP monitoring program found PPCPs and OWCs at low ng/L levels in source water samples.

1,2,3-TCP

DDW has recommended an MCL for 1,2,3-TCP of 0.000005 mg/L. Metropolitan completed compliance monitoring under the UCMR regulation and continues to conduct internal monitoring of 1,2,3-TCP, which has not been detected in any samples. Metropolitan will begin compliance monitoring for 1,2,3-TCP after the drinking water standard is adopted.

Strontium

USEPA proposes to reduce the Health Reference Level for strontium from 4.2 to 1.5 mg/L. In addition to monitoring for gross alpha, gross beta, and uranium, as discussed under the Radionuclides Rule section, Metropolitan also monitored for strontium during the reporting period. The strontium levels in Diemer, Skinner, and Weymouth plant effluents were between 0.4 and 1.2 mg/L, below the proposed Health Reference Level of 1.5 mg/L.

Summary of Key Watershed Management Activities

There are several key watershed management activities within Metropolitan's source waters associated with the CRA system, including activities in the Upper Colorado River and Lake Mead watersheds. Metropolitan's involvement in these watershed management efforts has had a positive impact on protecting source water quality for the Colorado River and Metropolitan's downstream watersheds. Updates through the writing of this report are included for completeness.

Colorado River Stakeholder Partnerships

Metropolitan engages in a number of stakeholder partnerships with external partners to collaborate on various Colorado River water quality and watershed management issues. These stakeholder partnerships include: Colorado River Basin Salinity Control Forum, Clean Colorado River Sustainability Coalition, Lake Mead Water Quality Forum, Lake Mead Ecosystem Monitoring Workgroup, Lower Colorado River Water Quality Partnership (Partnership), Nevada Environmental Response Trust Stakeholder Group, and Topock Stakeholder Forums. Metropolitan participates in regular meetings with these stakeholder groups and undertakes various activities such as sharing information on Colorado River water quality, monitoring cleanup of contaminated areas, and supporting the overall protection of the Colorado River. As appropriate, Metropolitan also sends joint letters with the Partnership to respond to water quality issues.

Colorado River Basin Salinity Control Program

Salinity in the Colorado River is an important water quality issue being addressed by the Colorado River Basin Salinity Control Forum (Forum) through the implementation of salinity control measures. In October 2014, the Forum completed and adopted its thirteenth triennial review of the salinity standards and Plan of Implementation for Colorado River salinity control. The Forum, which is comprised of representatives from the seven basin states (Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California), attributes an approximate 100 mg/L TDS (total dissolved solids) reduction for the Colorado River to Forum activities. Some of the salinity control projects coordinated between the Forum and federal agencies have included improved irrigation practices, rangeland management for non-point source control, and deep-well brine injection.

Metropolitan is committed to reducing salinity concentrations in southern California's water supplies through ongoing collaboration with the Forum and other pertinent agencies. In addition to serving on the Forum during the reporting period, Metropolitan contributed approximately $2.7 million per year to the Lower Basin Development Fund, which is 35 percent of the total funds required for cost sharing from the lower basin states. Metropolitan does not pay directly to the Basin States Program, but rather funds are collected based on a 2.5 mills per kilowatt-hour levy on California and Nevada purchases of hydropower generation from Hoover Power Plant. Along with federal appropriations, the funding is used for salinity control projects.

Metropolitan is also working with the Forum, U.S. Bureau of Reclamation (USBR) and the southern California Salinity Coalition (SCSC) to update the 1999 Salinity Management Plan, which includes an update of the Salinity Economic Impact Model (SEIM) used for preparing the Forum's water quality standards triennial report. The SEIM estimates economic damages caused by salinity and potential benefits of salinity control in the Colorado River. On June 1, 2012, SCSC convened a workshop to identify current salinity challenges and potential solutions to salinity management issues in southern California. In September 2012, USBR hired a consultant that completed a literature review of previous modeling references used in the development of the SEIM. Metropolitan worked with the Forum, SCSC, and USBR to expand the SEIM to account for damages in other reaches in the lower Colorado River. In January 2016, the Colorado River Basin Salinity Control Advisory Council approved funding for the model update to supplement USBR's resources. USBR plans to award a contract for updating the SEIM in 2017. Metropolitan will continue to provide support to update the SEIM while completing the 1999 Study update.

Uranium Mill Tailings Removal near Moab, Utah

A 16 million-ton pile of uranium mill tailings was left along the banks of the Colorado River near Moab, Utah. The tailings pile, located approximately 750 feet from the west bank of the Colorado River, are remains from a decommissioned mining corporation that ceased operation in 1984. Moving the pile offsite is critical to prevent the potential for a catastrophic flood event to wash the mill tailings directly into the Colorado River. In addition, the presence of the uranium mill tailings pile adjacent to the Colorado River impacts the public's confidence in the safety and reliability of the river as a source of drinking water supplies. In March 2008, $108 million was directed to the Moab Uranium Mill Tailings Remediation Action (UMTRA) project under the American Recovery and Reinvestment Act (ARRA) of 2009 to accelerate initial tailings removal. In April 2009, the U.S. Department of Energy (USDOE) began removing the tailings by rail to a disposal site located approximately 30 miles north of Moab in Crescent Junction, Utah.

In January 2016, USDOE achieved a significant milestone with removal of half of the original 16 million tons of tailings an as of November 2016, more than 8.4 million tons of the tailings pile has been removed. USDOE continues to maintain project progress on tailings removal while responding to critical project needs, such as implementing site safety measures and shifting resources to necessary equipment repairs and disposal cell expansion. Due to federal budget cuts, tailings removal has reduced from approximately 2 million tons annually (with ARRA funds) to between 600,000 and 900,000 tons annually. An increase in federal funding is needed to meet USDOE's targeted completion date for full removal of the tailings pile by 2025. The total cost of the remediation efforts is anticipated to be approximately $1 billion.

Metropolitan continues to advocate for expeditious removal of the tailings pile and monitor uranium levels in Colorado River water. Over the years, Metropolitan has sent letters to the Secretary of Energy and Congressional delegates advocating for increased funding to maintain effective and timely cleanup of the UMTRA site to ensure long-term protection of the Colorado River. USDOE continues to regularly inform Metropolitan of the UMTRA project remediation progress and project challenges.

Energy Exploration and Development

An increasing demand for energy is driving various energy development activities in the Colorado River basin including interests in hydraulic fracturing, uranium exploration near Grand Canyon, and activation of abandoned mines. The development of these energy resources make the Colorado River vulnerable to non-point source pollution, which could result from surface disturbance during construction of production facilities, underground mining and extraction, and wastewater discharge. In recent years, federal and state agencies have proposed various legislation to regulate the surge in energy development interests and address environmental impacts.

Metropolitan routinely monitors for uranium in its source waters and is not aware of any exceedances of regulated levels of uranium as a result of mining operations. However, Metropolitan recognizes that uranium mining in areas near the Colorado River can have impacts on the public's confidence in the safety and reliability of this water supply due to the potential for uranium mining operations to impact drinking water quality. During the reporting period, Metropolitan sent various letters commenting on energy exploration and development activities including a 2011 Partnership letter on BLM's draft EIS for the proposed Northern Arizona Proposed Withdrawal project, which continued to advocate for close federal oversight over mining claims to ensure Colorado River water quality protection; a 2013 Partnership letter on the USDOE's Draft Programmatic EIS for the USDOE Uranium Leasing Program; and in March 2015, Metropolitan responded to the Grand Canyon Trust's letter regarding the issue of inactive mines in northern Arizona. In addition, following the Gold King Mine spill, the Partnership agencies sent a letter to USBR and USGS in October 2015 requesting an improvement of the Lake Powell Water Quality Monitoring Program. The USBR established a workgroup, including the Partnership, to enhance Lake Powell's monitoring program to better manage and respond to upstream water quality issues.

Perchlorate Remediation in Henderson, Nevada

As a result of past disposal practices at two chemical manufacturing facilities in Henderson, Nevada, two large perchlorate plumes are located in close proximity to the Las Vegas Wash and Lake Mead. Since early 2007, perchlorate loading as measured in the Las Vegas Wash has typically been between 50 and 100 lbs/day. Several remediation efforts have been undertaken at the two sites, referred to as the Tronox (now Nevada Environmental Response Trust or NERT) and American Pacific Corporation or AMPAC (now Endeavour) sites, respectively, which have reduced perchlorate levels at Metropolitan's Whitsett Intake at Lake Havasu from 0.009 mg/L in 1998 to typically less than 0.002 mg/L since 2006. In January 2009, Tronox filed for Chapter 11 bankruptcy protection citing significant environmental liabilities taken on from its predecessor. The bankruptcy settlement resulted in the formation of the NERT, which has been given ownership and responsibility for site cleanup as of February 14, 2011, with Nevada Division of Environmental Protection (NDEP) providing regulatory project oversight. In April 2014, Tronox reached a $5.15 billion settlement with its predecessors, which awarded approximately $1.1 billion, directed to NERT, to clean up the former Tronox site. The settlement, which represents one of the largest environmental recoveries in history, went into effect in January 2015 and helps to ensure adequate funds are available for site cleanup and protection of the downstream Colorado River.

During the reporting period, NERT completed several improvements to optimize the current treatment system including refurbishment of the fluidized bed reactors (FBRs) and critical repairs to various process equipment. NERT also began operating additional extraction wells to maximize groundwater extraction and completed improvements to convert the GW-11 pond to an equalization basin. Through June 2016, remedial efforts at the Tronox/NERT site have removed an estimated 4,125 tons of perchlorate. This has resulted in over 90 percent reduction of perchlorate entering the Colorado River.

NERT is currently conducting remedial investigations for long-term soil and groundwater cleanup, while NDEP is initiating a regional investigation of downstream perchlorate contaminated areas to further reduce loading into Las Vegas Wash. Current efforts involve a soils investigation of former perchlorate production buildings at the site and a groundwater and surface water investigation near the Las Vegas Wash. In addition, NERT has commenced field studies of various remedial technologies, which include soil flushing and bioremediation, to assist with determining the final remedy. NERT anticipates completing the remedial investigations in 2020, followed by a feasibility study report in 2021 containing an evaluation of multiple remedial alternatives. Construction of the final remedy is expected to begin in 2022 with full cleanup anticipated to take several decades.

In June 2012, the former AMPAC site shut down the in-situ bioremediation (ISB) system and, in September 2012, started FBR treatment (similar to the Tronox/NERT FBR system) to increase perchlorate destruction rates. In 2012, AMPAC also expanded its extraction system to include five deep extraction wells in the Auto Mall area, which allowed for treatment of higher perchlorate loading. Effective December 14, 2015, Endeavour assumed full responsibility for conducting and completing the perchlorate remediation activities. Endeavour's full-scale FBR system now removes approximately 1,000 lbs/day of perchlorate compared to the ISB system, which only removed between 30 and 50 lbs/day.

Metropolitan is actively engaged in the perchlorate cleanup efforts. Metropolitan participates in regular meetings with NDEP and NERT to stay informed of remedial progress and budgetary issues, and provide input. Metropolitan also participates in site visits to review the current remediation performance and discuss planned remedial project efforts. Metropolitan reviews all pertinent project documents to provide input on the development of the long-term remedial plan. In May 2013, Metropolitan, through the Partnership, submitted a comment letter on the 2012 *Remedial Investigation and Feasibility Study (RI/FS) Work Plan for the Nevada Environmental Response Trust Site*. In 2013, Metropolitan, on behalf of NERT and stakeholders, also commissioned a third-party expert review of the RI/FS Work Plan to assist with assessment of perchlorate conditions at the site, and to evaluate and identify remediation alternatives.

Metropolitan continues to monitor perchlorate levels at several Colorado River sites and within its service area. Levels remain well below the MCL. Metropolitan will continue to be engaged with USEPA and other stakeholders as a draft federal MCL for perchlorate is developed.

Wastewater Management in the Las Vegas Valley

Las Vegas Valley wastewater treatment plants discharge tertiary treated wastewater effluent into Las Vegas Wash. Phosphorus loads from wastewater treatment plants can potentially negatively impact source waters by stimulating algal growth in downstream reservoirs and conveyance systems. Metropolitan collaborates with Las Vegas wastewater dischargers through various stakeholder forums including the Ecosystem Monitoring Workgroup. In addition, during the reporting period, Metropolitan reviewed the 5-year NPDES permit renewals, which continue to include provisions to protect the ecological systems and beneficial uses of the Las Vegas Wash, Boulder Basin of Lake Mead, and the Colorado River system downstream of Hoover Dam. Metropolitan submitted a joint review letter through the Partnership in March 2015 and acknowledged that optimized treatment and year-round phosphorus removal at the treatment plants is a key contribution to the long-term protection of downstream uses of the Colorado River in terms of phosphorus loading. In recent years, the plants have optimized their treatment processes with biological nutrient removal to achieve greater phosphorus removal and nitrogen reduction. Metropolitan will continue to track performance of the wastewater treatment plants with respect to phosphorus discharges and expects future water quality issues to be successfully addressed through collaborative processes between the dischargers and key stakeholders.

Las Vegas Wash Stabilization Program

Years of growth in the Las Vegas Valley has increased the amount of treated effluent, groundwater, urban runoff, and storm flows into Las Vegas Wash. This has resulted in increased erosion of the wash and the transport of sediment to Lake Mead. With support from multiple stakeholders, SNWA has been managing the Las Vegas Wash Stabilization Program. The program includes the construction of 22 erosion control structures along the wash to slow the stream flow and provide favorable conditions for restoring habitat along the wash. Since 1999, 19 structures have been built; during the reporting period, 8 weir structures were completed including Homestead, Lower Narrows, DU Wetlands No. 1, Duck Creek Confluence, Upper Narrows, Archery, Silver Bowl, and Three Kids Weirs. Completion of these erosion control structures is also critical to minimize the potential for future mobilization of subsurface perchlorate-laden geologic formations. However, the construction of weirs involves dewatering and temporarily discharging groundwater to Las Vegas Wash that has higher levels of perchlorate than what is currently contained in wash surface flows. Dewatering discharges were modeled to assess impacts at both the SNWA and Metropolitan intakes to determine the optimal dewatering discharge and operating period to minimize any downstream impacts. NDEP issues an NPDES permit to regulate perchlorate in dewatering discharges; actual discharges have been well below permitted levels.

In April 2016, NDEP issued a Finding and Order requiring NERT to provide an Engineering Evaluation/Cost Analysis (EE/CA) that evaluates the cost, feasibility, schedule and permitting requirements treating groundwater extracted during SNWA's construction dewatering for the Historic Lateral and Sunrise Weirs, which are under influence of the NERT perchlorate plume. NDEP and NERT are currently coordinating installation of a perchlorate treatment system to manage and treat groundwater extracted during construction of the weirs, which is expected to begin in June 2017.,

SNWA closely coordinates weir construction activities with Metropolitan, provides regular reports on perchlorate concentrations and loadings during dewatering, provides copies of quarterly reports, which are submitted to NDEP. In September 2016, Metropolitan reviewed and commented on documentation provided by NDEP and NERT regarding the proposed treatment system for the groundwater extracted during dewatering for the weir construction. Overall, Metropolitan strongly supports the Las Vegas Wash Stabilization Program, which is improving water quality in Lake Mead and controlling long-term perchlorate loading.

Chromium-6 Remediation at PG&E's Topock Gas Compressor Station

An important remediation effort is underway in the watershed for a chromium-6 plume from the PG&E Topock Gas Compressor Station located near Needles, California. PG&E is complying with a regulatory cleanup process subject to state and federal oversight from the Department of Toxic Substances Control (DTSC) and the U.S. Department of the Interior (DOI), respectively. In 2004, PG&E began implementing interim measures to control the flow of groundwater away from the Colorado River and to remove total chromium from the groundwater. In conjunction with DOI, DTSC finalized the Notice of Remedy Selection in January 2011. Also in January 2011, an environmental impact report was certified to determine any significant impacts resulting from the proposed remedial action.

The selected remedy involves installation of an in-situ bioremediation system with freshwater flushing. The In Situ Reactive Zone (IRZ) technology would use injection and extraction wells to continuously mix the contaminated plume groundwater with nutrient-added water to promote the reduction of chromium-6 to chromium-3. In addition, extraction wells near the Colorado River would act as a barrier to prevent contamination from reaching the river and additional injection wells located around the plume would inject fresh water and groundwater to push the plume toward the IRZ. PG&E prepared the final design based on the selected Final Remedy in November 2015. In April 2015, DTSC determined that a Subsequent Environmental Impact Report (SEIR) would have to be prepared to evaluate potential environmental impacts based on new design details, such as the installation of the freshwater wells in the final design. DTSC anticipates releasing the draft SEIR in January 2017 for public review. The final design would be approved when the SEIR is certified. Project construction is estimated for completion in 2022, after which the operations and monitoring phase is anticipated to take approximately 30 years or more.

Metropolitan participates in the Consultative Workgroup, Clearinghouse Task Force, and Topock Leadership Partnership meetings to provide consultation and recommendations on the remediation project. Since becoming involved in August 2003, Metropolitan has reviewed numerous work plans and technical data and has provided letters and technical memoranda to review and comment on the progress of the cleanup effort. Overall, Metropolitan supports the remediation plan and will continue participating in the stakeholder process to maintain progress and ensure long-term protection of the Colorado River. Metropolitan also conducts regular monitoring for chromium-6 at various locations upstream and downstream of the PG&E Topock Gas Compressor site. Chromium-6 has typically been at non-detect levels (< 0.00003 mg/L) in the Colorado River downstream of the site.

Lake Mathews Watershed Planning and Management

In addition to efforts along the Colorado River, Metropolitan engages in local watershed management efforts, working with local agencies to develop and implement water quality improvement plans. The DWQMP was completed in the early 1990s through a partnership between Metropolitan, County of Riverside, and RCFCWCD. The DWQMP was developed to protect the quality of water in Lake Mathews by taking a regional approach to managing runoff in the watershed. Metropolitan's construction of the Cajalco Creek Dam and Detention Basin in 2001 was a key element of the DWQMP and has been effective in removing sediment and attached pollutants from entering Lake Mathews.

Metropolitan, in conjunction with RCFCWD and County of Riverside, initiated a Lake Mathews watershed study in 2008. The Lake Mathews Watershed Water Quality Improvement Study, which was completed in December 2012, evaluated constituents such as total nitrogen, total phosphorus, sediment, and fecal coliform. The study also included modeling of various future development scenarios and evaluated DWQMP BMP water quality management strategies and low-impact development (LID) requirements. The watershed study results can be used to help manage existing uses and guide future development and stormwater management practices in the watershed. The results also assist Metropolitan and partnering agencies in reviewing development proposals and other projects within the watershed to ensure protection of Lake Mathews. This watershed-wide assessment and model provides an effective planning tool that evaluates the impacts of watershed development on Metropolitan's source water quality. During the reporting period, Metropolitan was involved with reviewing proposed developments to evaluate potential water quality impacts to Lake Mathews. Metropolitan coordinated closely with the RCFCWCD and the County of Riverside to provide input during the planning and approval process for the Boulder Springs-Dailey Ranch housing development. Metropolitan was also involved with reviewing the Cajalco Road Widening and Realignment Alternative Project and provided input to the County on the impacts to Metropolitan's facilities within the proposed project's road alternative.

Key Recommendations from the CRWSS 2015 Update

The following is a comprehensive list of recommendations developed based on the findings of the CRWSS 2015 Update and grouped by watershed. The recommendations marked with an asterisk (*) are a continuation or adaptation of previous recommendations from the CRWSS 2010 Update. These recommendations may be associated with a long-term activity or an activity that has evolved into a new but related effort.

Overall Colorado River Basin

1. *Participate in the Colorado River Basin Salinity Control Program and related efforts addressing salinity management in Metropolitan supplies**
   Metropolitan will continue to serve on the Colorado River Basin Salinity Control Forum, as representatives of California, and participate in the Forum Workgroup to support funding and implementation of salinity control projects, and completion of the program's triennial review.

2. *Complete the Salinity Management Plan Study Update**
   Metropolitan will collaborate with USBR, SCSC, and the Forum to complete the Salinity Management Plan Study Update, which will include an update of the economic impact model used by the Forum to assess Colorado River salinity impacts.

3. *Participate with the Lower Colorado River Water Quality Partnership**
   Metropolitan will continue to actively participate with SNWA and CAP to monitor Colorado River water quality issues of mutual interest and develop strategies and management actions to ensure source water protection.

4. *Track uranium exploration and other energy development activities**
   Metropolitan will continue to track uranium exploration and other energy development activities throughout the Colorado River Basin to ensure measures are taken to protect the water quality of the Colorado River.

5. *Comment on regulatory development for perchlorate and chromium-6**
   Metropolitan will track the federal regulatory processes for perchlorate and chromium-6 and the California regulatory progress on the perchlorate MCL, which is currently under review; coordinate with regulators, trade organizations, and other water utilities; and comment as appropriate in the drinking water standard setting process.

Upper Colorado River Watershed

6. *Support expeditious removal of the uranium mill tailings pile near Moab, Utah**
   Metropolitan will continue to support the efforts of USDOE in cleanup of the mill tailings site, advocating for continued and increased federal funding for expeditious removal of the tailings pile to ensure protection of downstream drinking water uses.
7. *Participate in the Lake Powell Water Quality Monitoring Workgroup*
   Metropolitan will continue to participate in monthly workgroup meetings, led by USBR to review and discuss Lake Powell water quality data.

Lake Mead Watershed

8. *Continue to track performance of Las Vegas Valley wastewater treatment plants**
   Metropolitan will continue to coordinate with Las Vegas area wastewater dischargers, review and comment, as necessary, on NPDES permit renewals and track phosphorus discharges from the wastewater treatment plants to ensure protection of downstream drinking water uses.
9. *Track NDEP's progress on development of a Nutrient Criteria Strategy for the State of Nevada**
   Metropolitan will track Nevada's Nutrient Criteria Strategy, an effort being pursued by NDEP in cooperation with USEPA Region IX with the end goal of improving Nevada's existing nutrient criteria.
10. *Participate in Lake Mead Water Quality Forum's Ecosystem Monitoring Workgroup**
    Metropolitan will continue to participate in the Ecosystem Monitoring Workgroup, formed to enhance multi-agency cooperation on ecosystem monitoring for Lake Mead and Colorado River watersheds.
11. *Continue to track and engage with stakeholders on perchlorate remediation efforts in Henderson, Nevada**
    Metropolitan will continue to coordinate with NDEP, NERT, and other key Colorado River stakeholders to monitor and provide input on the remedial investigation and efforts related to the Tronox/NERT and Endeavour perchlorate plumes.

Lake Mohave and Lake Havasu Watersheds

12. *Continue to review groundwater monitoring data for the Needles Sanitary Landfill**
    Metropolitan will continue to review the monitoring data for the Needles Sanitary Landfill. Although current groundwater monitoring indicates that contaminants are below MCLs for drinking water, there has been an increase in tetrachloroethene (PCE) at one of the site's monitoring wells (N-4).
13. *Continue to support the efforts of CCRSCo**
    Metropolitan will continue to participate in and support CCRSCo's efforts to protect the water

quality of the Colorado River, including working with USBR on the spill notification process and supporting CCRSCo's development of a watershed plan with funding from a USBR WaterSMART grant to enhance watershed planning efforts for the lower Colorado River.

14. *Continue to participate in advisory groups for chromium-6 remediation at the Topock Gas Compressor Station**
Metropolitan will continue to coordinate with the lead regulatory agencies and PG&E and actively participate in various workgroups to support efforts to remediate the chromium-6 groundwater plume adjacent to the Colorado River near Needles, California. In addition, Metropolitan will review the Subsequent EIR, groundwater model improvements, and decommissioning of IM-3 facilities during construction, anticipated in 2019, to ensure protection of Colorado River water quality.

15. *Track ADEQ's progress on remediating the chromium-6 contamination at the former McCulloch corporation facilities*
Metropolitan will track and support ADEQ's efforts to clean up the McCulloch contaminated groundwater site near Lake Havasu. ADEQ is in the preliminary phase of developing a remedial action plan for the project and will be engaging stakeholders in future project reviews.

16. *Continue to track ongoing water quality studies in the Lake Mohave and Lake Havasu watersheds**
Metropolitan will track a number of lower Colorado River-related water quality studies over the next five years. Notably, USBR's ongoing Lower Colorado River Contaminant Monitoring Program and ADEQ's proposed increase in beach monitoring.

Colorado River Aqueduct

17. *Continue to track the progress of the Eagle Mountain Pumped Storage Project**
Metropolitan will continue to track the proposed Eagle Mountain Pumped Storage Project and participate in the design review process to ensure protection of the CRA.

18. *Assess water quality effects of a potential Perris Dam seepage recovery project*
Metropolitan is currently investigating a project with DWR to recover seepage water from Lake Perris while assuring protection of CRA water quality. If the project moves forward, Metropolitan will provide an assessment in future CRWSS updates.

Lake Mathews Watershed

19. *Continue to coordinate with Riverside County Flood Control and Water Conservation District on development reviews**
Metropolitan will coordinate closely with RCFCWCD on development proposals that could impact water quality within the Lake Mathews Watershed including the Boulder Springs-Dailey Ranch development project. As appropriate, Metropolitan would recommend the application of the Lake Mathews watershed model to evaluate the effectiveness of proposed stormwater treatment options in protecting Lake Mathews' water quality.

20. *Track progress of the Cajalco Road Widening project and evaluate potential impacts to Lake Mathews**
    Metropolitan will continue to track the status of the Cajalco Road Widening and Safety Enhancement project, evaluate potential impacts to Lake Mathews based on the proposed alignments and provide input into the environmental review process.

Diamond Valley Lake Watershed

21. *Continue to be involved in long-term recreational plans for Diamond Valley Lake**
    Metropolitan will continue to assess recreational and other development proposals to ensure that any new facilities within the Diamond Valley watershed are consistent with existing permitted activities and are protective of Lake water quality. Metropolitan will update the Recreational Activity Plan, as needed, to reflect recreational improvements.

Lake Skinner Watershed

22. *Develop a Lake Skinner Source Water Protection Plan**
    Metropolitan has assessed various watershed activities with potential to impact Lake Skinner water quality as included in this CRWSS update. Metropolitan will develop a source water protection plan for the Lake Skinner watershed to further assess and document watershed activities and provide actions, policies, and practices necessary to ensure protection of Lake Skinner water quality.

23. *Consider improvements to water quality and flow monitoring for Lake Skinner tributaries**
    Metropolitan will consider developing a monitoring framework to obtain data to better evaluate watershed pollution threats. Additional data is needed to better understand the hydrologic and water quality characteristics within the Lake Skinner watershed. Information could be used to develop a watershed model, as may be recommended in the Lake Skinner Source Water Protection Plan.

24. *Identify and prioritize parcels for potential future land acquisition or conservation easements**
    Metropolitan previously acquired several properties within the Lake Skinner watershed for water quality protection. Metropolitan will evaluate the potential for future land acquisition and/or conservation easements and, if determined feasible, will rank properties based on their potential to impact lake water quality.

This page intentionally left blank

8 References

Chapter 8 References

1. Metropolitan Water District of Southern California. *Colorado River Watershed Sanitary Survey, 1996 Update.* 1996.

2. —. *Colorado River Watershed Sanitary Survey, 2000 Update.* 2000.

3. —. *Colorado River Watershed Sanitary Survey, 2005 Update.* 2005.

4. —. *Colorado River Watershed Sanitary Survey, 2010 Update.* 2012.

5. California Department of Water Resources. California State Water Project Overview. [Online] August 11, 2010. [Cited: June 8, 2016.] http://www.water.ca.gov/swp/.

6. Metropolitan Water District of Southern California. Annual Report for the Fiscal Year July 1, 2014 to June 30, 2015. [Online] July 2015. [Cited: June 8, 2016 .] http://mwdh2o.com/PDF_Who_We_Are/2015-MWD-Annual-Report-web.pdf.

7. —. *Water System Operations Detailed Business Plan FY2016/17.* 2016.

8. Colorado River Basin Salinity Control Forum. *2008 Review: Water Quality Standards for Salinity Colorado River System.* 2008.

9. U.S. Geological Survey. Groundwater Recharge in Upper Colorado River Basin May Hold Steady Under Climate Change . [Online] August 15, 2016. https://www.usgs.gov/news/groundwater-recharge-upper-colorado-river-basin-may-hold-steady-under-climate-change.

10. U.S. Department of the Interior. Hydrologic Unit Maps. *U.S. Geological Survey.* [Online] 2015. http://waterwatch.usgs.gov.

11. Jacobs, Jeffrey. The Sustainability of Water Resources in the Colorado River Basin. *National Academy of Engineering.* [Online] Winter 2011. http://www.nae.edu/File.aspx?id=55285. ISSN 0737-6278.

12. U.S. Bureau of Reclamation. Upper Colorado Region - Glen Canyon Dam. [Online] October 24, 2016. http://www.usbr.gov/uc/water/crsp/cs/gcd.html.

13. —. Lower Colorado Water Supply Report. *River Operations .* [Online] October 24, 2016. http://www.usbr.gov/lc/region/g4000/weekly.pdf.

14. —. Colorado River Basin Water Supply and Demand Study. [Online] 12 14, 2016. https://www.usbr.gov/lc/region/programs/crbstudy.html.

15. U.S. Department of the Interior Bureau of Reclamation. Lake Mead Area and Capacity Tables. *Bureau of Reclamation Lower Colorado Region.* [Online] September 2011. http://www.usbr.gov/lc/region/g4000/LM_AreaCapacityTables2009.pdf.

16. LaBounty, James F and Horn, Michael J. The Influence of Drainage from the Las Vegas Valley on the Limnology of the Boulder Basin, Lake Mead, Arizona-Nevada. *Lake and Reservoir Managment.* 1997, Vol. 13, 2.

17. U.S. Department of the Interior Bureau of Reclamation. Upper Colorado Region Water Operations: 24-Month Study Reports. *Bureau of Reclamation.* [Online] October 26, 2016. http://www.usbr.gov/uc/water/crsp/studies/.

18. U.S. Burea of Reclamation. Upper Colorado Region. *Annual Operating Plans.* [Online] 2016. https://www.usbr.gov/uc/water/rsvrs/ops/aop/index.html.

19. U.S. Climate Data. Climate Riverside - California. [Online] June 26, 2016. http://www.usclimatedata.com/climate/riverside/california/united-states/usca1695.

20. City Stats. City Stats. [Online] June 26, 2016. http://city-stats.org/ca/winchester/climate/winchester-climate-data.

21. *Analysis of microcystins in drinking water by ELISA and LC/MS/MS.* Guo, C, Prescott, M and A, Lee, et al. s.l. : Journal American Water Works Association, 2017, Vol. in Press.

22. U.S. Environmental Protection Agency. *Fact Sheet: The Drinking Water Contaminant Candidate List – The Source of Priority Contaminants for the Drinking Water Program.* s.l. : Office of Water (4607M), 2005. EPA 815-F-05-001.

23. *Developmental Toxicity of Boric Acid in Mice, Rats, and Rabbits.* Heindel, Jerrold J., et al. 2, Research Triangle Park, NC : s.n., February 1992, Fundamental Applied Toxicology, Vol. 18, pp. 266–77.

24. U.S. Environmental Protection Agency. Drinking Water Treatability Database Chromium. [Online] March 2010. https://iaspub.epa.gov/tdb/pages/contaminant/contaminantOverview.do?contaminantId=10040.

25. —. Radionuclides in Drinking Water: A Small Entity Compliance Guide. [Online] February 2012. http://www.epa.gov/ogwdw/radionuclides/pdfs/guide_radionuclides_smallsystems_compliance.pdf. 815-R-02-001.

26. Focazio, Michael J, et al. A National Reconnaissance for Pharmaceuticals and Other Organic Wastewater Contaminants in the United States - II) Untreated Drinking Water Sources. *Science and the Total Environment.* 2008, Vol. 402.

27. Benotti, Mark J, et al. Pharmaceuticals and Endocrine Disrupting Compounds in U.S. Drinking Water. *Environmental Science & Technology.* 2009, Vol. 43.

28. Snyder, Shane, et al. *Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water.* Denver : Awwa Research Foundation, 2009. ISBN: 978-1-84339-250-7.

29. Snyder, Shane, et al. *State of Knowledge of Endocrine Disruptors and Pharmaceuticals in Drinking Water.* Denver : Awwa Research Foundation, 2008. ISBN: 978-1-60573-030-1.

30. State Water Resources Control Board. Staff Report: Constituents of Emerging Concern Monitoring for Recycled Water. *California Environmental Protection Agency.* [Online] November 8, 2010. www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/recycledwater_cec.shtml.

31. State Water Resources Control Board, Division of Drinking Water. Division of Drinking Water's Recycled Water Information. [Online] September 16, 2016. http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/RecycledWater.shtml.

32. Water Research Foundation. *Evaluation of Analytical Methods for EDCs and PPCPs via Inter-Laboratory Comparison.* s.l. : Water Research Foundation, 2012. 4167.

33. Standard Methods Committee. *6810 Pharmaceuticals and Personal Care Products.* 2013 : Standard Methods for the Examination of Water and Wastewater.

34. *Occurrence and suitability of sucralose as an indicator compound of wastewater loading to surface waters in urbanized regions.* Oppenheimer, Joan, et al. 13, s.l. : Water Research, July 2011, Vol. 45, pp. 4019-4027.

35. National Estuarine Research Reserve. Microbes and Urban Watersheds: Concentratons, Sources, and Pathways. *Watershed Protection Techniques.* 1999, Vol. 3, 1.

36. U.S. Environmental Protection Agency. Stormwater Phase II Final Rule. *Small MS4 Stormwater Program Overview.* [Online] December 2005. https://www3.epa.gov/npdes/pubs/fact2-0.pdf.

37. *Sources of Fate of Nitrosodimethylamine and its Precursors in Municipal Wastewater Treatment Plants.* Sedlak, David L., et al. 2004. Proceedings of the Water Environment Federation Technical Exposition and Conference 2004. pp. 31–46.

38. U.S. Coast Guard. 2011-2015 NRC Reports. *National Response Center.* [Online] 2016. http://nrc.uscg.mil/FOIAFiles/CY14.xlsx.

39. U.S. Environmental Protection Agency. *Design Manual: Municipal Wastewater Disinfection.* Cincinnati : Center for Environmental Research Information, 1986. EPA/625/1-85/021.

40. —. Solid Waste Disposal Facility Criteria Technical Manual. [Online] April 1998. http://nepis.epa.gov/Exe/ZyNET.exe/P1003F0V.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&.

41. —. Semiannual Report of UST Performance Measures Mid Fiscal Year 2016. *Underground Storage Tank (UST) Performance Measures.* [Online] March 31, 2016. https://www.epa.gov/ust/ust-performance-measures.

42. Colorado River Basin Salinity Control Forum. 2014 Review Water Quality Standards for Salinity Colorado River System. [Online] October 2014. http://coloradoriversalinity.org/docs/2014%20Final%20REVIEW%20-%20complete.pdf.

43. U.S. Geological Survey. Pesticide National Synthesis Project. *U.S Geological Survey Fact Sheet FS-039-97 .* [Online] March 04, 2014. http://water.usgs.gov/nawqa/pnsp/pubs/fs97039/sw1.html.

44. California Department of Forestry and Fire Protection. CAL FIRE Incident Information. [Online] 2016. http://cdfdata.fire.ca.gov/incidents/incidents_archived.

45. *The Effect of Fire on Nutrients in a Chaparral Ecosystem.* DeBano, Leonard F. and Conrad, C.E. 3, 1978, Ecology, Vol. 59, pp. 489–497.

46. Ranalli, Anthony J. *A Summary of the Scientific Literature on the Effects of Fire on the Concentration of Nutrients in Surface Waters.* Denver : U.S. Department of the Interior, U.S. Geological Survey, 2004. Open-File Report 2004-1296.

47. Lim, Jeong-Hee. Water Resources Control Engineer. *Regional Water Quality Control Board, Colorado River Basin Region.* s.l. : Personal Communication, July 2016.

48. Lake Havasu City. Lake Havasu City Stormwater Management Program (Revised) in Compliance with Small MS4 General Permit (#AZG2002-002) and ADEQ Consent Order dated March 5, 2013. [Online]

March 2014. https://www.lhcaz.gov/docs/default-source/department-documents/swmpupdate2014.pdf?sfvrsn=4.

49. Mohave County. Drainage Design Manual. [Online] May 19, 2014 . https://www.mohavecounty.us/ContentPage.aspx?id=124&page=15&cid=392&index=5.

50. Boyles, Michael. National Park Service Lake Mead National Recreation Area. *Acting Chief, Resource Management and Visitor Services.* s.l. : Personal Communication, 2016.

51. Federal Register. Record of Decision for Development Concept Plans for Cottonwood Cove and Katherine Landing, Lake Mead National Recreation Area, Nevada and Arizona. *Federal Register: The Daily Journal of the United States Government.* [Online] April 2016. https://www.federalregister.gov/articles/2016/04/18/2016-08837/record-of-decision-for-development-concept-plans-for-cottonwood-cove-and-katherine-landing-lake-mead.

52. U.S. Department of the Interior National Park Service. Lake Mead National Recreation Area. *National Park Service.* [Online] 2016. https://www.nps.gov/lake/planyourvisit/maps.htm.

53. California Department of Boating and Waterways. Reports, Posters, and Publications. *California Department of Boating and Waterways.* [Online] 2011. Colorado River Boating Trail Guide Davis Dam to Parker Dam. http://www.dbw.ca.gov/Pubs/DavistoParker/DavistoParker.pdf.

54. U.S. Department of the Interior Bureau of Land Management. Bureau of Land Management Recreation Fee Program Summary FY2008 Accomplishments. *Bureau of Land Management.* [Online] 2008. http://www.blm.gov/style/medialib/blm/az/pdfs/buss_plans.Par.24180.File.dat/LAKE-HAVASU-RECREATION-SITES-pictures.pdf.

55. McCoy, Myron. Bureau of Land Management Field Office. *Personal Communication.* 2011.

56. Kilbane, Caroline. Outdoor Recreation Planner. *Bureau of Land Management, Lake Havasu Field Office.* s.l. : Personal Communication, 2016.

57. Carter, Larry. Concessions Program. *Bureau of Land Management, Lake Havasu Field Office.* s.l. : Personal Communication, July 18, 2016.

58. National Park Service. Two-Stroke Personal Watercraf Engine Regulations. *National Parks Service Laws and Policies.* [Online] December 31, 2012. [Cited: July 14, 2016.] https://www.nps.gov/lake/learn/management/twostroke.htm.

59. U.S. Department of the Interior Bureau of Land Management. Record of Decision and Approved Resources Management Plan. *Bureau of Land Management.* [Online] May 2007. http://www.blm.gov/pgdata/etc/medialib/blm/az/pdfs/nepa/library/resource_management/lhfo_ROD.Par.74616.File.dat/ROD_ARMP_Complete.pdf?bcsi_scan_A8C0312CFFB9AD05=PJySwu34PeuM06e/rKZPJVg6iTUbAAAAB5FdDA==&bcsi_scan_filename=ROD_ARMP_Complete.pdf. 1610 (330).

60. —. Notice of Final Supplementary Rules on Public Lands Managed by the Lake Havasu Feld Office, Arizona and California. *The Federal Register.* [Online] September 24, 2009. https://federalregister.gov/a/E9-23247. 74 FR 49010.

61. U.S. Department of the Interior National Park Service. Lake Mead National Recreation Area. *National Park Service.* [Online] 2002. Lake Mead National Recreation Area Lake Management Plan Final Environmental Impact Statement, Volume 2. http://www.nps.gov/lake/parkmgmt/upload/Lake_Managment_Plan_Vol_1.pdf?bcsi_scan_1DC256F8CFDF8019=0&bcsi_scan_filename=Lake_Managment_Plan_Vol_1.pdf.

62. —. Lake Mead Water Quality and Limnology. *National Park Service.* [Online] U.S. Department of the Interior, August 10, 2011. Long-Term Limnological and Aquatic Resource Monitoring and Research Plan for Lakes Mead and Mohave. http://www.nps.gov/lake/naturescience/water-quality-and-limnology.htm.

63. National Parks Service. Water Quality and Limnology. *Long-term Limnological and Aquatic Resource Monitoring for Lakes Mead and Mohave Category 1.* [Online] https://www.nps.gov/lake/learn/nature/water-quality-and-limnology.htm.

64. Palmer, C.J., et al. Surface Water Monitoring for Indicator Bacteria in High-Use Sites of the Lake Mead National Recreation Area 2003-2011. *Lake Mead Water Quality Forum Ecosystem Monitoring Workgroup.* [Online] December 5, 2012. https://ndep.nv.gov/forum/EcoMtg/Bacteria_report_LaMEM_12_5_12.pdf.

65. U.S. Geological Survey. Water–Quality Monitoring at Lake Mead National Recreation Area, Arizona and Nevada. *USGS Nevada Water Science Center.* [Online] September 8, 2014. http://nevada.usgs.gov/lmqw/.

66. Tietjen, Todd, Ph.D. *Microcystisin Lakes Mead, Mohave and Havasu: 2014 -2015.* [Powerpoint Presentation] Southern Nevada Water Authority : s.n., 2016.

67. National Park Service. UPDATE: SWIMMING ADVISORY CONTINUES AT LAKES MEAD, MOHAVE. *Lake Mead National Recreation Area .* [Online] June 5, 2015. https://www.nps.gov/lake/learn/news/swimming-advisory-june-2015.htm.

68. U.S. Bureau of Reclamation. *Lower Colorado River Phase II Contaminant Monitoring Program 2008-2014 Report (Draft).* 2015.

69. U.S. Department of the Interior Bureau of Reclamation. *Draft Lower Colorado River Contaminant Monitoring Program 2008–2009 Status Report.* 2011.

70. Smart, Meghan. *Arizona Division of Environmental Quality.* July 25, 2016. Regional Water Quality Plan 2009.

71. U.S. Environmental Protection Agency. Enforcement & Compliance History Online (ECHO). *U.S. Environmental Protection Agency.* [Online] December 23, 2011. http://www.epa-echo.gov/echo/.

72. —. Envirofacts | Permit Compliance System (PCS) Search. *U.S. Environmental Protection Agency.* [Online] October 7, 2011. http://www.epa.gov/enviro/facts/pcs/search.html.

73. Sheth, Gary. U.S. Environmental Protection Agency, Region 9. *USEPA Tribal Water Quality Permits.* s.l. : Personal Communication, July 18, 2016.

74. Koester, Andy. Surface Water Permits (AZPDES). *Arizona Department of Environmental Quality.* s.l. : Personal Communication, July 21, 2016.

75. Hartley, Bonnie. Nevada Division of Environmental Protection. s.l. : Personal Communication, July 22, 2016.

76. Willet, Leonard. Hoover Dam Compliance Manager. *U.S. Bureau of Reclamation.* s.l. : Personal Communication, June 4, 2016.

77. Marbury, Frank. City of Kingman. *Personal Communication.* 2011.

78. City of Bullhead City. 208 Plan Amendment and Wastewater Master Plan Update. [Online] September 2012.

https://resources.mohavecounty.us/file/PlanningAndZoning/WaterQualityManagement/BHC%20208%20Plan%20including%20all%20amendments%20since%202003.pdf.

79. Regional Water Quality Control Board Colorado River Basin. Waste Discharge Requirements for City of Needles Wastewater Treatment Plant. *Colorad River Basin Board Orders - Year 2015.* [Online] March 15, 2015. http://www.waterboards.ca.gov/coloradoriver/board_decisions/adopted_orders/orders/2015/0018needles.pdf.

80. Lake Havasu City. Fiscal Years 2016 and 2017 Biennial Budget. [Online] July 1, 2015. https://www.lhcaz.gov/docs/default-source/department-documents/budgetbookfys16and17.pdf?sfvrsn=48.

81. —. Water Conservation Plan Lake Havasu City, Arizona . [Online] December 8, 2015. http://www.havasuwatersavers.org/pdf/2015_water_conservation_plan.pdf.

82. Wilson, Doyle C. 2009 Annual Water Symposium. *Arizona Hydrological Society.* [Online] 2009. Subsurface Effluent Injection Adjacent to the Colorado River, Lake Havasu City, Arizona. http://www.azhydrosoc.org/MemberResources/Symposia/2009/Papers/Wilson.pdf.

83. Arizona Department of Environmental Quality. Notice of the Preliminary Decision to Issue a Significant Amendment to an Aquifer Protection Permit. *Lake Havasu City - North Regional Wastewater Treatment Plant.* [Online] January 2016. http://legacy.azdeq.gov/calendar/pn_lake_havasu.pdf.

84. Wilson, Doyle C. Lake Havasu City. s.l. : Personal Communication, 2016.

85. Chadburn, Julie. Complaince and Regulatory Affairs Administrator . *Clark County Water Reclamation District.* s.l. : Personal Communication, June 2016.

86. Arizona Criminial Justice Commission. Prescription Drug Reduction Initiative. [Online] 2016. Springerville Police Department.

87. Arizona Department of Environmental Quality. *Summary Report for March/April 2014 Groundwater Monitoring and Sampling Event Former McCulloch Site.* Lake Havasu City : Tetra Tech, Inc., 2014. Project No. 117-1303050.

88. Lower Colorado River Area Committee. Lower Colorado River Corridor Area 2. *Lower Colorado RIver Geographic Response Plan.* [Online] February 2014. https://ndep.nv.gov/bca/docs/LCGRP/LCRGRP%20Area%202%20February%202014%20-%20No%20Maps.pdf.

89. Regional Water Quality Control Board Colorado River Basin Region. Monitoring and Reporting Program (R7-2015-0037) for Needles Waste Management Facility Class III Landfill. [Online] June 2015. http://www.waterboards.ca.gov/coloradoriver/board_decisions/adopted_orders/orders/2015/0037needles_wdr.pdf.

90. California Regional Water Quality Control Board. Board Orders. *State Water Resources Control Board.* [Online] 2003. Monitoring and Reporting Program No. R7-2003-0046 and Closure and Post-Closure Maintenance for County of San Bernardino, Owner/Operator Needles Waste Management Facility Class III Landfill Class II Surface Impoundments. http://www.swrcb.ca.gov/rwqcb7/board_decisions/adopted_orders/orders/2003/03_46mr.pdf.

91. Arizona Department of Environmental Quality. LUST Database Search. *ADEQ.* [Online] http://www.azdeq.gov/databases/lustsearch.html.

92. State Water Resources Control Board. GeoTracker. [Online] http://geotracker.waterboards.ca.gov/.

93. Nevada Division of Environmental Protection. Bureau of Corrective Actions. *Department of Conservation & Natural Resources.* [Online] State of Nevada, October 19, 2011. Underground Storage Tank Lists. http://ndep.nv.gov/bca/data.htm.

94. Electric Light & Power. Coal-fired Mohave Generating Station decommissioning nears finish. [Online] 05 06, 2013. http://www.elp.com/articles/2013/05/coal-fired-mohave-generating-station-decommissioning-nears-finis.html.

95. State Water Resources Control Board. Compliance with California and Federal Underground Storage Tank Regulations. [Online] October 21, 2015. http://www.swrcb.ca.gov/ust/tech_notices/docs/ca_fed_regs.pdf.

96. —. Underground Storage Tank (UST) Program. *Division of Water Quality.* [Online] July 27, 2016. Draft California Leaking Underground Fuel Tank (LUFT) Guidance Manual-Version 2.0. http://www.swrcb.ca.gov/ust/.

97. Palmer, William D. From Septic to Sewers. *Public Works Magazine Online.* July 1, 2007. http://www.pwmag.com/industry-news.asp?sectionID=775&articleID=529165&artnum=1.

98. Thomas, Doug. Wastewater Division Manager. *Lake Havasu City.* s.l. : Personal Communication, July 18, 2016.

99. Colorado River Regional Sewer Coalition. *Lower Colorado River Watershed Quality Update.* Arizona : PBS&J, 2009.

100. Howard, Rhea. Permit Technician. *Mohave County Public Health Department.* July 2016.

101. Hendricks, Kris. LLC Contract Operator . *City of Needles.* 2016. Reclamation: Managing Water in the West, Wastewater Treatment Needs Along the Lower Colorado River.

102. Colorado River Regional Sewer Coalition. *Lower Colorado River Watershed Quality Update.* Lake Havasu City : PBS&J, 2009.

103. Arizona Department of Environmental Quality. Water Quality Division: Engineering Review: Notice of Transfer for On-Site Wastewater Treatement Facilties. *ADEQ.* [Online] 2006. http://www.azdeq.gov/environ/water/engineering/not.html. A.A.C. R18-9A316 (B)(3).

104. State Water Resources Control Board. Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy). [Online] December 13, 2012. http://www.waterboards.ca.gov/water_issues/programs/owts/summary.shtml.

105. —. Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy). [Online] January 13, 2014. http://www.waterboards.ca.gov/water_issues/programs/owts/docs/owts_fs.pdf.

106. Blanton, Mike. Rangeland Management Specialist. *Bureau of Land Management, Kingman Office.* s.l. : Personal Communication, July 2016.

107. Daniels, Mona. Outdoor Recreation Planner. *Bureau of Land Management, Needles Office.* s.l. : Personal Communication, July 2016.

108. Peterson, Jennifer. Concentrated Animal Feeding Operation (CAFO) Program. *Arizona Department of Environmental Quality.* s.l. : Personal Communication, July 2016.

109. Gonzales, Linda. Budget Control Development Specialist III. *Arizona Department of Agriculture, Animal Services Divsion.* s.l. : Personal Communication, July 2016.

110. Dunn, Kai. Senior Water Resources Control Engineer – NPDES Unit. *California Regional Water Quality Control Board – Colorado River Basin Region (R7).* s.l. : Personal Communication, July 2016.

111. Arizona Department of Environmental Quality. Water Quality Division: Permits: Concentrated Animal Feeding Operation Program. [Online] 2016. http://legacy.azdeq.gov/environ/water/permits/cafo.html.

112. —. Nonpoint Source Management Plan Planning Horizon State Fiscal years 2015-2019. [Online] December 11, 2014. http://legacy.azdeq.gov/environ/water/watershed/download/NPS_5yr_Plan_final.pdf.

113. The National Wildfire Coordinating Group. SH Ranch Complex Fire . *Incident Status Summary (ICS-209).* [Online] July 24, 2015. https://fam.nwcg.gov/fam-web/hist_209/hist_r_print_209_head_2005?v_number=AZ-AZS-050848&v_report_date=07/24/2005&v_hour=1918&v_gaid=SW.

114. InciWeb Incident Information System. [Online] 2016. http://inciweb.nwcg.gov/.

115. Mohave Valley Daily News. A year later, refuge springing back to life. [Online] August 7, 2016. http://www.mohavedailynews.com/news/a-year-later-refuge-springing-back-to-life/article_4d75afc0-5d32-11e6-93bd-970c75612aa4.html.

116. U.S. Department of the Interior Bureau of Land Management. Arizona Districts and Fire Zones. [Online] March 23, 2016. http://www.blm.gov/az/st/en/prog/fire/districts.html.

117. U.S. Fire Restrictions. Arizona State Area Stage 1 Fire Restrictions. [Online] June 22, 2016. http://firerestrictions.us/.

118. Mohave Valley Daily News. Restricted use: State law, variety of bans limit options for fireworks . [Online] July 2014, 2016. http://www.mohavedailynews.com/news/restricted-use-state-law-variety-of-bans-limit-options-for/article_70a458a8-0284-11e4-a77c-001a4bcf887a.html.

119. Eagle Crest Energy Company. Eagle Mountain Pumped Storage Project: Making Renewable Energy Dependable. [Online] 2016. http://www.eaglemountainenergy.net/.

120. HydroWorld. Eagle Crest Buys Site for 1,300-MW Pumped-Storage Hydro Project. [Online] July 7, 2015. http://www.hydroworld.com/articles/2015/07/eagle-crest-buys-site-for-1-300-mw-pumped-storage-hydro-project.html.

121. Cadiz Water Project. The Cadiz Water Project in Southern California. [Online] 2015. http://www.cadizwaterproject.com/.

122. Nasdaq Globe Newswire. Sweeping Legal Victories for Cadiz Water Project Stand. [Online] July 12, 2016. https://globenewswire.com/news-release/2016/07/12/855448/0/en/Sweeping-Legal-Victories-for-Cadiz-Water-Project-Stand.html.

123. Sanitation Districts of Los Angeles County. Sanitation Districts of Los Angeles County Cease Negotiations for Eagle Mountain Landfill Project and Look to Expand Evaluation of Long Term Waste

Management Strategies. [Online] May 22, 2013. http://www.lacsd.org/civicax/filebank/blobdload.aspx?BlobID=8354.

124. Kashak, Edward. Engineering Geologist, Dairy Program Lead. *Regional Water Quality Control Board, Santa Ana.* s.l. : Personal Communication, 2016.

125. California Regional Water Quality Control Board, Santa Ana Region. General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities) within the Santa Ana Region. [Online] June 7, 2013. http://www.waterboards.ca.gov/santaana/board_decisions/adopted_orders/orders/2013/13_001_General_WDR_CAFOs_Dairies_Related_Facilities.pdf.

126. Western Riverside County Agriculture Coalition. San Jacinto Salt Offset and Dairy Impacts Report – 2016 Update. [Online] April 1, 2016. http://www.waterboards.ca.gov/santaana/water_issues/programs/dairies/docs/2016/SJ_Dairy_GW_Impacts-2016_update_4-1-16_final.pdf.

127. —. San Jacinto Dairy Salt Offset Groundwater Monitoring Additional Control Measures Work Plan for Dairies with Potential Groundwater Impacts. [Online] Apri 1, 2016. http://www.waterboards.ca.gov/santaana/water_issues/programs/dairies/docs/2016/FINAL_Control_Measures_WP_2-23-16_update_4-1-16.pdf.

128. County of Riverside. *Lake Mathews Watershed Drainage Water Quality Management Plan.* 1992. pp. 4–128.

129. Santa Ana Regional Water Quality Control Board. 2015 Renewal of the Riverside County Municipal NPDES Storm Water Permit. *Riverside County Municipal NPDES Storm Water Permit.* [Online] 2016. http://www.waterboards.ca.gov/santaana/water_issues/programs/stormwater/rc_2015amendment.shtml.

130. Roth, Michael. NPDES Permits. *Santa Ana Regional Water Quality Control Board.* s.l. : Personal Communication, August 2016.

131. Riverside County Flood Control and Water Conservation District. Riverside County Drainage Area Management Plan. *Riverside County Flood Control and Water Conservation District.* [Online] August 29, 2015. Riverside County Drainage Area Management Plan, Santa Ana and Santa Margarita Regions. http://rcflood.org/downloads/NPDES/Documents/SA_SM_DAMP/SAR_DAMP2015.pdf.

132. —. Water Quality Management Plan, A Guidance Document for the Santa Ana Region of Riverside County. [Online] October 22, 2012. http://rcflood.org/downloads/NPDES/Documents/SA_WQMP/SantaAnaWQMPGuidance.pdf.

133. —. Design Handbook for Low Impact Development Best Management Practices. [Online] September 2011. http://rcflood.org/downloads/NPDES/Documents/LIDManual/LID_BMP_Design_Handbook.pdf.

134. Wester Riverside County Regional Conservation Authority. Riverside County Multiple Species Habitat Conservation Plan (MSHCP). [Online] July 13, 2016. Riverside County Multiple Species Habitat Conservation Plan (MSHCP)..

135. County of Riverisde. Lake Mathews/Woodcrest Area Plan. *Riverside County General Plan.* [Online] December 8, 2015. County of Riverside General Plan Lake Mathews/Woodcrest Area Plan. http://planning.rctlma.org/Portals/0/genplan/general_plan_2016/area_plans/LMWAP_120815m.pdf?ver=2016-04-01-100957-257.

136. Riverside County Clerk of the Board. Riverside County Ordinances. [Online] 2016. http://www.rivcocob.org/ordinances/.

137. Metropolitan Water District of Southern California and Riverside County Habitat Conservation Agency. *Lake Mathews Multiple Species Habitat Conservation and Natural Community Conservation Plan.* 1995.

138. Riverside County Transportation and Land Management Agency. Western Riverside County Multiple Species Habitat Conservation Plan. *Riverside County TLMA.* [Online] 2003. http://www.rctlma.org/mshcp/volume1/index.html.

139. Riverside County Regional Park and Open-Space District. Agendas. *Riverside County Clerk of the Board Office.* [Online] September 15, 2011. Submittal to the Board of Directors County of Riverside, State of California: Mockingbird Canyon to Harford Springs Trail Alignment and Environmental Compliance Project - Consultant Services - Agreement Amendment - District I. http://rivcocob.com/agenda/2011/10_04_11/13.01%20reg.pdf.

140. —. Staff Report Park District Trails Committee Project Status. [Online] February 26, 2014. http://www.rivcoparks.org/wp-content/uploads/Trails-Staff-Report-2-26-14.pdf.

141. U.S. Coast Guard. 2011-2015 NRC Reports. *National Response Center.* [Online] 2016. http://nrc.uscg.mil/FOIAFiles/CY14.xlsx.

142. Metropolitan Water District of Southern California. *Safety and Environmental Services Event Database.* [E-mail Communication] July 2016.

143. Meyer, Brenda. Principal Engineer. *Western Municipal Water District.* s.l. : Personal Communication, August 2016.

144. California Department of Resources Recycling and Recovery. Solid Waste Information System (SWIS) Facility/Site Search. *Cal Recycle.* [Online] 2016. http://www.calrecycle.ca.gov/SWFacilities/Directory/Search.aspx.

145. Cardenas, Miriam. Community Relations Specialist. *Waste Management of Southern California (El Sobrante Landfill).* s.l. : Personal Communication, February 2015.

146. State Water Project Contractors Authority. *California State Water Project Watershed Sanitary Survey 2006 Update.* 2006.

147. Riha, Matt. Riverside County Department of Environmental Health. *Personal Communication.* 2011.

148. Riverside County Department of Environmental Health. Onsite Wastewater Treatment Systems Technical Guidance Manual. [Online] March 2015. http://www.rivcoeh.org/Portals/0/documents/guidance/landuse/Tech%20Guidance%20Manual%20FINAL.pdf.

149. Riverside County Board of Supervisors. Initiation of Amendments to Riverside County Ordinance 650 . *Submittal to the Board of Supervisors of Riverside County, State of California.* [Online] March 3, 2016.

150. Reyes, Greg. Solid Waste Office Supervisor. *Riverside County Environmental Health.* s.l. : Personal Communication, August 2016.

151. California Department of Forestry and Fire Protection. CAL FIRE Incidents. [Online] 2016. http://cdfdata.fire.ca.gov/incidents/incidents_archived.

152. Metropolitan Water District of Southern California, California Department of Forestry and Fire Protection, California Department of Fish and Game, and U.S. Fish and Wildlife Service. *Lake Mathews Fire Management Plan - Volumes I–III.* 1994.

153. California Department of Forestry and Fire Protection Riverside Unit. Riverside Fire Plan. *California Department of Forestry and Fire Protection.* [Online] 2005. Riverside Unit Fire Management Plan 2005. http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf396.pdf.

154. CAL FIRE/ Riverside County Fire. 2016 Unit Strategic Fire Plan. [Online] May 2016.

155. County of Riverside. San Jacinto Valley Area Plan. *County of Riverside General Plan.* [Online] December 8, 2015. http://planning.rctlma.org/Portals/0/genplan/general_plan_2016/area_plans/SJVAP_120515m.pdf?ver=2016-04-01-101029-070.

156. Regional Water Quality Control Board, San Diego. San Diego Region - Riverside County Municipal Storm Water Permit. [Online] November 18, 2015.

157. County of Riverside. Stormwater Management Program | Santa Margarita Watershed. *Riverside County Flood Control and Water Conservation District.* [Online] July 2005. County of Riverside Santa Margarita Region Stormwater Management Plan. http://rcflood.org/downloads/NPDES/Documents/SM_Indiv_SWMP/County%20SWMP%20Final.pdf?bcsi_scan_1DC256F8CFDF8019=0&bcsi_scan_filename=County%20SWMP%20Final.pdf.

158. Riverside County Flood Control and Water Conservation District. Stormwater Management Plan | Santa Margarita Watershed. *Riverside County Flood Control and Water Conservation District.* [Online] September 2011. Santa Margarita Region Stormwater Management Plan, September 2011. http://rcflood.org/downloads/NPDES/Documents/SM_Indiv_SWMP/DistrictSWMP_Sept2011.pdf.

159. Regional Conservation Authority, Western Riverside County. Reserves. *Southwestern Riverside County Multi-Species Reserve.* [Online] 2016. http://wrc-rca.org/habitat-conservation/reserves/.

160. Southwestern Riverside County Multi-Species Reserve. Image Credit.

161. Metropolitan Water District of Southern California. *Lake Skinner Water Quality Protection Plan.* Los Angeles : s.n., 1998. pp. 4–166.

162. County of Riverside. Multipurpose Open Space Element. *County of Riverside General Plan.* [Online] December 8, 2015. http://planning.rctlma.org/Portals/0/genplan/general_plan_2016/elements/Ch05_MOSE_120815.pdf?ver=2016-04-01-100801-367.

163. Riverside County Parks. Welcome to Lake Skinner Brochure. *Lake Skinner- Home.* [Online] September 2010. http://www.rivcoparks.org/wp-content/uploads/Lake-Skinner-Brochure-09.10.pdf.

164. Moen, Christine. Former Reserve Manager. *Fire Management Plan Section of the Southwest Riverside County Multi-Species Reserve Management Plan.* September 3, 2008.

165. County of Riverside. Ordinance No. 328 An Ordinance of the County of Riverisde Amending Ordinance No. 328 Prescribing Rules and Regulations for the Government of County or District-Owned or Operated Parks and Open-Space Areas. [Online] May 31, 2007. http://www.rivcoparks.org/wp-content/uploads/Ordinance-No-328.pdf.

166. Metropolitan Water District of Southern California. Site Closure Request Report RWQCB TSMC: 50-4162.05:SPEASE, Investigative Order No. R9-2007-228. [Online] November 1, 2011. http://geotracker.waterboards.ca.gov/esi/uploads/geo_report/5326288878/T0606511682.PDF.

167. Kim, Kristine. Land Use & Water Resources Program. *Riverside County Department of Environmental Health.* s.l. : Personal Communication, July 21, 2016.

168. County of Riverside General Plan. Riverside Extended Mountain Area Plan. [Online] December 8, 2015. http://planning.rctlma.org/Portals/0/genplan/general_plan_2016/area_plans/REMAP_120815m.pdf?ver=2016-04-01-101022-710.

169. Dierking, Bonnie. Riverside County Environmental Health Local Solid Waste Management Enforcement Agency Program Chief. s.l. : Personal Communications, 2016.

170. Metropolitan Water District of Southern California. *Draft Framework for a Lake Skinner Source Water Protection Plan.* 2008.

171. Johnson, Jeff. Riverside County Department of Environmental Health. *Personal Communication.* 2011.

172. Southwestern Riverside County Multi-Species Reserve. *Southwestern Riverside County Multi-Species Reserve Year 2013 Sheep Grazing Report.* Temecula : s.n., 2013.

173. San Diego Regional Water Quality Control Board. Irrigated Agriculture and Nurseries. *Tentative General Waste Discharge Requirements for Discharges of Wastes from Commercial Agricultural and Nursery Operations within the San Diego Region (General Agricultural Order).* [Online] July 7, 2016. [Cited: July 27, 2016.] http://www.waterboards.ca.gov/sandiego/water_issues/programs/irrigated_lands/irrigated_ag_d.shtml.

174. Region Water Quality Control Board - San Diego. WDR/NPDES Public Hearing Notices. *Notice of Public Hearing - Tentative Order Nos. R9-2016-0004 and R9-2016-0005.* [Online] November 9, 2016. http://www.waterboards.ca.gov/sandiego/public_notices/hearings/npdes_notices/npdes.shtml.

175. California Department of Forestry and Fire Protection. *Personal Communication.* 2008.

176. U.S. Environmental protection Agency. Understanding the Safe Drinking Water Act. [Online] June 2004. https://www.epa.gov/sites/production/files/2015-04/documents/epa816f04030.pdf.

177. U.S. Environmental Protection Agency. Drinking Water Contaminants - Standards and Regulations. [Online] May 9, 2016. http://water.epa.gov/drink/contaminants/.

178. State Water Resources Control Board. Upcoming Regulations for Drinking Water. [Online] July 21, 2016. http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Regulations.shtml.

179. —. Article 16. Secondary Water Standards. *Chemicals and Contaminants in Drinking Water.* [Online] May 2, 2006. http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chemicalcontaminants.shtml.

180. Office of Environmental Health Hazard Assessment. Notice of Intent to List Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS). [Online] September 16, 2016. http://oehha.ca.gov/proposition-65/crnr/notice-intent-list-perfluorooctanoic-acid-pfoa-and-perfluorooctane-sulfonate.

181. U.S. Environmental Protection Agency. Fact Sheet PFOA and PFOS Drinking Water Health Advisories. [Online] November 2016. https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfos_updated_5.31.16.pdf.

182. State Water Resources Conctrol Board Division of Drinking Water. 1,2,3-Trichloropropane (1,2,3-TCP) Maximum Contaminant Level (MCL) Development Process. [Online] July 20, 2016. http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/123-tcp/tcp_mcl_presentation.pdf.

183. U.S. Environmental Protection Agency. Contaminant Candidate List (CCL) and Regulatory Determination. [Online] September 29, 2016. https://www.epa.gov/ccl/contaminant-candidate-list-3-ccl-3.

184. *Occurrence and suitability of sucralose as an indicator compound of wastewater loading to surface waters in urbanized regions.* Oppenheimer, Joan, et al. 13, s.l. : Water Research, July 2011, Vol. 45, pp. 4019-4027.

185. Colorado River Basin Salinity Control Forum. 2014 Review Water Quality Standards for Salinity Colorado River System. [Online] October 2014. http://coloradoriversalinity.org/docs/2014%20Final%20REVIEW%20-%20complete.pdf.

186. —. Briefing Document: Colorado River Basin Salinity Control Program. [Online] May 1, 2016. http://coloradoriversalinity.org/docs/CRBSCP%20Briefing%20Document%202016-05-01.pdf.

187. U.S. Department of Energy. Image Credit. *Modified Image Provided by USDOE.*

188. —. Moab UMTRA Project Crescent Junction Site Storm Water Pollution Prevention Plan. [Online] March 2015. http://www.gjem.energy.gov/moab/documents/swppp/swppp_CJ_Rev3.pdf.

189. —. Moab Resumes Rails Shipments after Rockslide. *Office of Environmental Management.* [Online] January 28, 2015. http://energy.gov/em/articles/moab-resumes-rail-shipments-after-rockslide.

190. U.S. Geological Survey. Land disturbance associated with oil and gas development and effects of development-related land disturbance on dissolved-solids loads in streams in the Upper Colorado River Basin, 1991, 2007, and 2025: U.S. Geological Survey Scientific Investigations Rep. [Online] 2010. http://pubs.usgs.gov/sir/2010/5064/. Scientific Investigations Report 2010-5064.

191. —. Assessment of continuous (unconventional) oil and gas resources in the Late Cretaceous Mancos Shale of the Piceance Basin, Uinta-Piceance Province, Colorado and Utah, 2016. [Online] 2016. https://pubs.er.usgs.gov/publication/fs20163030.

192. United States Court of Appeals for the Tenth Circuit. Brief of Interested Public Lands, Natural Resoruces, Energy, and Adminsitrative Law Professors as Amici Curiae in Support of Respondent-Appellants. [Online] http://www.eenews.net/assets/2016/08/18/document_ew_02.pdf.

193. U.S. Environmental Protection Agency. *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources.* 2015.

194. —. Natural Gas Extraction - Hydraulic Fracturing. [Online] August 16, 2016. https://www.epa.gov/hydraulicfracturing.

195. Environmental Working Group. Image Credit. *Modified Image Provided by EWG.*

196. San Juan Basin Health Department. Animas River Agriculture FAQs. [Online] March 16, 2016. http://sjbhd.org/wp-content/uploads/2016/03/Spring-Agriculture-FAQs.pdf?f6619c.

197. U.S. Environmental Protection Agency. Frequent Questions Related to Gold King Mine Response. [Online] August 5, 2016. https://www.epa.gov/goldkingmine/frequent-questions-related-gold-king-mine-response.

198. —. Emergency Response to August 2015 Release from Gold King Mine. [Online] October 11, 2016. https://www.epa.gov/goldkingmine.

199. U.S. Government Accountability Office. Abandoned Mines: Information on the Number of Hardrock Mines, Cost of Cleanup, and Value of Financial Assurances. [Online] July 14, 2011. http://www.gao.gov/assets/130/126667.pdf. GAO-11-834T.

200. U.S. Environmental Protection Agency. Abandoned Mine Drainage. [Online] October 24, 2016. https://www.epa.gov/nps/abandoned-mine-drainage.

201. U.S. Government Accountability Office. BLM and Forest Service Have Taken Some Actions to Expedite the Mine Plan Review Process but Could Do More. [Online] January 2016. http://www.gao.gov/assets/680/674752.pdf.

202. Las Vegas Wash Coordination Committee. Las Vegas Wash: What is being done? Channel Stabilization: Erosion. *Image Credit.* [Online] [Cited: December 13, 2011.] http://www.lvwash.org/html/being_done_stabilization_erosion.html.

203. Southern Nevada Water Authority. Image Credit. *Modified Image Provided by SNWA.*

204. U.S. Environmental Protection Agency. Nevada: Las Vegas Wash: Section 139 Success Stories: US EPA. *US Environmental Protection Agency.* [Online] [Cited: January 12, 2012.] http://www.epa.gov/owow/NPS/success/state/nv.htm.

205. Pacific Gas and Electric. *Site Cleanup Progress and River Protection IM-3 10-Year Operation Status Update.* 2015.

206. Riverside County Transportation Department. Cajalco Road Widening and Safety Enhancement Project. [Online] 2016. http://rcprojects.org/cajalco/.

207. Tetra Tech, Inc. *Lake Mathews Watershed Water Quality Improvement Study Final Report.* Los Angeles : Metropolitan Water District of Southern California, County of Riverside, Riverside County Flood Control and Water Conservation District, 2012.

208. State Water Resources Control Board. GeoTracker. [Online] 2016. http://geotracker.waterboards.ca.gov/.

209. California Regional Water Quality Control Board Santa Ana Region. General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities). [Online] June 7, 2013. http://www.waterboards.ca.gov/santaana/board_decisions/adopted_orders/orders/2013/13_001_General_WDR_CAFOs_Dairies_Related_Facilities.pdf.

210. Metropolitan Water District of Southern California. Diamond Valley Lake Trails. *Diamond Valley Lake.* [Online] 2007. www.dvlake.com/DVL_trails.pdf.

211. —. *Stage 2 Disinfectants/Disinfection Byproducts.* 2013. Public Water System Identification No. CA1910087.

212. Southern Nevada Water Authority. *2015 Las Vegas Wash Capital Improvements Plan.* 2015.

213. Associated Press. Willow Fire Evacuation Order Lifted for 900 Homes in Arizona. *Photo Credit.* [Online] August 10, 2015. http://www.cbs5az.com/story/29752145/willow-fire-evacuation-order-lifted-for-900-homes-in-arizona.

214. Kashak, Edward. Engineering Geologist, Dairy Program Lead. *California Regional Water Quality Control Board, Santa Ana Region.* s.l. : Personal Communication, August 2016.

215. County of Riverside. Riverside County Drainage Area Management Plan - Santa Ana Region. [Online] January 29, 2014. http://www.waterboards.ca.gov/santaana/water_issues/programs/stormwater/docs/rcpermit/damp/SAR_DAMP2014.pdf.

9 Appendices

Colorado River Watershed Sanitary Survey
2015 Update

This page intentionally left blank

Chapter 9 Appendices

Appendices are included in electronic format.