Lower Colorado River Watershed Management Plan

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Prepared for

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Executive Summary

The Lower Colorado River (LCR) Watershed includes the Havasu-Mohave Lakes and Imperial Reservoir hydrologic units that cover nearly 8,639 square miles of land south of Hoover Dam along the Colorado River mainstem in Arizona, California, and Nevada. In the planning area, highly regulated releases from Hoover Dam largely control the flow of the river for 260 miles south towards the United States–Mexico border. Several tributaries have the potential to affect water quality negatively in the LCR due to stormwater pollution runoff. Drought, invasive species, and land development are also possible influences to water quality degradation. Designated uses for the LCR include agriculture (irrigation and livestock watering), full- and partial-body-contact recreation, domestic water supply, fish consumption, and aquatic life and wildlife. Land use consists primarily of barren land followed by agriculture and widely separated urban development.

The Watershed Management Plan (WMP) for the Lower Colorado River was written as part of the WaterSMART grant through the U.S. Bureau of Reclamation to expand and diversify membership for the Clean Colorado River Sustainability Coalition (CCRSCo) and develop this watershed management plan. The WMP reflects the goals and objectives identified through a stakeholder driven process, involving landowners, municipalities, Tribes, Townships, and Counties to improve and protect water quality in the Lower Colorado River from various pollutant sources. The goals and objectives of this plan were derived from community stakeholder meetings, public participation, and CCRSCo to address negative impacts to water quality in the planning area. Issues were narrowed down and prioritized, by CCRSCo and various stakeholders, to determine suspected sources and causes of pollution. Information was obtained and analyzed through aerial photographs, topographic maps, plat maps, soil surveys, biological assessments, and reports administered by various state and federal agencies, Tribes, and non-governmental organizations, historical research, and discussions with landowners throughout the watershed.

Reducing point and non-point sources of pollution, analyzing future drought effects, eradicating non-native species, and investigating future land development will improve water quality in the LCR through goals described in this WMP. The goals and objectives of this WMP will be accomplished by implementing appropriate best management practices on critical sites and areas, and providing information and education to residents, landowners, Tribes, Townships, and Counties to protect open space, natural floodplains, and water quality health through effective and efficient land use planning and conservation.

The primary elements of this WMP include:

- Stakeholder participation
- Baseline data analysis and summary
- Watershed assessment
- Watershed management activity recommendations.

Acronyms and Abbreviations

%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
μg/L	microgram per liter
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
AZ	Arizona
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	best management practices
CA	California
CaCO3	calcium carbonate
CAFO	Concentrated Animal Feeding Operations
CAP	Central Arizona Project
CCRA	Clean Colorado River Alliance
CCRSCo	Clean Colorado River Sustainability Coalition
CCRWUP	California's Colorado River Water Use Plan
CDBW	California Department of Boating and Waterways
CDTSC	California Department of Toxic Substances Control
CDWR	California Department of Water Resources
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Coalition	Colorado River Regional Sewer Coalition
CSWRCB	California State Water Resources Control Board
CWA	Clean Water Act
DDE	Dichlorodiphenyldichloroethylene
DEO	U.S. Department of Energy
DNR	Department of Natural Resources
DOI	U.S. Department of the Interior
DPP	Drought Preparedness Plans
EA	environmental assessment
EDC	endocrine-disrupting compound
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HACCP-NRM	Hazard Analysis and Critical Control Point – Natural Resource Management
HUC	Hydrologic Unit Code
I-	Interstate
IBI	Index of Biological Integrity
IBWC	International Boundary and Water Commission
IDD	Irrigation and Drainage District
kWh	kilowatt-hours
LCR	Lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program

LCRWQP	Lower Colorado River Water Quality Partnership
LDCA	Laguna Division Conservation Area
LUST	leaking underground storage tanks
M&I	municipal and industrial
MCL	maximum contaminant level
mg/L	milligrams per liter
MHV	Lake Mohave groundwater basin
mL	milliliters
mL/L	milliliters per liter
MWD	Metropolitan Water District of Southern California
N/A	not applicable
NDEP	Nevada Division of Environmental Protection
NGO	non-governmental organization
NHDES	New Hampshire Department of Environmental Services
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NPSWRD	National Park Service Water Resources Division
NRA	National Recreation Area
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NV	Nevada
NWR	Imperial National Wildlife Refuge
PBT	Persistent Bioaccumulative Toxic
PCP	personal care product
PEC	pharmaceuticals and other emerging contaminants
PG&E	Pacific Gas and Electric
planning area	Imperial National Wildlife Refuge
ppb	parts per billion
PPCP	pharmaceuticals and personal care product
RCRA	Resource Conservation and Recovery Act
Reclamation	U.S. Bureau of Reclamation
RV	recreational vehicle
SWP	System Water Plans
TDS	total dissolved solids
TMDL	total maximum daily load
TSS	total suspended sediments
UCANR	University of California Agriculture and Natural Resources
U.S.	United States
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
VOC	volatile organic compound
WCP	Water Conservation Plans
WMP	Watershed Management Plan
WQARF	Water Quality Assurance Revolving Fund
WUR	Water Use Reports
WWTP	wastewater treatment plant
YPG	Yuma Proving Ground

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PROJECT PARTNERS AND ACKNOWLEDGEMENTS

The Clean Colorado River Sustainability Coalition (CCRSCo) is a voluntary association comprised of local, state, tribal, and other stakeholder representatives from Arizona, Nevada, and California formed to facilitate the protection and enhancement of the Colorado River. This project is the result of a vision for developing a comprehensive watershed management plan to identify issues and strategies consistent with CCRSCo's principles, including providing forums for discussing regional water quality issues, monitoring, education, and facilitating cooperation among the various stakeholders.

We would like to thank the following individuals who selflessly provided their time and expertise:

Dr. Doyle Wilson, Lake Havasu City, who provided project oversight, expertise and critical review,

Mr. Andy Jones, Colorado River Sewage Systems for his vision, enthusiasm and leadership in the stakeholder meetings. Rest in peace Andy,

Mr. Bob Lueck, Bullhead City, for his vision, expertise and critical review,

Mr. Todd Tiejten, Southern Nevada Water Authority for providing water quality data,

Maria Lopez, Metropolitan Water District of Southern California for her input and critical review,

Steven Escobar and Raymond Mejia, Chemehuevi Indian Tribe for their input and critical review, and

Mayor Mark Nexsen, Lake Havasu City for his support,

The development of the Lower Colorado River Watershed Management plan was a stakeholder driven process. Input from stakeholders enhanced the development and prioritization of water quality issues in the Lower Colorado River. Participants in the stakeholder meetings are listed below.

Finally, this project was made possible with funding through the U.S. Bureau of Reclamation's (Reclamation's) WaterSMART Program.

Stakeholder Meeting Participants	
Raymond Vander Riet	Arizona State University
Wayne Posey	Buckskin Sanitary District
Raymond Mejia	Chemehuevi Indian Tribe
Greg Turner	Clark County Water Reclamation District
Mark S. Nexsen	Lake Havasu City
Maria Lopez	Metropolitan Water District of Southern California
Rick Daniels	Needles
Todd Tietjen	Southern Nevada Water Authority
Dave Bohl	Anglers United
Suzanne Ehret	Arizona Game and Fish
Jeff Ladd	Bureau of Reclamation
Richard Kim	California Fish and Wildlife Service
Lex Koscielak	Chemehuevi Indian Tribe
Marc Brown	Crazyhorse Campgrounds
Lionel Puheyesva	Lake Havasu City
Dr. Doyle Wilson	Lake Havasu City
David Lane	Lake Havasu City
Jerri Bracamonte	Lake Havasu City
Andy Astor	Lake Havasu City
Jim Salscheider	Lake Havasu Marine Association
Gary Kellogg	Lake Havasu Marine Association
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Art Tate	Pirate Cove Resort and Marina
Wilfred Nabahe	Colorado River Indian Tribes
Curt Russell	PG&E
Dr. Brian Paulson	Town of Laughlin
Kelly Garry	Vision 20/20
Jeremy Abbott	Vision 20/20

Chapter 1 Introduction

1.1 DOCUMENT OVERVIEW

The Clean Colorado River Sustainability Coalition (CCRSCo) was awarded a Cooperative Watershed Management Program grant through the U.S. Bureau of Reclamation's (Reclamation's) WaterSMART Program with the purpose of expanding and diversifying its membership and developing a Watershed Management Plan (WMP) for a good portion of the Lower Colorado River (LCR).

As a product of the WaterSMART grant, CCRSCo has developed this WMP to address water quality issues and propose management solutions for the Lower Colorado River from the Hoover Dam downstream to the south end of the Imperial National Wildlife Refuge (NWR) (the planning area). The planning area is made up of approximately 8,639 square miles of lands drained in Arizona, California, and Nevada and includes 260 miles of the Lower Colorado River main stem, which include the Havasu–Mohave Lakes watershed (Hydrologic Unit Code [HUC] 15030101) and the Imperial Reservoir watershed (HUC 15030104). The WMP also considers inputs affecting water quality, such as sedimentation, point and non-point source polluters, agriculture, urban/suburban runoff, etc. from Lake Mead, Bill Williams River, and Sacramento Wash as significant potential point sources.

1.2 PLANNING PURPOSE AND PROCESS

The purpose of a WMP is to identify existing and potential water quality impairments in the planning area watersheds and to propose collaborative management strategies for addressing these impairments. The project purpose summarized by CCRSCo is:

> *The watersheds are plagued by water quality issues, including the invasive quagga mussel, non-native plant growth, cyanobacteria, mine contamination, and E. coli outbreaks, some of which have been exacerbated by the drought conditions of the past 16 years. The Coalition [CCRSCo] currently has limited representation from Tribes, businesses, agriculture, and the recreation and environmental sectors. The Coalition [CCRSCo] will… expand the Coalition's understanding of important water quality issues and the impacts of drought. In addition, the Coalition will develop and prioritize project concepts and develop a watershed management plan based on the scientific understanding of the river's water quality issues* (CCRSCo 2018).

The plan focuses on water quality issues concerning residents and stakeholders in the Lower Colorado River in fulfillment of CCRSCo's principals and policies (below). It does not address diversifying and increasing CCRSCo membership, water rights, or enforcement.

> *Within this concept, the Coalition [CCRSCo] acts in support of member Indian tribes, counties, cities, towns and political subdivisions within the United States along the Lower "Colorado River and its adjacent developed areas from Hoover Dam to the Southerly International Boundary with Mexico, south of Yuma, Arizona..."(1)*
>
> A. *To provide a forum for discussion and study of regional water quality issues of mutual interest to its members.*
>
> B. *To monitor, analyze and react to water quality trends impacting the sustainability of the Lower Colorado River.*

C. *To uncover, clarify, identify and comprehensively plan for the solution of regional water quality problems, which are common to its members.*

D. *To facilitate cooperation among governmental, non-profit, private, and academic units for specific projects relating to sustainability of water quality in the Lower Colorado River improvements or for the adoption of common policies with respect to problems and issues which are common or of mutual interest to its members.*

E. *To do any and all things that are incident and conducive to the attainment of the above purposes and objectives to the same extent as natural persons might or could do, which now or hereafter may be authorized by the laws of the United States of America and the State of Arizona* (CCRSCo 2018).

An effective management plan should identify realistic goals, propose multiple management alternatives, and adapt over time to address changing watershed conditions. This WMP was developed in accordance with U.S. Environmental Protection Agency (EPA) guidelines for developing a WMP (EPA 2008). Figures 1-1 and 1-2 identify the nine elements identified by EPA for developing a WMP.

This WMP addresses elements 1 through 4 in Figure 1-1: build partnerships, characterize the planning area watersheds, set goals and identify management strategies, and design an implementation program. Watershed characterization included gathering existing data on current watershed conditions and the identification of existing and potential point and nonpoint pollutant sources. Watershed condition information collected for the planning area included physical and natural features of the land and waterbodies, land use, population and social characteristics, and chemical assessments of waterbodies. Existing and potential point and nonpoint pollutant sources were identified using the most complete, available data sets through a host of federal, state, local, and other stakeholder resources and firsthand knowledge from stakeholders. Characterization assessment focused on existing data sets and studies in the planning area. While no additional studies were completed or new data collected for the WMP, the watershed characterization identified data gaps for future study and consideration.

During this step, indicators and metrics for measuring the success of management actions were developed, along with the identification of critical areas targeted for management actions. Issues and concern statements were addressed through two stakeholder meetings for this WMP. The final step in the WMP was the development of an implementation strategy. The implementation strategy includes a schedule, milestones, and criteria for measuring progress, monitoring and evaluation criteria, and identification of technical and financial assistance needed in plan implementation.

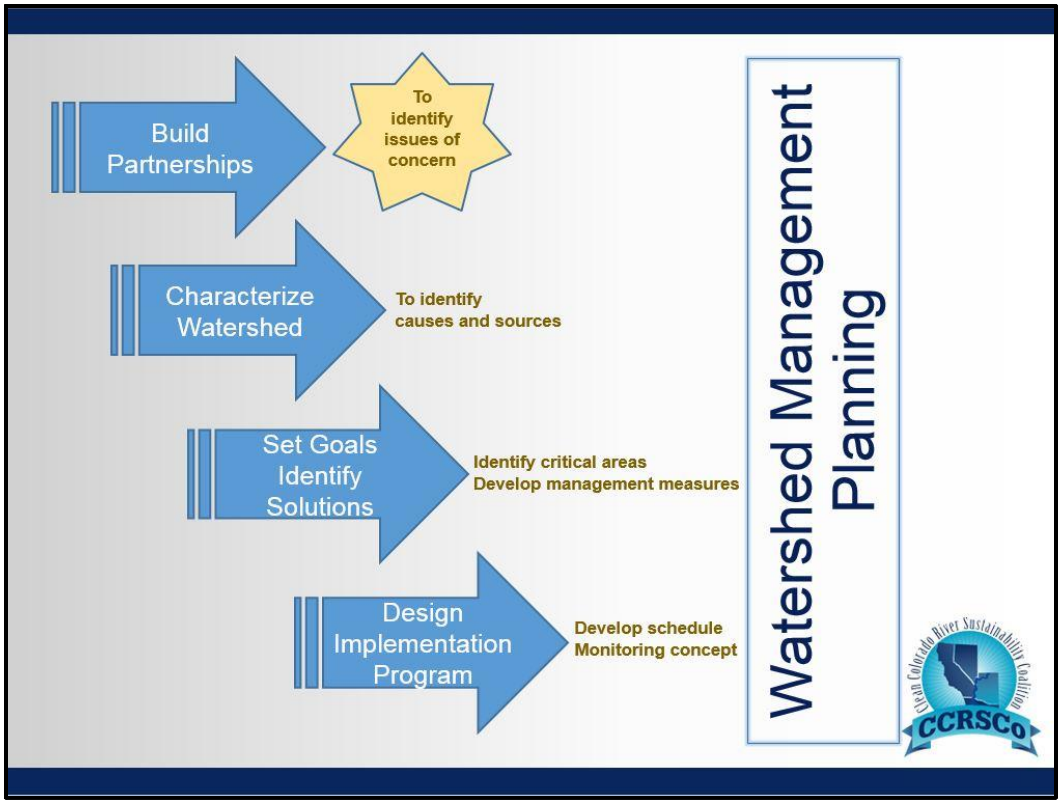


Figure 1-1. Elements of watershed planning (modified from EPA 2013).

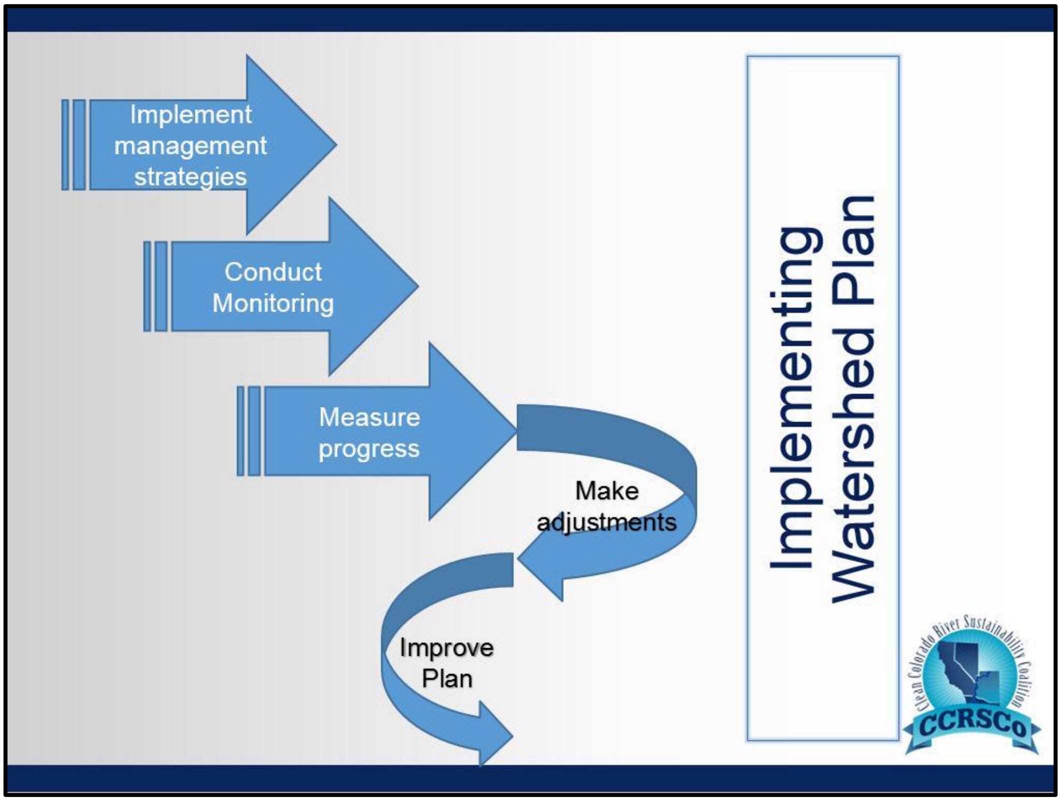


Figure 1-2. Elements of watershed plan implementation (modified from EPA 2013).

1.3 WATERSHED MANAGEMENT TEAM

The Watershed Management Team is made up of CCRSCo members and watershed stakeholders. CCRSCo is a voluntary association open to local, state, tribal, and other stakeholder representatives from Arizona, Nevada, and California. The purpose of the organization is to facilitate the protection and enhancement of the Lower Colorado River to achieve and sustain high-quality water for all users of the river (CCRSCo 2017).

The Colorado River Regional Sewer Coalition (Coalition) was founded in 1997 for the original purpose of seeking federal funding for improving wastewater treatment systems, including centralized sewer construction that addressed the nitrate issue on the Lower Colorado River (CCRSCo 2018). In 2005, the Coalition became involved with the Clean Colorado River Alliance, an initiative created by Arizona Governor Janet Napolitano and the Arizona Department of Environmental Quality (ADEQ) after the river was listed as the most endangered in the country. This alliance identified the main pollutants of concern that potentially could affect water quality on the river. With the completion of expanded sewer infrastructure in Bullhead City and Lake Havasu City in 2011 and the prospect of extremely limited federal and state funding for further projects, the Coalition contemplated the above issues and sought whether there were other Lower Colorado River watershed-scale interests focused on water quality. Finding none, the Coalition decided in 2013 to refocus its efforts, through a modification of its bylaws, on the river system's water quality and rename itself the Clean Colorado River Sustainability Coalition.

CCRSCo members and watershed stakeholders participating in the watershed management process included representatives from various government agencies, local tribes, non-governmental organizations, utilities, businesses, agricultural entities, and individual members of the public. The Watershed Management Team participants represented a wide variety of interests that have either a direct dependence on the river or a keen interest in managing for healthy water quality in the Lower Colorado River mainstem (Table 1-1). Team members contributed their technical expertise during the watershed characterization process and worked collaboratively to develop watershed goals and identify management solutions. Specialists from SWCA Environmental Consultants, a third-party environmental consultant provided additional resource, planning, and public participating technical assistance.

Table 1-1. Watershed Management Team

CCRSCo Members	
Arizona State University Colleges at Lake Havasu City	Lake Havasu City
Buckskin Sanitary District	Metropolitan Water District of Southern California
BullHead City	Mohave County
Bureau of Reclamation	Needles
Chemehuevi Indian Tribe	Southern Nevada Water Authority
Clark County Water Reclamation District	Town of Parker
Colorado River Sewage Systems - JV	Anglers United
La Paz County Board of Supervisors	Lake Havasu Marine Association

1.3.1 Public Participation Approach

A successful WMP depends on the involvement and commitment of a diverse range of stakeholders and participation from the public. Throughout the planning process, CCRSCo engaged with stakeholders and conducted public outreach to build watershed management partnerships. The two goals of the public participation approach in this WMP were to 1) engage stakeholders in the planning process, and 2) educate the public on watershed management issues and the management planning process and receive public feedback and buy-in on WMP goals and objectives.

1.3.1.1 ***Education Strategies and Outreach Goals***

1.3.1.1.1 STAKEHOLDER RECRUITMENT

To recruit stakeholders for the watershed management planning process, CCRSCo developed a Stakeholder Recruitment Plan. The plan included a listing of potential new stakeholder group members and an outreach strategy to recruit these potential new members. CCRSCo held two Stakeholder Coordination Meetings during the WMP process.

The first stakeholder meeting, held on June 26, 2017, began the overall WMP process. This was an official CCRSCo meeting. Invitations to participate in the meeting were sent to all current CCRSCo members, along with a subset of targeted members. The overall goals of the meeting included the following:

- welcoming potential new members and answering their questions;
- describing the watershed management planning process;
- identifying and prioritizing the critical issues for the WMP; and
- setting preliminary goals and developing project concepts for the WMP.

The meeting included a presentation about the watershed planning process, followed by a workshop session to meet the meeting goals.

The outcome of the first meeting resulted in prioritizing preliminary issues in the watershed. Through the process of discussion and brainstorming in the community workshop, identified six issues: cyanobacteria algal blooms, water resilience, invasive species, hexavalent chromium contamination, hydrocarbon leaks regional mines, agricultural runoff, and land development.

Following the completion of the Project Concepts Phase of the management plan, CCRSCo held a second official CCRSCo stakeholder meeting on April 25, 2018. The goals of the second coordination meeting included:

- providing an overview and discussion of the current watershed conditions, inventory, and data analysis;
- reviewing and finalizing the watershed management goals and formulating watershed management objectives; and
- providing stakeholders with the opportunity to contribute to the development of the overall goals and management objectives to restore and protect the watershed.

The second stakeholder meeting included a presentation of the priority issues that were previously identified and the process by which goals and management strategies for implementation of the WMP were developed. During this meeting an additional priority issue was identified and it was decided to carry that issue forward in the WMP.

1.3.1.1.2 PUBLIC OUTREACH

In addition to stakeholder outreach, CCRSCo hosted one public outreach meeting in Lake Havasu City on October 19, 2017, to build partnerships in the watershed community and educate the public about issues in the watershed. The purpose of the meeting was to present the WMP process to the general public and potential new stakeholders. The public outreach meeting had the following goals:

- presenting the watershed management planning process, goals, and objectives;
- presenting the WMP items completed (characterizing the watershed, identifying critical issues, and developing goals and solutions); and
- receiving comments and input from the public on critical issues and goals and solutions.

The meeting was attended by the public with Lake Havasu City mayor Mark Nexsen providing opening remarks. A presentation about the watershed management planning process was given along with the issues of concern identified thus far. The presentation was followed by a question and answer session asking attendees for discussion and input on their issues and concerns. A handout of the presentation describing the watershed management planning process and WMP components completed was provided to all that attended.

1.4 DOCUMENT ORGANIZATION

This WMP is organized into the following sections:

- **Watershed Characterization**
  - *Chapter 2 – Watershed Description*
  - *Chapter 3 – Watershed Conditions*
  - *Chapter 4 – Pollutant Source Assessment*
  - *Chapter 5 – Priority Issues and Concerns*
- **Watershed Goals and Management Strategies**
  - *Chapter 6 – Implementation Program Design*
  - *Chapter 7 – Watershed Goals*
- **Implementation Program**
  - *Chapter 8 – Implementation Schedule and Costs*

Chapter 2 Watershed Description

In the Lower Basin, the Colorado River is highly regulated, and the riparian corridor bears little resemblance to the historical floodplain. The construction of Glen Canyon, Hoover, Davis, Parker, Palo Verde, Imperial, Laguna, and Morelos Dams on the Colorado River has created a managed flow system within the U.S., resulted in intermittent flows in the Colorado River Delta within Mexico, and altered natural habitat along the rest of the river. Changes include loss of native riparian vegetation and floodplains; altered aquatic habitat structure and function; declining groundwater elevations resulting from the lack of surface water recharge and groundwater pumping; regulated flows; altered water quality (temperature, salinity/conductivity, pollutants); discontinuity of sediment and nutrient transport; and introduction of numerous nonnative species (plants and animals) (Reclamation, 2004).

This chapter describes the physical, environmental, and social characteristics of the Study's planning area. The planning area (Figure 2-1) includes 260 miles of the Lower Colorado River mainstem consisting of the Havasu–Mohave Lakes watershed (HUC 15030101) and the Imperial Reservoir watershed (HUC 15030104). CCRSCo identified as a goal to build a strong membership along all of the Lower Colorado River to the international border to facilitate water quality monitoring and coordinated hydrologic unit planning for sustainable high water quality use. Though CCRSCo consists of diverse interest groups, certain perspectives are missing and others may be under represented. The eventual goal is to build a strong membership along all of the Lower Colorado River to the international border. The expansion will help facilitate water quality monitoring and will be integral to hydrologic unit planning for sustainable high water quality use. CCRSCo can expand diversification by focusing on increasing membership within the Havasu-Mohave Lakes and Imperial hydrologic units. Several agricultural entities, businesses, non-profits, and other Indian tribes and communities lie inside these units. The WMP considers inflow from Lake Mead, Bill Williams River, and Sacramento Wash as significant potential point sources. Watershed characterization data for the planning area were collected using Web-based government data centers and mapping resources, the *Arizona Water Atlas,* Volumes 4 and 7 (Arizona Department of Water Resources [ADWR] 2009a, 2009b]), and other publicly available data for the planning area. This chapter of the management plan is divided into the following sections:

- Physical and Natural Features
- Biological Resources
- Land Use and Land Cover
- Demographic Characteristics

2.1 PHYSICAL AND NATURAL FEATURES

2.1.1 Watershed Boundaries and Tributaries

Overview of Lower Colorado River
Source: SWCA

The planning area is located within the Havasu–Mohave Lakes watershed (HUC 15030101) to the north and the Imperial Reservoir watershed to the south (HUC 15030104). Planning area watershed boundaries and tributaries are shown in Figure 2-2. The Mohave Lakes watershed drains approximately 4,479 square miles of lands in Arizona, California, and Nevada. The Imperial Reservoir watershed drains an area of approximately 5,543 square miles of land in Arizona and California. Two tributary watersheds, Sacramento Wash (HUC 13010103) and Bill Williams River (HUC 13010204), though not detailed in the WMP, are recognized for their potential to deliver impaired quality water into the specific planning area.

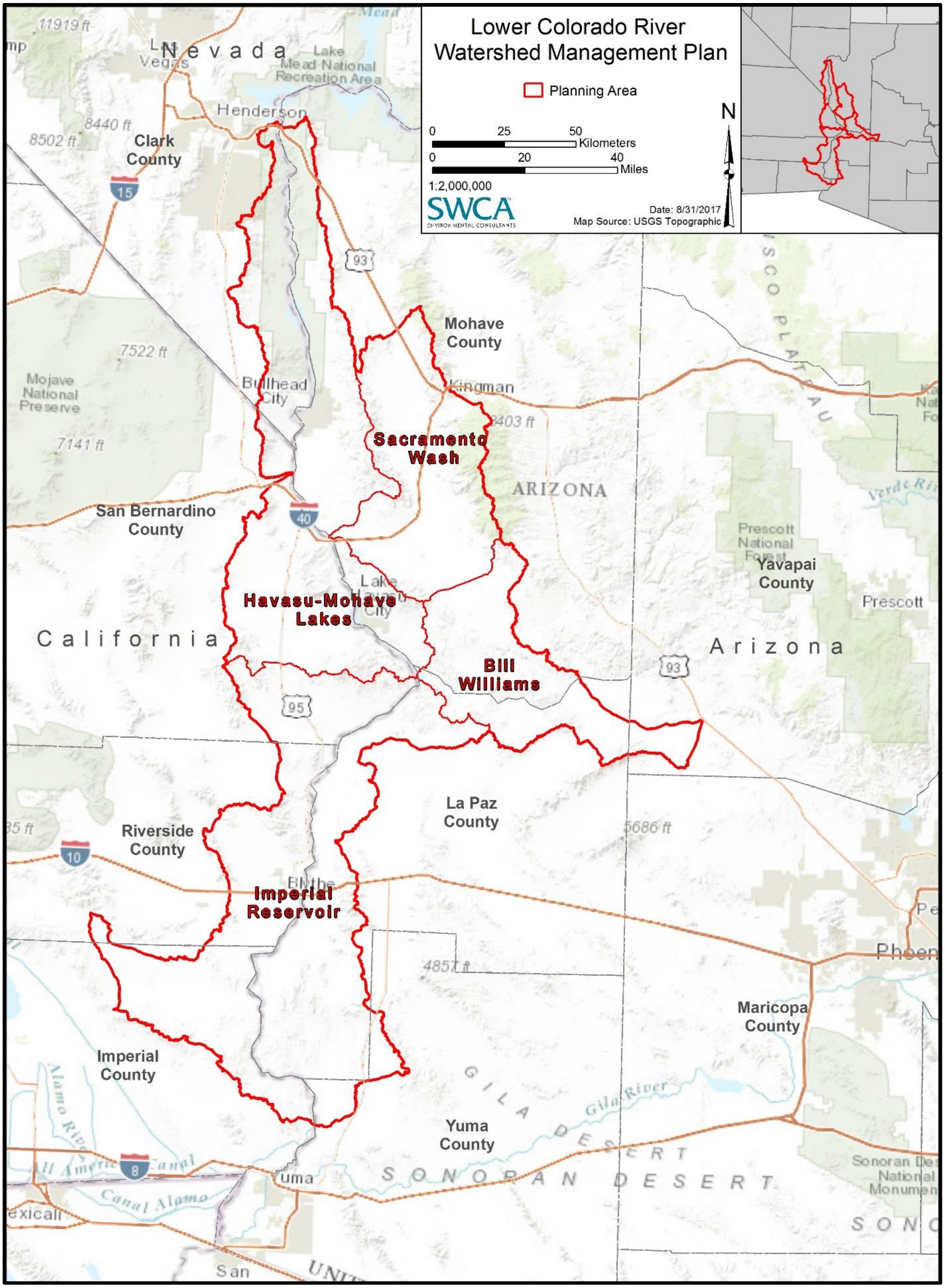


Figure 2-1. Planning area overview.

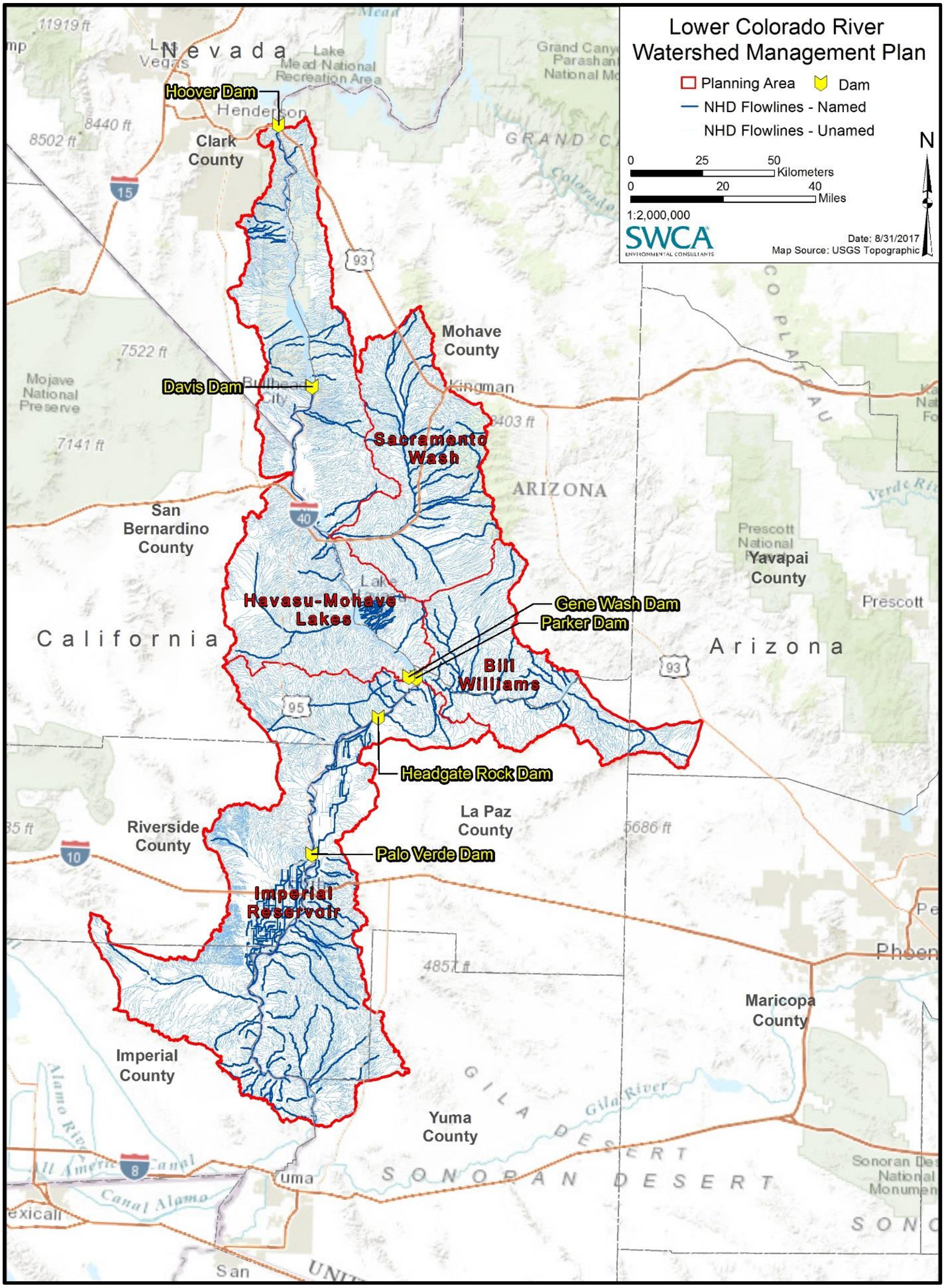


Figure 2-2. Name and Unnamed tributaries in the planning area.

2.1.2 Physical Description

The following subsections describe the project area, including climate, surface water, groundwater, and geological and soil characteristics.

2.1.2.1 *Climate/Precipitation*

The planning area is located in the arid to semi-arid climates of the Mojave and Sonoran Deserts. Characterized by long, hot summers and short, mild winters, the average highs are between 95 and 105, and the average lows are in the mid-50s (degrees Fahrenheit [°F]). The warmest months are typically July and August, where temperatures are consistently over 100°F. The area receives little annual rainfall, approximately 4 to 5 inches per year with a low relative humidity. In the winter, frontal storm systems bring mild precipitation from the Pacific Ocean. The monsoon season in summer brings heaver rains to the area from the tropical waters of the Gulf of Mexico and Gulf of California.

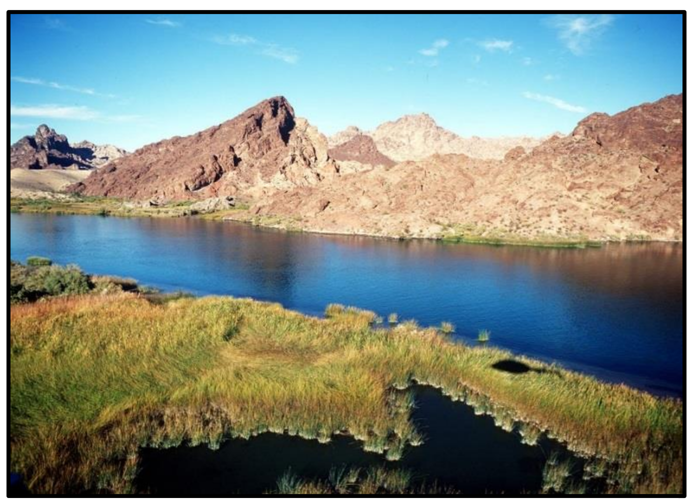
2.1.2.2 *Surface Water*

Surface water flow through the Grand Canyon is swift with several rapids yet the river south of Lake Mead is much calmer. Elevation levels drop to less than 800 feet until the River meets the Southern International border with Mexico nearly 350 miles downstream (CCRSCo 2018). To break up the flow of the lower stretches of the river there are two reservoirs south of Lake Mead, Lake Mohave and Lake Havasu. Different flow regimes have implications on how introduced contaminants react in the river. Surface water is faster and more turbulent in the Upper Basin transporting pollutants quickly downstream, whereas the slower moving waters of the Lower Basin may cause pollutants to linger at any given location (CCRSCo 2018).

Along the Lower Colorado River lies a combination of shallow canyons and broader alluvial floodplain valleys containing associated wetlands. Accompanying the shallow canyons are small mountain ranges and active river channel movement within the floodplain areas that are not inundated (e.g. Lake Mohave and Lake Havasu) (CCRSCo 2018). A discussion of the major surface water features in the planning area follows and Figure 2-3, below, shows locations of each the surface waters.

2.1.2.2.1 RESERVOIRS

Lake Mead, Lake Mohave and Lake Havasu are the three primary reservoirs on the Lower Colorado River locked behind the permanent dams of Hoover, Davis and Parker. Lake Mead is included here although it is outside of the planning area because most of the water passes through Lake Mead and Hoover Dam. In addition to these three major reservoirs, two smaller reservoirs, Gene Wash and Copper Basin reservoirs in California are located within the planning area just west of Lake Havasu and Parker Dam, California. These small reservoirs are only connected to the LCR by diversion of Colorado River water at MWD’s Whitsett pumping plant.



Lower Colorado River
Source: Stephens, 1999

Reservoirs in the planning area are managed for multiple purposes, including water storage, recreation, and habitat. The three main reservoirs experience seasonal heating causing stratification of the water column in spring and summer months. As fall approaches air temperatures are cool and surface waters begin to cool, weakening and eventually erasing stratification. This process is referred to as overturning. The process mixes water temperature and other physical properties to remain similar throughout the water column (CCRSCo 2018). The seasonal difference the reservoirs experience has an important effect on distribution, and chemical transport with the river's mainstem.

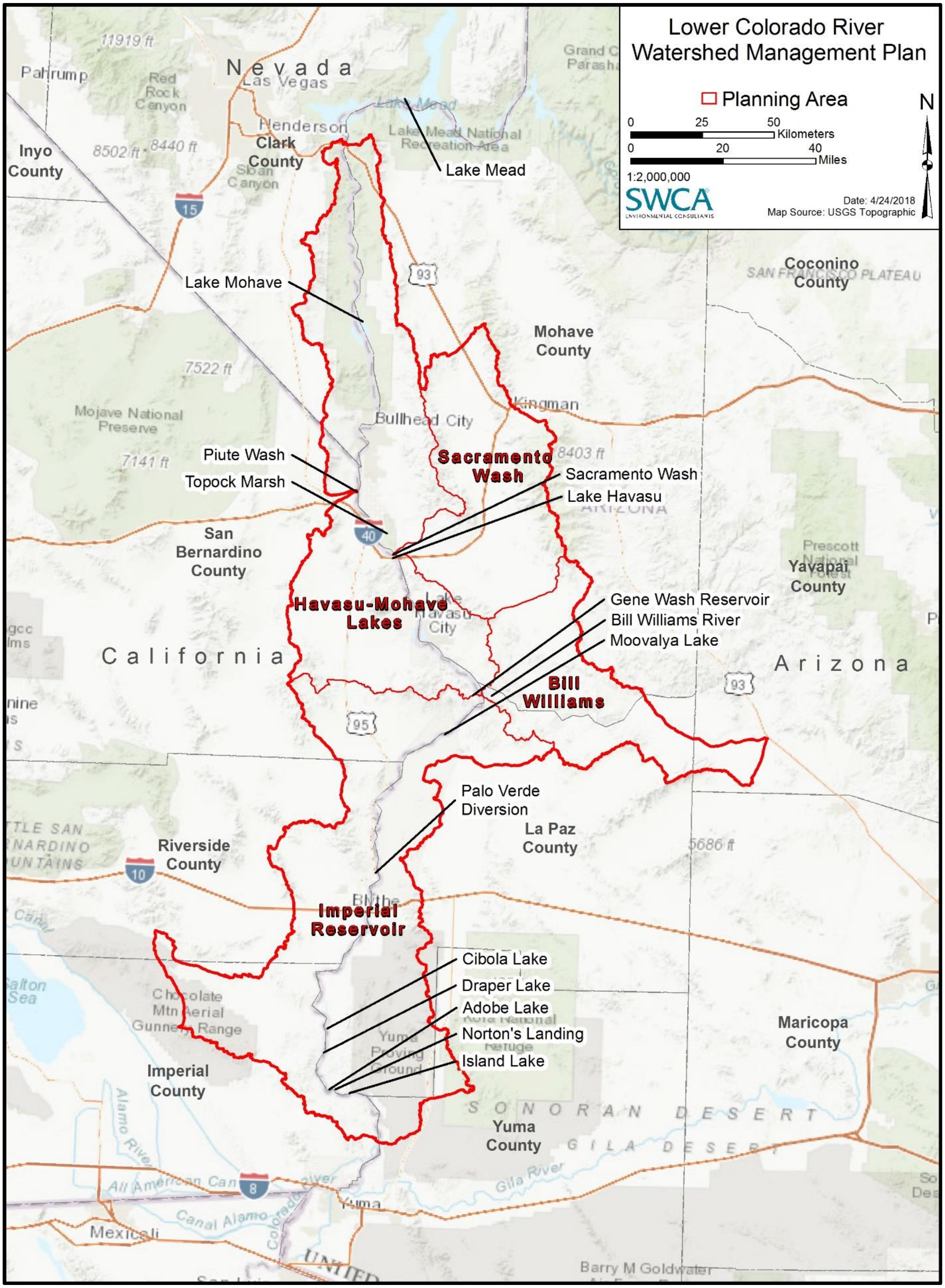


Figure 2-3. Surface waters within the planning area.

Lake Mead

Lake Mead covers an area totaling approximately 248 square miles in southeastern Nevada and northwestern Arizona. Major tributaries to the reservoir include the Colorado River in Arizona and the Virgin River in Nevada. The reservoir has a maximum water storage capacity of 27,620,000 acre-feet and a maximum water surface elevation of 1,221 feet (Reclamation 2011). This reservoir is monitored most closely for its water elevation serving as a guidepost on which the Secretary of the Interior may declare water shortages (CCRSCo 2018).

Lake Mohave

Lake Mohave, a 1,818,300 acre-feet capacity reservoir formed by the Davis Dam on the lower Colorado River mainstem is 66 river-miles downstream of Hoover Dam (National Park Service [NPS] 2017). Approximately one-half of the reservoir is located in Nevada and one-half in Arizona. Lake Mohave reservoir is the largest capacity surface waterbody in the planning area (Reclamation 2017b). Mohave Lake is considerably smaller than Lake Mead and other than slower flow velocities; the lake is more like a long, wide stretch of the river. Lake Mead acts as a detention basin, holding water temporarily to help regulate flow from Hoover Dam released for water orders downstream from Lake Havasu. Water elevations in Lake Mohave are maintained within a narrow range in order to balance water orders and protect diversion points (CCRSCo 2018).

Lake Havasu

Lake Havasu, a 648,000 acre-feet capacity reservoir formed by Parker Dam on the lower Colorado River mainstem is 45 miles long covering 20,390 acres in Arizona and California (Reclamation, 2018b.) Major tributaries to the reservoir include the Colorado River, Sacramento Wash, and Bill Williams River. The maximum surface elevation of Lake Havasu at Parker Dam is 450 feet (Reclamation 2017c). Like Lake Mohave, Lake Havasu acts as a detention basin to help regulate flow down river. Agricultural demand is very high in the spring/summer months capable of depleting water volumes equal to Lake Havasu's capacity in as little as 17 days. The lake's water elevation is also kept within narrow ranges, similarly to Lake Mohave, in order to balance water orders and protect diversion points (CCRSCo 2018).

Alamo Dam and reservoir

Alamo Lake, a 1,409,000 acre-feet capacity reservoir formed by Alamo Dam on the Bill Williams River, encompassing nearly 17,000 acres. Alamo Dam was constructed by the U.S. Army Corps of Engineers (USACE) as a flood control dam to regulate outflows into the Bill Williams River. These flows rarely enter Lake Havasu in any great capacity. The maximum surface elevation of Alamo Lake at Alamo Dam is 1,267 feet (USACE, 2018).

Gene Wash Reservoir

The Gene Wash Reservoir is a small, 6,300-acre-foot capacity reservoir managed by the Metropolitan Water District of Southern California (MWD) as part of California's Colorado River Aqueduct system (MWD 2017). Formed by the Gene Wash Dam, the reservoir receives water pumped from the Colorado River Aqueduct Whitsett Intake on the Colorado River at Lake Havasu. Water from the Gene Wash Reservoir is pumped up to the Copper Basin Reservoir within the planning area via the Colorado River Aqueduct and eventually distributed to metropolitan areas in southern California (MWD 2017). These two smaller reservoirs are highly controlled and direct water away from the river and into the California Aqueduct.

Moovalya Lake

Moovalya Lake is a reservoir located along the Colorado River in California and Arizona, approximately one mile north of Parker, Arizona. The reservoir is formed by Headgate Rock Dam and is used to re-route water away from the river to various agricultural irrigation and drainage districts in Arizona and California (CCRSCo 2018). The reservoir is used for water storage for irrigation purposes on the Colorado River Indian Reservation (Reclamation 2014).

2.1.2.2.2 PERENNIAL WASHES

Bill Williams River

The Bill Williams River is the only perennial tributary in the planning area. Bill Williams River drains more than 5,500 square miles of rugged, mountainous terrain in west-central Arizona. The confluence of the Bill Williams River and Colorado River is just north of the Parker Dam, at the boundary between the Havasu Lake watershed and the Imperial Reservoir watershed. Bill Williams River mostly contributes water to Lake Havasu through subflow; however, during strong, local storm precipitation floodwaters contribute a significant amount of sediment.

2.1.2.2.3 EPHEMERAL WASHES

The majority of tributaries to the Colorado River in the planning area are small, ephemeral washes. These washes are dry for a good portion of the year, with flowing surface water corresponding to periods of heavy rainfall. Two of the larger washes are the Piute Wash and the Sacramento Wash. The Piute Wash (Mohave Lakes watershed) is located on the California side of the Colorado River and drains southeastern Nevada and portions of the Piute Valley in California. The Piute Wash empties into the Colorado River upstream of Red Spring. Sacramento Wash, located in the Sacramento Wash watershed (HUC 15030103), drains the Sacramento Valley in Mohave County, Arizona. Sacramento Wash empties into the Colorado River in the Lake Havasu National Wildlife Refuge (NWR). Topock Marsh is formed by the confluence of Sacramento Wash and the Colorado River.

2.1.2.2.4 OTHER SURFACE WATERS

Other surface waters in the watershed include surface water diversion and irrigation canals, as well as small, naturally formed lakes in the southern portion of the planning area (south of the Palo Verde Diversion Dam). There are several small, springs throughout the watershed.

Palo Verde Diversion Backwater

Located on the Colorado River nine miles northeast of Blythe, California, Palo Verde Diversion Dam is a semi-porous barricade of gravel, sand, and rock fill, with a crest width of 20 feet, a length of 1,850 feet, including the spillway, and a maximum height of 46 feet above the streambed (Reclamation 2017d). The Palo Verde Dam is another small diversion dam used to re-route water to various drainage and irrigation districts to Arizona and California (CCRSCo 2018).

A-10 Backwater

A-10 is located on the Colorado River along Interstate (I-10). The backwaters are located on the Arizona side of the California/Arizona border (Yuma Zone 2017). The small water feature offers recreational activities for fishing and is a popular spot for water sports.

Cibola Lake

Cibola Lake, located on Cibola NWR, in La Paz County, Arizona, offers sanctuary to various species of wildlife and recreational activities such as fishing, hunting, hiking, and climbing.
The lake remains closed from Labor Day until March 15 for waterfowl mating.

Draper Lake

Draper Lake is located about 30 miles from Blythe, California, at an elevation of 213 feet above sea level. The lake offers fishing and other recreational activities and is managed by the California Department of Fish and Wildlife (Hook and Bullet 2017).

Adobe Lake

Adobe Lake attaches to the Colorado River just north of Yuma, Arizona. The lake contains a variety of fish species and is located just outside the Imperial NWR. The lake is accessible by boat for recreational activities.

Norton's Landing *Source: Stephens, 2008*

Norton's Landing

Norton's Landing area is accessible only by boat and was used originally as a stopover for steam driven paddleboats that serviced the Red Cloud Mine. Currently, the landing offers river tours and other recreational activities (Yuma Zone 2017).
The site is historic, with a large collection of artifacts from early life on the river, which brings in tourists from all around.

Island Lake (end of planning area)

Island Lake is a small lake at the southern portion of the planning area. This is a small backwater lake accessible from the river (California Department of Boating and Waterways [CDBW] 2017).

Springs

Some of the small springs throughout the watershed have been known to carry nitrate concentrations above 10 milligrams per liter (mg/L) during extended rainfall periods. One spring just south of Lake Havasu City, is known to seep almost all the time and has elevated concentrations of nitrate. These nitrates originate primarily from atmospheric deposition and are carried into the subsoils during short precipitation events in the region, only to be flushed out during extended wet periods like the fall-winter-spring of 2004–2005 (Wilson 2009).

Within the Lake Mead National Recreation Area (NRA) there are several springs in Black Canyon. Black Canyon Springs is located downstream of Hoover Dam between Lake Mead and Mohave and contains numerous small springs and seeps. These springs and seeps discharge from various points within the canyon and contain important hydrological features and unique riparian habitat. The spring facilitates several recreation aspects and supports various wildlife and aquatic ecosystems (Moran 2015).

Wetlands (National Wetlands Inventory) Data

Topock Marsh/Topock Bay

The Topock Marsh, part of the Havasu NWR, represents a large percentage of the remaining backwaters of the Lower Colorado River. These backwaters serve as layover and wintering grounds for migratory birds and resident wildlife. The Topock Marsh totals 4,000 acres and was developed from a historical river meander in 1966 when the South Dike outlet structure was built (U.S. Fish and Wildlife Service [USFWS] 2015). Water levels of the marsh are managed, at the South Dike outlet structure, through closing and opening of gates.

2.1.2.3 *Groundwater*

The planning area is made up of 24 groundwater basins located in Nevada, Arizona, and California. The Colorado River is in a regional topographic low and structural trough, so shallow, intermediate, and deep groundwater flow eventually travels to the river. For example, there is evidence, such as water temperature, deuterium and oxygen isotope trends, that groundwater flow occurs from Dutch Flat in the southern Sacramento Valley, is transported under the Mohave Mountains via a detachment fault, to the Colorado River proper. Having just said that and on a much shallower scale, the CR is a losing stream in most reaches, leaking water to the underlying aquifer. The relatively shallow aquifers today immediately around Lake Havasu and Lake Mohave are only there because of the river impoundment and water soaking into the alluvial basin fill sediments (D. Wilson, personal communication, September 5, 2018).

Groundwater basins boundaries are shown in Figure 2-4.

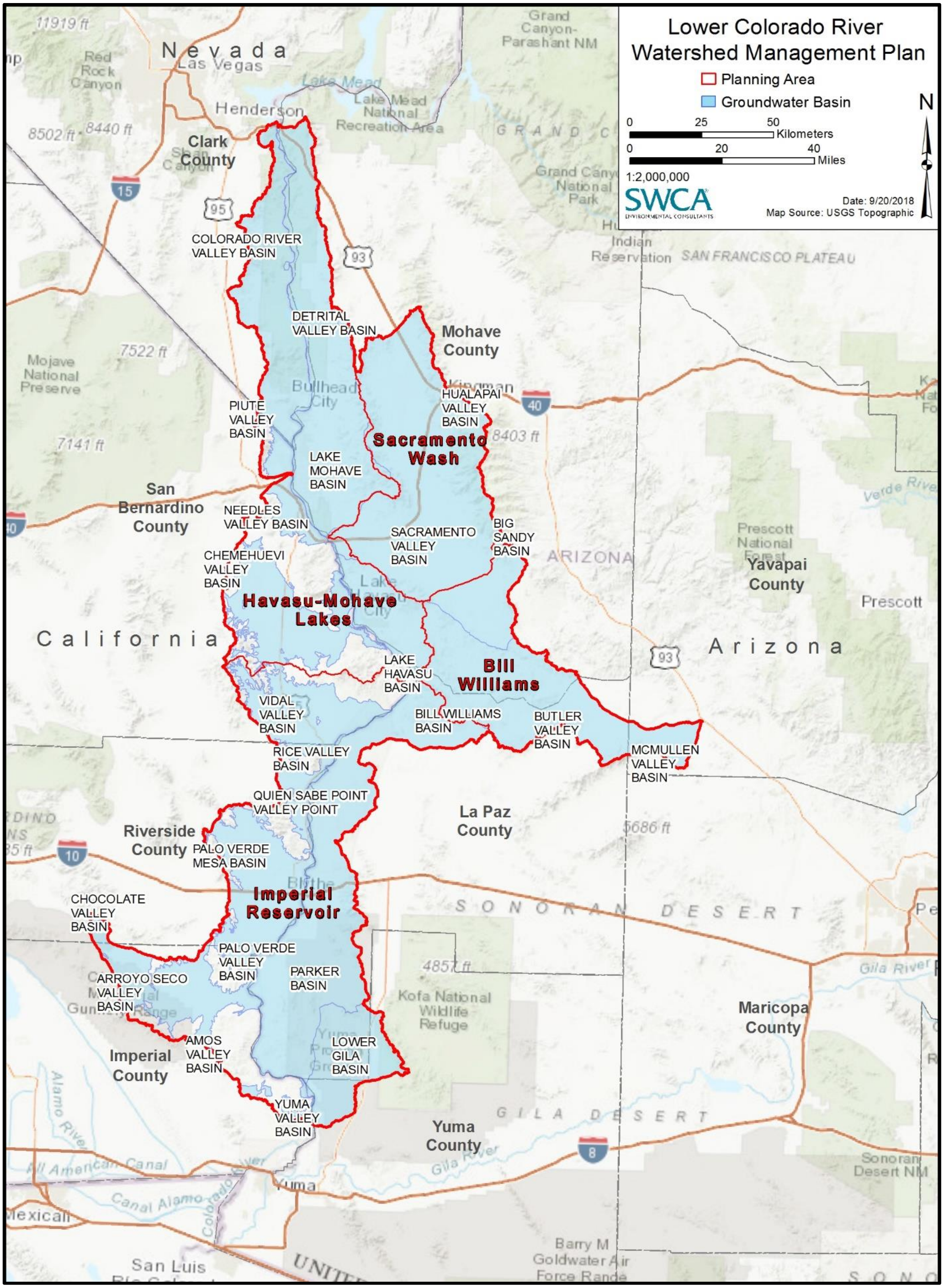


Figure 2-4. Groundwater basins in the planning area.

2.1.2.3.1 NEVADA

Colorado River

The Colorado River Valley Groundwater Basin lacks wells; therefore, information is minimal on the quality and quantity of the groundwater.

2.1.2.3.2 ARIZONA

Lake Mohave

Lake Mohave Basin, long and narrow, is adjacent to the Colorado River. Alluvial sand, silt, and gravel deposits form water-bearing lands next to Lake Mohave and the Colorado River. Groundwater flows from north to south and locally toward the lake, flowing east in California and west in Arizona (Arizona Department of Water Resources [ADWR] 2009a).

Sacramento Valley

The Sacramento Valley Basin has sloping alluvial fans extending from surrounding mountains to the valley floors spreading north to south. Elevations range from 8,400 feet to roughly 500 feet where the alluvial washes enter the Colorado River (ADWR 2009a). Groundwater flow in the basin, originates north of Golden Valley, then flows south and west towards the Colorado River near Topock.

Lake Havasu

Consolidated rock covers the majority of the Lake Havasu Basin. The basin fill consists of sand, silt, gravel, and an underlying conglomerate unit and has a direct hydraulic connection to the Colorado River. In general, groundwater flow is southerly. Locally it flows westerly from Arizona and easterly from California with groundwater occurrence and movement near the Colorado River (ADWR 2009a).

Bill Williams

The basin is characterized by moderately thick pre–Basin and Range sedimentation under a lower basin fill to depths greater than 1,000 feet. Groundwater flow in the basin moves toward the Bill Williams drainage (ADWR 2009a).

Parker Basin

Plains and valleys with low-lying mountains characterize Parker Basin. Groundwater flows from the south to the east toward the Colorado River (ADWR 2009b).

2.1.2.3.3 CALIFORNIA

Needles

The Needles Valley Groundwater Basin is found in alluvium and in the Bouse Formation. Groundwater in the basin flows east through the basin toward the Colorado River. Piute Wash drains surface water east toward the Colorado River (California Department of Water Resources [CDWR] 2004a).

Palo Verde Mesa

The Palo Verde Mesa Basin is bounded by mountains on all sides and is drained by the McCoy Wash into the Colorado River. Alluvial deposits of Quaternary age make up the groundwater basin. The alluvium consists of lenticular beds of sand, gravel, silt, and clay (CDWR 2004b). Groundwater flows easterly toward Palo Verde Valley.

Palo Verde Valley

The Palo Verde Valley Groundwater Basin drains its surface and groundwater into the Colorado River. The water-bearing deposits of the basin include alluvium, the Bouse Formation, and a fanglomerate deposit. Groundwater within the basin is constantly being mixed with waters from the Colorado River (CDWR 2004c).

2.1.2.4 *Dams*

Dams are a key component of the surface water hydrology in the planning area. Dams form the major surface waterbodies and regulate the surface water flow of the Colorado River. Dams in the planning area are primarily managed for reservoir water storage, flood control, and power generation. Hoover Dam is located just north of the planning area on the Colorado River. In the planning area, there are two major dams: Davis Dam and Parker Dam, located on the Colorado River. Additional smaller dams are located on the Colorado River downstream of Parker Dam. Gene Wash Dam is located to the west of Parker Dam in Gene Wash in California. Table 2-1 provides additional information on dams in and adjacent to the planning area (see also Figure 2-5, below).

Parker Dam
Source: Stephens, 2012

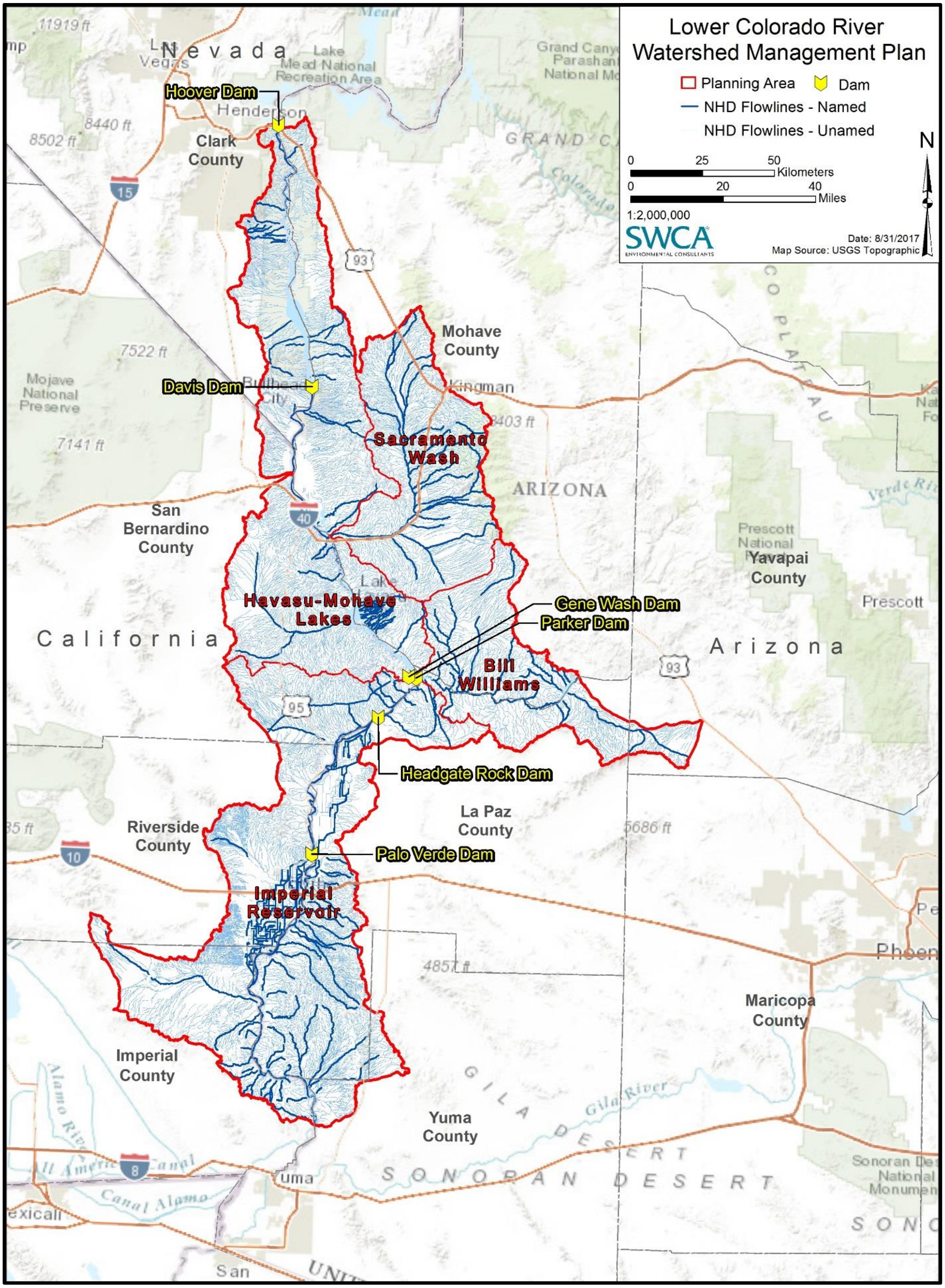


Figure 2-5. Dams in the planning area.

Table 2-1. Dams in the Planning Area

Dam	Location	Watershed	Type	Additional Information
Hoover Dam*	Colorado River at Black Canyon (outside the planning area)	Lake Mead	726-foot-tall concrete arch structure, completed in 1936.	Hoover Dam forms the Lake Mead reservoir in Nevada and Arizona. The dam was authorized to control flooding, improving navigation and regulating flow of the River, providing storage and delivery of stored water, and for the generation of electrical energy to homes in California, Nevada, and Arizona.
Davis Dam†	Colorado River at Pyramid Canyon	Havasu-Mohave Lakes	200-foot-tall earthen rock-fill embankment structure, completed in 1950.	Davis Dam forms Lake Mohave in Nevada and Arizona. The primary purpose is to regulate Colorado River flows from Hoover Dam for delivery to Mexico, and provide energy to homes in Arizona and California and supports agricultural wells' irrigation pumping.
Parker Dam‡	Colorado River at Parker	Havasu-Mohave Lakes	320-foot-tall concrete arch structure, completed in 1938.	Parker Dam forms the Lake Havasu reservoir in Arizona and California. The primary purpose of the dam is storage of the Lake Havasu reservoir water for the Colorado River Aqueduct and Central Arizona Project. The MWD uses 50% of this power generation for Colorado River Aqueduct water pumping.
Alamo Dam+	Bill Williams River	Alamo Lake	283-foot-tall flood control dam completed in 1968.	Alamo Dam forms Alamo Lake. The lake is a multi-purpose facility providing benefits for flood control, water supply and conservation, recreation, and fish and wildlife enhancement.
Gene Wash Dam¶	Gene Wash, approximately 1.5 miles west of the Colorado River at Parker Dam	Havasu-Mohave Lakes	140-foot-tall, concrete arch structure, completed in 1937.	Gene Wash Dam forms the Gene Wash Reservoir. The primary purpose of this dam is water storage for the Colorado River Aqueduct.
Headgate Rock Dam¶	Colorado River, north of Parker	Imperial Reservoir	38-foot-tall, earthen fill structure, constructed in 1942.	Headgate Rock Dam forms the Lake Moovalya reservoir. Lake Moovalya provides irrigation water for the Colorado River Indian Reservation and the Headgate Rock Dam Power Plant.
Palo Verde Diversion Dam**	Colorado River, north of Blythe	Imperial Reservoir	50-foot-tall, concrete gated weir, constructed in 1957.	Palo Verde Diversion Dam was constructed to divert Colorado River water to the Palo Verde Irrigation District.

* Reclamation (2013a)

† Reclamation (2013b)

‡ Reclamation (2013c)

+USACE (2018)

§ Reclamation (2007)

¶ MWD (2017)

Reclamation (2014)

** Reclamation (2017d)

2.1.2.5 *Floodplains*

Historically, the Colorado River was a dynamic river with large seasonal variations in surface water flows. The River would frequently flood low-lying lands, creating an abundance of floodplain habitats, wetlands, marshes, and backwater river channels. The construction of dams and river channelization efforts regulated Colorado River surface flows and resulted in the loss of much of the historic floodplains and their habitats. Today, the rich soils of these historic floodplains are primarily used for agriculture and farming. In the planning area, these historic floodplain agricultural areas are generally located south of Davis Dam, north of Lake Havasu and south of Parker Dam near the communities of Parker and Blythe.

Colorado River dams are operated to manage, in part, minimize flooding impacts along the Colorado River. Seasonal flooding in the planning area is most prevalent along Colorado River tributaries and coincides with heavier rainfall from the monsoon season in mid- to late summer months and winter rains from late fall to early spring.

2.1.3 Topography/Elevation Data

The planning area is located in the Basin and Range physiographic region. Topography in the planning area is distinguished by isolated roughly parallel mountain ranges trending northwest-southeast and separated by broad alluvial valleys. Elevation in the planning area ranges from 55 feet along the Colorado River to 8,417 feet at Hualapai Peak near Kingman, Arizona.

2.1.3.1 *Geology and Soils*

Geology in the planning area is within the Basin and Range Province, in which high- and low-angle normal faults, resulting from thinning and stretching of the crust over a more than 10-million-year period beginning about 20 million years ago, formed graben and half graben basins bordered by highlands. The basins filled with volcanic lava flows and pyroclastic debris and stream and lake sediments as they developed. The surrounding mountains consist of 1.2- to 1.4-billion-year-old (Proterozoic) metamorphic and intrusive igneous rocks and Tertiary volcanic rocks, both of which contain gold, silver, and copper ores and other mineral deposits that have been mined over the past century (see Section 5.2).
The planning area north of Parker, Arizona, contains a relatively narrow zone within the Basin and Range Province called the Colorado River Extensional Corridor. This corridor is dominated by low angle normal faults, some of which cut under the Colorado River and the surrounding mountains (e.g., south of Parker Dam to at least Bullhead City), have acted as conduits for ore formation, and have helped to form the topography of today. Both sides of the river are bordered by numerous small mountain ranges, punctuated by broad valleys at Lake Havasu and south of Parker to Poston, Arizona. The longest mountain range is the Black Mountains in Mohave County, Arizona, that stretch for 100 miles from I-40 to Hoover Dam. They consist of several volcanic and magmatic centers that experienced eruptions equivalent to those by the Yellowstone super volcano. Table 2-3 summarized the general stratigraphy of the planning area.

Table 2-3. Generalized Stratigraphic Section of the Planning Area

Unit Name	Primary Rock Types
Quaternary surficial deposits, undivided	Gravel, sand
Early Pleistocene to latest Pliocene surficial deposits	Gravel, sand
Pliocene to middle Miocene volcanic and sedimentary rocks	Rhyolite, dacite, basalt, volcaniclastics, fanglomerate, limestone
Middle Miocene to Oligocene volcanic rocks	Dacite, latite, trachyte
Cretaceous to Late Jurassic meta-sedimentary and meta-igneous rocks	Phyllite, schist, marble, sandstone, conglomerate
Proterozoic metamorphic and igneous rocks	Gneiss, amphibolite, grantoids

Source: AGS geologic map of Arizona (http://www.azgs.az.gov/services_azgeomap.shtml)

Soils develop from the weathering of the local geology (hard rock or sediments) and as such, the multitude of rocks types and variety of environmental conditions existing in the planning generate a complex soil distribution. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), published soil survey maps for Mohave County, the Kofa area of La Paz County, along the southern portion of the planning area in Yuma County, Arizona, for Clark County, Nevada, and for the Colorado River Indian Tribes area and Chemehuevi off-highway vehicle area in California. Soil survey maps and descriptions have not been published within the planning area in other parts of La Paz and Yuma Counties in Arizona, and Imperial, Riverside, and San Bernardino Counties in California.

2.2 BIOLOGICAL RESOURCES

Species richness and diversity in the planning area is highest/concentrated near the surface water features.

2.2.1 Vegetation

Vegetation in the planning area consists of Mohave Desert scrub, Arizona Upland Sonoran Desert scrub, and Lower Colorado River Sonoran Desert scrub. Vegetation is sparse to moderately dense (less than 50% cover) of drought-tolerant plant species, evergreen and drought deciduous, single leaf, unbranched leaf vein, and broad-leaved shrubs, and/or succulent species, specifically cacti and rosette stem succulents and sarcocaulescent trees and shrubs (ADWR 2009a, 2009b). Native plants found throughout the planning area include saguaro and a variety of other cacti, ocotillo, creosote, smoketree, and various species of paloverde, acacia, yucca, and mesquite. A decline of native vegetation in the watershed can be contributed to factors such as surface water diversions, dam construction, urban development, and groundwater pumping (Lower Colorado River Multi-Species Conservation Program [LCR MSCP] 2008).

2.2.1.1 *Exotic/Invasive Species*

As per Executive Order 13112, invasive species are defined as a species that is:

1) *Non-native (or alien) to the ecosystem under consideration and*
2) *whose introduction causes or is likely to cause economic or environmental harm or harm to human health.*

Invasive species can be plants, animals, and other organisms (e.g. microbes). Human actions care the primary means of invasive species introductions (USDA 2016). Arizona, California, and Nevada each maintain their own lists of invasive species, provided in the links below. Each state provides state-specific resources with an interest in the prevention, control, or eradication of invasive species. This plan addresses specific invasive species, identified in the project area, by stakeholders at various meetings.

- Arizona – https://www.invasivespeciesinfo.gov/unitedstates/az.shtml
- California – https://www.invasivespeciesinfo.gov/unitedstates/ca.shtml
- Nevada – https://www.invasivespeciesinfo.gov/unitedstates/nv.shtml

Invasive species have become an increasing threat to the lower Colorado River's natural ecosystems. Non-native species outcompete and displace native species due to the lack of natural predators and disease. Non-native riparian land plants in the planning area include but are not limited to tamarisk saltcedar (*Tamarix* sp.), giant reed (*Arundo donax*), Mediterranean grass (*Schismus barbatus*), and Sahara mustard *(Brassica tournefortii*).

Specific aquatic invasive species, determined in stakeholder meetings, that are present or are a threat in the Lower Colorado River watershed include those such as rock snot (*Didymosphenia geminata*), quagga mussel (*Dreissena bugensis*), New Zealand mud snail (*Potamopyrgus antipodarum*), northern crayfish (*Orconectes virilis*), apple snail (*Pomacea* spp.), giant salvinia (*Salvinia molesta*), Eurasian water milfoil (*Myriophyllum spicatum*), water lettuce (*Pistia stratiotes*), and water hyacinth (*Eichhornia crassipes*). Refer to Section 5.1.3 and Section 4.1.2.11 for more information on aquatic and terrestrial exotic/invasive species.

2.2.2 Wildlife

Desert shrub/scrub lands support a variety of wildlife species. Standing water from the winter and plant growth in the spring provide areas for foraging, food, and shelter for many resident and migrating species. Species that typically occur in the planning area include desert tortoise, several snakes, and lizards (including desert iguana, chuckwalla, red racer snake, western diamond rattlesnake, and common kingsnake), mourning dove, gambel's quail, phainopepla, numerous types of waterfowl, burrowing and great horned owls, bald eagle, peregrine falcon, various pocket mice and kangaroo rats, a host of bats, western spotted skunk, beaver, javelina, desert bighorn sheep, kit and gray foxes, coyote, and bobcat. The Bill Williams NWR at the south end of Lake Havasu has recorded more than 350 species of birds and 57 mammal species.

2.2.2.1 ***Threatened and Endangered Species***

There are a number of Endangered Species Act (ESA)-listed threatened and endangered species and associated critical habitats found throughout the planning area. Table 2-4 summarizes the ESA-listed species.

Table 2-4. Threatened and Endangered Species Occurring in Lower Colorado River Watershed

Common Name	Scientific Name	Status	Occurrence
Mammals			
Black-footed ferret	*Mustela nigripes*	Endangered	Not likely to occur in the planning area.
Sonoran pronghorn	*Antilocapra americana sonoriensis*	Experimental	Likely to occur in the planning area. The population is bounded by the Colorado River to the west, I-10 to the north and east, 1-19 to the east, and the U.S.–Mexico border to the south.
Birds			
California condor	*Gymnogyps californianus*	Endangered	Likely to occur in the planning area along Hwy 95 between Henderson, Nevada, and Lake Havasu City, Arizona.
California least tern	*Sterna antillarum browni*	Endangered	Likely to occur in the northern portion of the planning area north of Lake Havasu City, Arizona, and south of Henderson, Nevada.
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	Likely to occur in the planning area; the species' range is the entire Colorado River Watershed.
Yellow-billed cuckoo	*Coccyzus americanus*	Threatened	Likely to occur in the planning area; the species occurs throughout the entire state of Arizona.
Yuma clapper rail	*Rallus longirostris yumanensis*	Endangered	Likely to occur because the species' range is along the entire Colorado River corridor. [d]
Reptiles			
Desert tortoise	*Gopherus agassizii*	Threatened	Likely to occur in the northern portion of the planning area.
Northern Mexican gartersnake	*Thamnophis eques*	Threatened	Unlikely to occur in planning area.
Fishes			
Bonytail chub	*Gila elegans*	Endangered	Likely to occur in the planning area; the range overlaps the entire Colorado River to Yuma, Arizona. [a]
Flannelmouth sucker	*Catostomus latipinnis*	Potential Listing	Likely to occur in the planning area. [b]

Common Name	Scientific Name	Status	Occurrence
Headwater chub	*Gila nigra*	Proposed Threatened	Not likely to occur in the planning area.
Humpback chub	*Gila cypha*	Endangered	May occur in the planning area northeast of Henderson, Nevada.
Pahrump poolfish	*Empetrichthys latos*	Endangered	Not likely to occur in the planning area.
Razorback sucker	*Xyrauchen texanus*	Endangered	Likely to occur; the species' entire range is along the Colorado River. [c]
Roundtail chub	*Gila robusta*	Proposed Threatened	Not likely to occur in the planning area.
Woundfin	*Plagopterus argentissimus*	Endangered	Likely to occur in the northern portion of the planning area west of the Colorado River in Nevada.
Common Name	*Scientific Name*	Status	Occurrence
Flowering Plants			
Arizona cliffrose	*Purshia subintegra*	Endangered	Not likely to occur in the planning area.
Peirson's milk-vetch	*Astragalus magdalenae* var. *peirsonii*	Threatened	Not likely to occur in the planning area.

Source: USFWS (2017)

Reclamation (2005)

a LCR MSCP (2015a)

b LCR MSCP (2015b)

c LCR MSCP (2013)

d LCR MSCP (2015c)

2.2.2.1.1 LOWER COLORADO RIVER MULTI-SPECIES CONSERVATION PROGRAM

The Lower Colorado River Multi-Species Conservation Program is a 50-year federal and non-federal partnership program that aims to balance Colorado River water resources, including water diversions and dams, with the conservation of native species and their habitat. The focus of the LCR MSCP is on the recovery of ESA-listed species in the Lower Colorado River, from Lake Mead to the Mexican border.

Southwestern willow flycatcher (above)
Source: SWCA

The LCR MSCP guiding documents, which include a Habitat Conservation Plan, Biological Assessment, Programmatic Environmental Impact Statement, and Record of Decision, cover the federal and non-federal water diversions, hydropower production, and flow and non-flow-related actions and projects on the lower Colorado River (LCR MSCP 2017). The LCR MSCP covers 27 species, six of which are ESA-listed species and 20 of which are non-federally listed.

2.2.2.2 *Sensitive Areas*

Sensitive areas in the planning area include multiple wilderness areas and NWRs (Figure 2-8). In addition, there are several conservation areas and reserves. Construction at Laguna Division Conservation Area (LDCA) began in November 2011 and was completed in spring 2015. The LDCA is a mosaic of native land cover types (LCR MSCP 2012) designed to restore, protect, and enhance native habitat to benefit the LCR MSCP. The Palo Verde Ecological Reserve encompasses nearly 1,350 acres of land and is available to LCR MSCP habitat restoration activities (LCR MSCP 2006). Beal Lake Conservation Area (225 acres) is located on a portion of Havasu NWR and was established to create a haven for native fishes. Big Ben Conservation Area is within the planning area and consists of 15 acres of backwater dedicated to native fish and a 15-acre upland that is restored with native plants (LCR MSCP 2018). Hart Mine Marsh, located on the southern end of Cibola NWR, is managed by drainage waters from the refuge's agricultural fields with approximately 255 of Hart Mine Marsh restored. Imperial Ponds Conservation Area consists of fields, marshes, and backwaters managed for water fowl and is located on Imperial NWR (LCR MSCP 2018). Mohave Valley Conservation Area, encompassing nearly 90 acres, is dedicated to habitat restoration and benefit for threatened and endangered species. Planet Ranch Conservation Area, 3,418 acre-feet, is currently working to balance water needs while minimizing risks of impacting marsh or riparian habitat downstream and Pretty Water Conservation Area designates 566 acres for restoration and establishing suitable habitat for a number of wildlife species (LCR MSCP 2018).

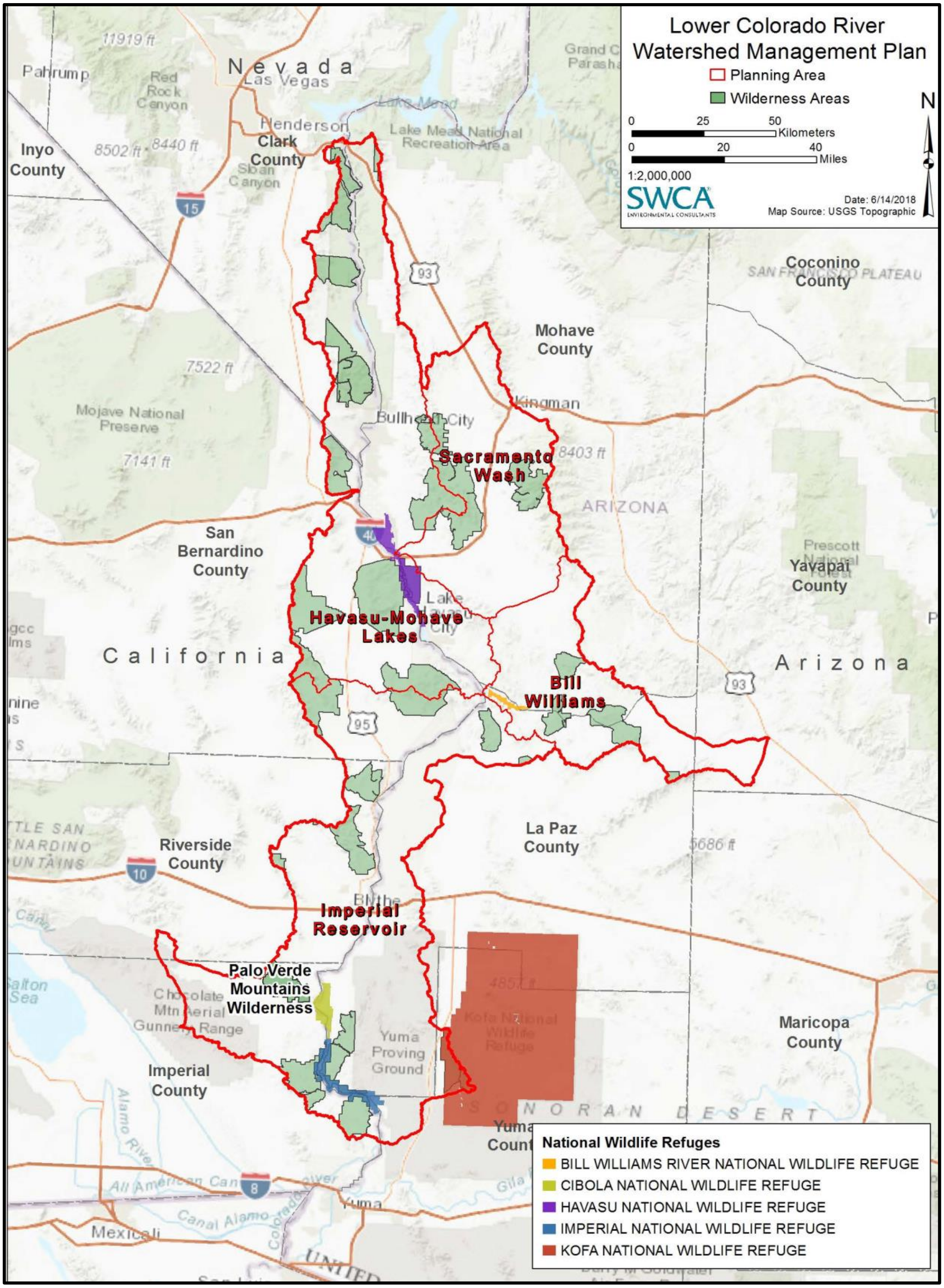


Figure 2-8. Sensitive areas in the planning area.

2.2.2.3 *Wilderness Areas*

There are 20 congressionally designated wilderness areas in the planning area (Table 2-5). Wilderness areas, designated under the Wilderness Act of 1964, are managed for the preservation and protection of the area's natural condition. The NPS, Bureau of Land Management (BLM), and USFWS manage wilderness areas in the planning.

Table 2-5. Wilderness Areas in the Planning Area

Wilderness	Managing Agency
Mount Wilson Wilderness	BLM
Black Canyon Wilderness	NPS
Eldorado Wilderness	NPS and BLM
Ireteba Peaks Wilderness	NPS and BLM
Nellis Wash Wilderness	NPS
Spirit Mountain Wilderness	NPS and BLM
Bridge Canyon Wilderness	NPS
Dead Mountains Wilderness	BLM
Havasu Wilderness	USFWS
Chemehuevi Mountains Wilderness	BLM
Whipple Mountains Wilderness	BLM
Gibraltar Mountain Wilderness	BLM
Riverside Mountains Wilderness	BLM
Big Maria Mountains Wilderness	BLM
Palo Verde Mountains Wilderness	BLM
Trigo Mountain Wilderness	BLM
Little Picacho Wilderness	BLM
Picacho Peak Wilderness	BLM
Indian Pass Wilderness	BLM
Imperial Refuge Wilderness	USFWS

2.2.2.4 *National Wildlife Refuges*

The USFWS manages NWRs, administered under the National Wildlife Refuge System Administration Act of 1966, as amended, for the protection and conservation of fish and wildlife. There are four NWRs in the planning area: Havasu NWR, Bill Williams River NWR, Cibola NWR, and Imperial NWR. Details of the four NWRs in the planning are further described in Table 2-6.

Table 2-6. National Wildlife Refuges in the Planning Area

NWR	Location	Year Established	Acres	Primary Purpose
Lake Havasu	Arizona and California	1941	37,515	Protection of migratory bird habitat along 30 river-miles of the Colorado River (300 miles of shoreline).
Bill Williams River	Arizona	1993	6,100	Formerly included in the Lake Havasu NWR, this refuge is managed for the protection of the Bill Williams River and cottonwood-willow forest riparian habitat.

NWR	Location	Year Established	Acres	Primary Purpose
Cibola	Arizona and California	1964	18,444	Originally established as mitigation for Colorado River shoreline modifications, the refuge protects and recreates Colorado River habitats for wintering grounds for migratory waterfowl and other wildlife. Hart Mine Marsh located at southern end of Cibola is used to manage drainage waters from the refuge's agricultural fields (LCR MSCP 2009).
Imperial	Arizona and California	1941	25,768	Protection of wetland habitats formed by the Imperial Dam along 30 miles of the Lower Colorado River. Part of the Refuge is the Imperial Ponds Conservation Area, which has converted nonnative vegetation with native vegetation and developed habitat for various species covered under the LCR MSCP (LCR MSCP 2013).

2.3 LAND USE AND LAND COVER

Land use in the planning area is approximately 89% open space (mostly semi-desert), 3.9% agricultural (including pasture/hay), and 2.1% urban (developed areas). Additional land uses in the planning area include mining, residential, and recreation. The different types of land cover found in the planning area are presented below in Table 2-7 and shown in Figure 2-9.

Table 2-7. Land Cover in the Planning Area

Class	Acres
Agriculture	212,574
Developed and Other Human Use	114,119
Forest and Wetland	107,948
Non-Vascular & Sparse Vascular Rock Vegetation	90,665
Open Water	70,519
Semi-desert	4,880,280
Shrubland and Grassland	49,577

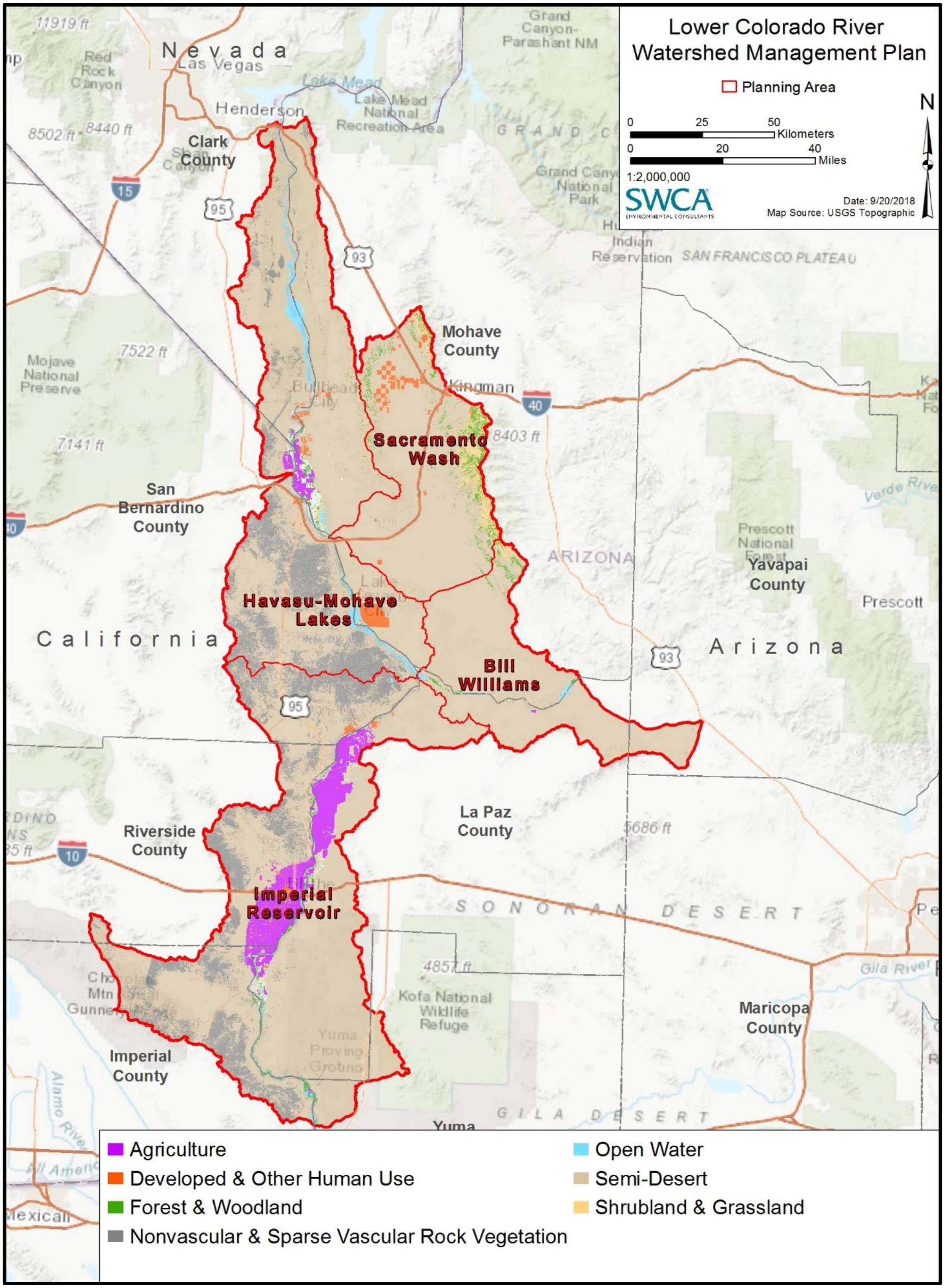


Figure 2-9. Land cover in the planning area.

2.3.1 Open Space

Open space refers to any open piece of land that is undeveloped and is accessible to the public; whereas, developed open space refers to a mixture of some constructed material and a lot of landscaping vegetation (U.S. Geological Survey [USGS] 2017a). Most commonly, these areas are used for parks, golf courses, and large-lot single-family homes.

2.3.2 Agriculture

Agricultural practices in the planning area are primarily located in flat, alluvial valleys along the Colorado River in California and Arizona near the communities of Mohave Valley, Needles, Parker, Blythe, and Palo Verde in Arizona. There are four irrigation districts in the planning area: Mohave Water Conservation District, Mohave Valley Irrigation and Drainage District (IDD), Lake Havasu IDD, and Cibola Valley IDD. The Palo Verde Irrigation District is located in California.

Agricultural water use is the largest water use in the planning area, accounting for 2,068,200 acre-feet of water use annually. The surface water allocation for irrigation is 1,511,500 acre-feet. Groundwater used for agricultural practices is 556,700 acre-feet (ADWR 2009a, 2009b). The USDA estimated agricultural demand, based on irrigation districts along the Colorado River: Cibola Valley Irrigation District, Yuma County Water Users' Association, Welton Mohawk IDD, North Gila Valley IDD, Stugest Gila Monster-Farms, Inc., Yumas Mesa IDD, and Unit B IDD.

Tribes residing in the LCR are allocated roughly 30% of the water allotment in Arizona. Roughly 99.7% of their entitlement is used to irrigate crops. Of the over 600,000 acre-feet applied for farming there was roughly 300,000 acre-feet of return flow (Colorado River Indian Tribes 2018). Agricultural demand is also based on tribes residing in the area to include Colorado River Indian Tribes Chemehuevi Tribe, and Fort Mohave Indians. Refer to section 2.4.6.3 for more information about the tribes listed above.

Agricultural field outside of Yuma, Arizona
Source: Stephens, 2009

Colorado River surface water diversions support irrigation for agricultural practices within the planning area through various local irrigation canals (aqueducts, pipelines, tunnels) and areas outside the planning area through the CAP canal in Arizona, the Colorado River Aqueduct, and the All-American Canal in California. Irrigation canals and surface water diversions in the planning area are presented in Figure 2-7.

2.3.3 Mining Activities

The planning area contains a significant amount of abandoned surface and underground mining sites mainly for gold and silver exploration. Water quality may be potentially impacted from acid mine drainage seeps, mine tailings, and other mining activities. Currently, there are 512 closed mines, 585 unknown, occurrence or prospect mining activities and 44 active mines in the planning area (USGS, 2017). Table 2-9 and Figure 2-10 provide additional information on mining in the planning area. Active mines include various material source mines, and gravel pit mines that do not produce large volumes of waste. Therefore, only the large metal operation mines that produce large volumes of mining waste (tailings) are described below (see Table 2-9).

Table 2-9. Active Mines in the Watershed and Mining Commodities

Name	County	State	Commodities
Billy Mack Mine	La Paz	AZ	Primary: copper, gold Secondary: silver
Carnation Mine	La Paz	AZ	Primary: copper, gold Secondary: silver
Pride Mine	La Paz	AZ	Primary: gold Secondary: silver, copper Tertiary: iron
Mineral Hill Mine	La Paz	AZ	Primary: copper, iron Secondary: gold, silver Tertiary: beryllium
Bonanza Mine	Mohave	AZ	Primary: copper, silver Secondary: gold
Moss Mine	Mohave	AZ	Primary: gold, silver
Tyro Mine	Mohave	AZ	Primary: gold, silver
Portland Mine	Mohave	AZ	Primary: gold, silver
Argyle Mine	Mohave	AZ	Primary: silver, lead, gold, zinc, copper Tertiary: arsenic
Tennessee – Schuylkill	Mohave	AZ	Primary: silver, copper, zinc
Jackpot Mine	Mohave	AZ	Primary: gold, silver, zinc, lead
Emerson Mine	Mohave	AZ	Primary: gold, silver, copper Secondary: lead, zinc Tertiary: arsenic
Twentieth Century Mine	Mohave	AZ	Primary: zinc Secondary: silver, lead, gold, copper, indium Tertiary: arsenic
New Moon Mine	Mohave	AZ	Primary: zinc Secondary: lead, silver, gold, copper Tertiary: arsenic
Mineral Park	Mohave	AZ	Primary: silver, molybdenum, copper Secondary: gold
Emerald Isle	Mohave	AZ	Primary: copper
Emerald Isle Deposit	Mohave	AZ	Primary: copper
Black Beauty Mine	Mohave	AZ	Primary: silver, gold
Western Union Mine	Mohave	AZ	Primary: silver, gold, zinc, lead Tertiary: vanadium
White Horse Mine	Mohave	AZ	Tertiary: zinc, gold, copper
Taylor Mine	Mohave	AZ	Primary: feldspar

Source: USGS (2017)

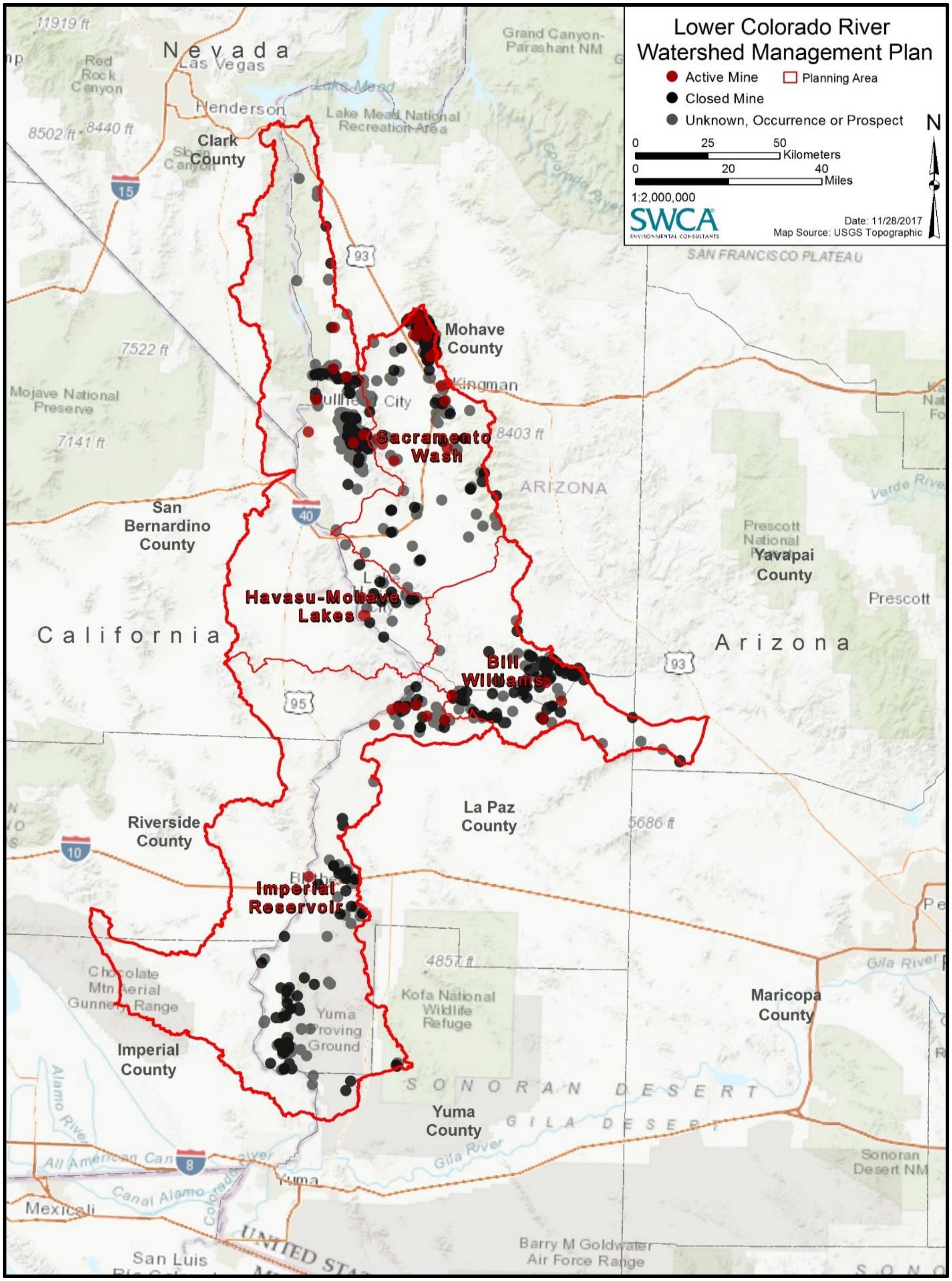


Figure 2-10. Mines in the planning area.

2.3.4 Recreation Areas

Much of the recreation occurring in the planning area is concentrated on the main stem of the Colorado River. Recreation in the planning area includes water-based recreation, recreational vehicle (RV) camping, hiking, and 4×4 off-roading, as well as hunting and shooting. Recreation areas in the planning area include public (federal, state, and local) recreation areas and parks, as well as many privately owned and operated campgrounds and marinas. There are proposed recreation areas within the planning area, e.g. Blue Water Trail.

2.3.4.1 *Lake Mead National Recreation Area*

The Lake Mead NRA, managed by the NPS, includes Lake Mead (outside the planning area), Lake Mohave, and lands surrounding these reservoirs. Lake Mead is one of the most popular recreation areas in the country, attracting more than nine million visitors annually (Reclamation 2015). Popular recreation activities in the Lake Mead NRA include water-based recreation of boating, swimming, and fishing, as well as camping, sightseeing, and other outdoor activities.

2.3.4.2 *Lake Havasu*

Lake Havasu is the most popular recreation area in the planning area, with an annual visitation count of approximately 2.5 million. Water-based recreation is the main attraction to Lake Havasu. Recreation activities include boating, kayaking, fishing, swimming, and shoreline hiking.

2.3.4.3 *State Parks and State Recreation Areas*

Five state parks and state recreation areas are located on the Colorado River in the planning area. South of the community of Laughlin in Nevada is the Big Bend of the Colorado State Recreation Area. In Arizona, there are two state parks located on Lake Havasu: Lake Havasu State Park and Cattail Cove State Park. Buckskin Mountain and River Island State Parks are located in Arizona south of the Parker Dam. Near the south end of the planning area is the Picacho State Recreation Area in California. These state parks and recreation areas are primarily used for water-based recreation, camping, and hiking.

2.3.4.4 *Private Resorts, Campgrounds, and Marinas*

There many privately owned resorts, tent and RV campgrounds, marinas, and other private recreation facilities in the planning area along the Colorado River. These private recreation facilities are concentrated near population centers, including Laughlin, Bullhead City, Lake Havasu City, Parker, and Blythe.

2.3.5 Developed Areas

Development in the planning area is concentrated along the Colorado River. The largest population center in the planning area is Lake Havasu City, which had a population of approximately 54,410 in 2017, followed by the Laughlin-Bullhead City-Mohave Valley area (~50,000) area.

2.3.6 Land Ownership

Several landowners manage more than 5.5 million acres of land within the planning area, mainly BLM. The five principal land holdings within the LCR include BLM, private landowners, Yuma Proving Ground, and the National Park Service. BLM manages the majority of the land within the project area,
57%, primarily used for grazing, resource conservation, and recreation. Private landowners maintain over 15% of the land for domestic, commercial, and agricultural uses. The Department of Defense's Yuma Proving Ground and Chocolate Mountain Aerial Gunnery Range manages approximately 9% of the project area in the southern portion of the project area, and the National Park Service oversees almost 7% of the land around Lake Mohave (Lake Mead NRA).

The remaining lands are Indian Reservations, State Trust Lands, Wildlife Refuges, State Lands, Chemehuevi Trust Patent, Reclamation, USFWS, Clark County, NV, Local and/or State Parks, BIA, Nevada State Lands, California Department of Fish and Game, Arizona Game and Fish Department (AGFD), California Department of Parks and Recreations, and County Lands. Table 2-10 and Figure 2-11 show the land ownership in the planning area.

Table 2-10. Landownership by Acreage and Percentage in LCR

Landowner	Acres	Percentage
Bureau of Land Management	3,136,776	56.81%
Private	846,710	15.34%
Military	521,189	9.44%
National Park Service	383,596	6.95%
Indian Reservations	238,312	4.32%
State Trust Lands	145,002	2.63%
Wildlife Refuges	98,347	1.78%
State Lands--State Lands Commission	38,368	0.69%
Chemehuevi Trust Patent	35,964	0.65%
Reclamation	31,010	0.56%
U.S. Fish and Wildlife	20,883	0.38%
Clark County, NV	9,295	0.17%
Local or State Parks	5,062	0.09%
Bureau of Indian Affairs	4,038	0.07%
Nevada State Lands	2,760	0.05%
California Department of Fish and Game	1,945	0.04%
Arizona Game and Fish Department	1,184	0.02%
California Department of Parks and Recreation	638	0.01%
County Land	69	0.00%
Total	**5,521,148**	**100.00%**

Source: USGS, 2018

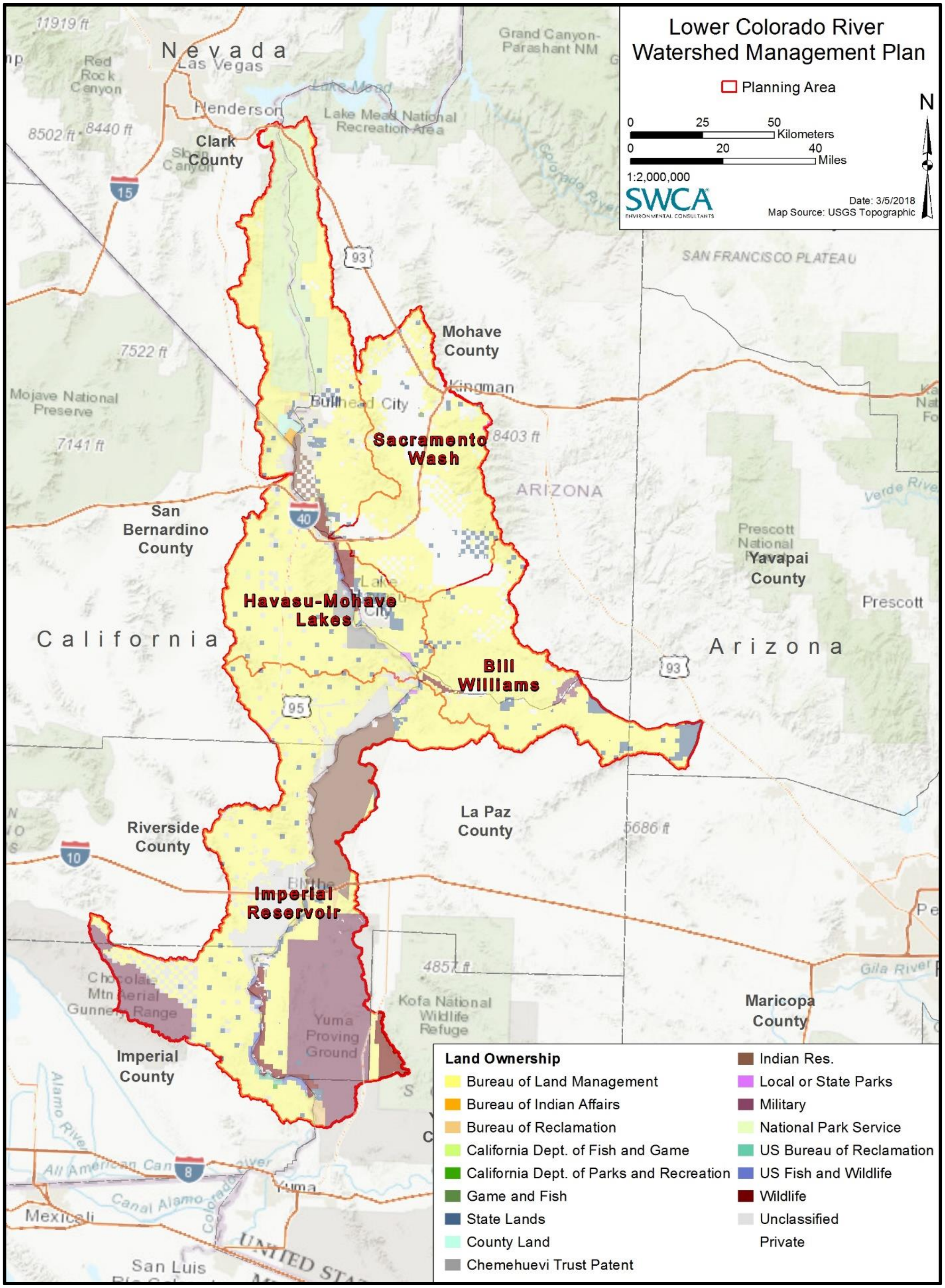


Figure 2-11. Land ownership in the planning area.

2.3.6.1 *Counties*

Counties in the Mohave Lakes watershed include Clark County, Nevada; Mohave County, Arizona; and San Bernardino County, California. Counties in the Imperial Reservoir watershed include San Bernardino, Imperial, and Riverside Counties in California and La Paz and Yuma Counties in Arizona.

2.3.6.2 *Municipalities*

Municipalities in the Mohave Lakes watershed include Laughlin, Nevada; Bullhead City and Lake Havasu City, Arizona; and Needles, California. Parker, Arizona, and Blythe, California, are located in the Imperial Reservoir watershed.

2.3.6.3 *Indian Reservations*

There are three Indian Reservations located in the planning area—the Fort Mojave Indian Reservation and Chemehuevi Indian Reservation in the Mohave-Havasu Lakes watershed, and the Colorado River Indian Reservation in the Imperial Reservoir watershed. The Lower Colorado River planning area has a wealth of cultural and historical significance for the Native American tribes residing in and around the planning area. Tribal communities in the area maintain historic sites, and community gatherings to celebrate them serve to commemorate the past (ADWR 2009a, 2009b).

2.3.6.3.1 FORT MOJAVE RESERVATION

The Fort Mojave Indian Reservation is located near Needles, California, and is made up of 42,000 acres of lands in Nevada, California, and Arizona. The reservation is home to the Fort Mojave Indian Tribe, known as the *Pipa Aha Macav* ("the People by the River"). The majority of the reservation is developed agricultural land. Agriculture and recreation (tribal gaming resorts, boating, and RV camping) are the two primary industries on the reservation (Fort Mojave Indian Tribe 2017).

2.3.6.3.2 CHEMEHUEVI RESERVATION

The Chemehuevi Indian Reservation is located in the planning area in San Bernardino County, California. The Chemehuevi Indian Tribe, known as the *Nuwu* ("the People"), is a branch of the Southern Paiute who historically lived a nomadic lifestyle, occupying the Mohave Desert and Colorado River (Chemehuevi Indian Tribe 2017). The reservation encompasses approximately 32,000 acres in California, with 30 miles of the Colorado River shoreline at Lake Havasu. The reservation is primarily undeveloped. The Havasu Landing Resort and Casino is a Chemehuevi Indian tribal enterprise located at Havasu Lake, California. It offers a campground, marina, vacation rentals, and a casino.

2.3.6.3.3 COLORADO RIVER INDIAN RESERVATION

The Colorado River Indian Reservation is located on 300,000 acres of lands along the Colorado River in California and Arizona. The Colorado River Indian Tribes consists of the Mohave, Chemehuevi, Hopi, and Navajo Indian Tribes. The largest community in the Colorado River Tribes Reservation is Parker, Arizona. The dominant land use on the reservation is agriculture. The primary industries include agriculture, sand and gravel mining, real estate development, tourism, and gaming and lodging (Colorado River Indian Tribes 2017). Table 2-13 lists the tribes residing in and near the planning area.

2.3.6.4 *Other Entities*

2.3.6.4.1 U.S. BUREAU OF RECLAMATION

The Lower Colorado Region was established by the Bureau of Reclamation in 1943 to design, construct, manage and maintain projects and facilities in the southwestern United States. The Region geographically encompasses southern Nevada, southern California, most of Arizona, a small corner of southwest Utah, and the Gila and Little Colorado River Basins in west-central New Mexico – or about one-tenth of the land area of the western United States. Reclamation's numerous projects and facilities in the Region – including the Salt River Project and Theodore Roosevelt Dam, Hoover Dam and the All-American Canal, the Yuma and Gila Projects, Parker-Davis Project, the Central Arizona Project, and the Robert B. Griffith Project (now Southern Nevada Water System).

Under the Law of the River, the Secretary of the Interior manages the last 688 miles of the Colorado River, from Lee Ferry in northern Arizona to the border with Mexico. This includes the contracting, delivery, and accounting of all water use from the mainstream of the lower Colorado River. The Region implements these management functions on the Secretary's behalf. Staff schedule water releases from mainstream facilities on a monthly, daily and, for some facilities, hourly basis; measure, record and report water diverted and returned to the mainstream; administer contracts for water delivery; account for all water use; and, with Reclamation's Upper Colorado Region and in close coordination with a broad range of partners and stakeholders throughout the Basin, develop the Annual Operating Plan for Colorado River Reservoirs (AOP). Documented decisions include the amount of water to be released from Lake Powell through Glen Canyon Dam to the Lower Basin; whether a "surplus, normal, or shortage" condition will govern the operation of Lake Mead; and the amount of water available to Mexico under the 1944 Treaty and subsequent U.S.-Mexico agreements (referred to as "Minutes"). Because the water supply for the coming year is uncertain, operational changes are made within the appropriate operating guidelines and documented in the AOP as water supply conditions change during the year.

The Colorado River system is operated in accordance with the Law of the River, which is the collective reference for the treaties, compacts, decrees, statutes, regulations, contracts, and other legal documents and agreements applicable to the allocation, appropriation, development, exportation, and management of the waters of the Colorado River Basin. There is no single, universally agreed upon definition of Law of the River, but it is useful as a shorthand reference to describe this longstanding and complex body of legal agreements governing the Colorado River.

Apportioned water in the Basin exceeds the average long-term (1906 to 2015) historical natural flow of approximately 16.1 million acre-feet (MAF). Up to this point, the imbalance has been managed, and all requested deliveries were met in the Lower Basin as a result of the considerable amount of reservoir storage capacity in the System (approximately 60 MAF or nearly four years of average natural flow of the river). This is in part due to fact that the Upper Basin States of Colorado, New Mexico, Utah, and Wyoming are still developing into their apportionments, and the continuing efforts that Basin States are making to reduce their demand for Colorado River water. Reclamation works through a variety of programs with water resource stakeholders to develop innovative strategies to ensure adequate supplies are available to meet these increasing demands into the future.

2.3.6.4.2 BUREAU OF INDIAN AFFAIRS

The BIA manages the Water Management, Planning, and Pre-Development Program intended to help tribes in conserving, managing, and using Indian trust lands' water resources. The priorities of the program are to develop technical research and train tribes to serve as managers of adjudicated waters

(BIA 2017). Cooperation and coordination through partnerships with other governmental entities help maintain the quantity and quality of surface water, groundwater, inventories, monitoring, and modeling.

The long-term strategic goals (outcomes) for the BIA Water Programs are as follows:

- The United States acquires water rights in cases in which it is the party to litigate on behalf of Indian tribes;
- The United States obtains a congressional approval of tribal water rights via negotiated settlement; and
- Tribes have plans to use their water, supporting trust land uses and managing their water resources.

2.3.6.4.3 U.S. DEPARTMENT OF DEFENSE (YUMA PROVING GROUND)

The Department of Defense's Yuma Proving Ground (YPG) is in the lower reaches of the planning area in southern La Paz County and norther Yuma County, Arizona. YPG occupies roughly 870,000 acres in Yuma and La Paz Counties, Arizona, and is located 23 miles northeast of Yuma, Arizona. The site is nearly 1,309 square miles, extending approximately 60 miles north-south and 50 miles east-west. Geology of YPG is characterized by wide, gently sloping plains interrupted by steep, rising mountains.

Beneath YPG lie two aquifers. The first is a shallow, loose aquifer of alluvial deposits, and the second is a deep aquifer of consolidated volcanic rock. Groundwater is approximately 30 feet below the ground surface adjacent to the Colorado River, and depths increase to 750 feet at the Castle Dome Heliport.

Contamination exists at the site, including petroleum hydrocarbons, volatile organic compounds (VOCs), semi-VOCs, and metals. Additional concerns are from propellants, explosives, and pyrotechnics. Contaminated areas are fenced and prohibit the public from trespassing, areas of contaminations are confined to the site boundaries (ADEQ 2017a). Most of the contaminated sites are fenced in where public access is prohibited and contaminated groundwater is limited to the site boundaries; therefore, no risk of contamination exists to the public drinking water supply in Yuma, Arizona (ADEQ, 2017a).

Relevant Authorities

Colorado River Compact of 1922

The Colorado River Compact of 1922 was negotiated by the seven Colorado River Basin states and the federal government. The compact defined the relationship between the lower basin states, where most of the water demand is, and the upper basin states, where most of the water originates.

The seven states struggled to come to an agreement about how the Colorado River Basin waters should be allocated among them. Eventually, under the direction of Secretary of Commerce Herbert Hoover, the basin was divided into an upper and lower half, with each basin maintaining its right to develop and use 7.5 million acre-feet of Colorado River water annually (Reclamation 2008). The compact helped reserve water for future growth in the upper basin and allowed the lower basin to plan and develop for the future.

The Arizona v. *California U.S. Supreme Court Decision of 1964*

The Supreme Court delivered a decision to settle a 25-year-old dispute between Arizona and California in 1963. Arizona intended to build the CAP so it could take full advantage of its apportionment to the Colorado River (Reclamation 2008). California was against the development and believed Arizona's use of the Gila River, a Colorado River tributary, constituted its use of its Colorado River apportionment.

In 1964, Supreme Court issued a decree confirming the apportionment of the Lower Basin tributaries was reserved for exclusive use of the states in which the tributaries are located and confirmed a significant role of the Secretary of the Interior in managing the mainstream of the Colorado River within the Lower Basin. The Court defined the appropriations by the laws that authorized preparation and analysis of annual water use reports in the three lower basin states (Reclamation 2008). A Supplement Decree was issued in 1979 by the Supreme Court addressing current rights and entitlements recognized under state laws that exempt them over later contract entitlements. A final consolidation decree was issued in 2006 to incorporate previous decisions and to settle water rights for the Fort Yuma Indian Community.

California Colorado River Water Use Plan

California's Colorado River Water Use Plan (CCRWUP) was developed to provide its Colorado River water users with a framework for programs, projects, and other activities allowing California to efficiently satisfy its annual water supply demands within the annual apportionment of Colorado River water (Colorado River Board of California 2000). The outline specifies the transition California will make to sustain its basic apportionment of Colorado River water whenever necessary.

Components of the CCRWUP range widely in scope and deal with water quality and quantity. The CCRWUP intends to reassure Colorado River water rights holders that they will have a reliable source of water intended for planning, financing, and implementing other necessary measures in a timely manner to meet water management and supply needs. Additionally, the CCRWUP practices regional approaches and approved processes and was founded on interagency cooperation.

The CCRWUP was developed to be flexible and dynamic enough for modification, updates, and further development of projects and programs within the framework of the CCRWUP if found to be more cost appropriate and/or efficient (Colorado River Board of California 2000). Water rights holders would be unable to meet their water needs if the CCRWUP did not exist; therefore, users established the principal supply and sole source of water via the plan.

Proposed Lower Colorado River Basin Drought Contingency Plan

As lead federal agency, the U.S. Bureau of Reclamation is working on a collaborative effort with partners in the LCR basin (Arizona, California, and Nevada, as well as water agencies and users in those states) to develop a contingency plan identifying actions that can be taken to reduce the risk of water shortages in LCR. The LCR Basin States have been negotiating the Drought Contingency Plan since 2015. In January 2017, then Secretary of Interior, Sally Jewell issued a Secretarial Order directing the U.S. Department of the Interior (DOI) and its bureaus to continue with the efforts to finalize the contingency plan (DOI 2017b).

The goal of the yet-to-be-adopted plan is identifying long-term tools to meet water supply needs in the region and to address protection of reservoirs along the River that are facing historic low water levels (i.e., Lake Mead).

Minute 323 of the 1944 United States- Mexico Water Treaty

The above Secretarial Order also directed Reclamation to continue working with the International Boundary and Water Commission (IBWC), the Republic of Mexico, the Colorado River basin states, and non-governmental organizations on finalizing the cooperative agreement with Mexico known as Minute 323 (DOI 2017b).

Minute 323 amends Minute 319 as of September 2017, and was provoked by the greater uncertainty for Colorado River basin conditions and water availability. The amendment mandates that Lake Mead elevation be used as an indicator for water delivery reductions, and that both the United States and Mexico need to take immediate measures to keep reservoir elevations above critical levels (IBWC 2017).

2.3.7 Demographic Characteristics

2.3.7.1 *Population*

Although much of the planning area is sparsely populated, the Lower Colorado River is the most densely populated stretch of the Colorado River. Population in the planning area is concentrated on the communities of Bullhead City, Arizona (39,424), Lake Havasu City, Arizona (53,010), and Blythe, California (19,839).[1] Other population centers in the planning area include Laughlin, Nevada, Needles, California, and Parker, Arizona. Tables 2-14 and 2-15 show population characteristics for the counties and major municipalities/towns in which the planning area is located.

Table 2-14. Planning Population Change from 2000 to 2015

County	2000	2015	% Change
Clark County (NV)	1,375,765	2,035,572	47.96%
Riverside County (CA)	1,545,387	2,298,032	48.70%
San Bernardino County (CA)	1,709,434	2,094,769	22.54%
Imperial County (CA)	142,361	178,206	25.18%
Mohave County (AZ)	155,032	203,362	31.17%
La Paz County (AZ)	19,715	20,335	3.14%
Yuma County (AZ)	160,026	202,987	26.85%
Municipality			
Laughlin (NV)	7,076	7,622	7.72%
Bullhead City (NV)	33,769	39,424	16.75%
Lake Havasu City (AZ)	41,938	53,010	26.40%
Needles (CA)	4,830	4,942	2.32%
Parker (AZ)	3,140	3,068	-2.29%
Blythe (CA)	12,155	19,839	63.22%

Source: U.S. Census Bureau (2017)
Note: Table shows communities in the planning area with a 2015 population greater than 1,000.

2.3.7.2 *Economics*

The dominant economic driving forces in the planning area are agriculture and recreation (Table 2-15). Yuma County is considered the nation's winter vegetable capital and is where most agriculture in the planning area occurs. Additional agricultural lands occur on Colorado River Indian Tribes lands in La Paz County, Arizona and large agricultural production areas exist in Mohave Valley, Arizona. Recreation provides jobs for the service industry (University of Arizona 2017). The Colorado River receives millions of visitors annually, and many people living in the developed regions of the planning area rely heavily on tourism and recreation for economic stability (ADWR 2009a, 2009b).

[1] Population for 2015, calculated using the U.S. Census Bureau American Community Survey (Headwaters Economics Profile System 2017).

Table 2-15. Planning Area Economics, 2015

County	Economic Driver	Mean Income
Clark County (NV)	Accommodation/Food Services	$51,575
Riverside County (CA)	Manufacturing	$56,603
San Bernardino County (CA)	Retail	$53,433
Imperial County (CA)	Retail	$41,079
Mohave County (AZ)	Retail	$38,488
La Paz County (AZ)	Food Services	$34,466
Yuma County (AZ)	Retail	$40,743
Municipality		
Laughlin (NV)	Arts, Entertainment, Recreation	$32,847
Bullhead City (NV)	Accommodation/Food Services	$35,948
Lake Havasu City (AZ)	Accommodation/Food Services	$42,847
Needles (CA)	Transportation and Warehousing	$30,443
Parker (AZ)	Public Administration	$43,271
Blythe (CA)	Public Administration	$42,798

Note: Data are calculated by using the U.S. Census Bureau American Community Survey annual surveys conducted in 2011–2015 and are representative of the average characteristics during this period.

2.3.8 Lower Colorado River Water Diversions

Several entities that divert water from the lower Colorado River (LCR) are located in Arizona and California, and a few in Nevada. Figure 2-6 illustrates the four largest diverters for years 1970, 1980, 1990, 2000, 2010, and 2017. Overall, the largest water diverter in the LCR is the Imperial Irrigation District in California, with uses exceeding other entities by almost twice the volume (refer to Table 2-2 and Figure 2-7 for more detail). The Central Arizona Project (CAP) has been the second largest diverter since 2000, pulling water directly from Lake Havasu.

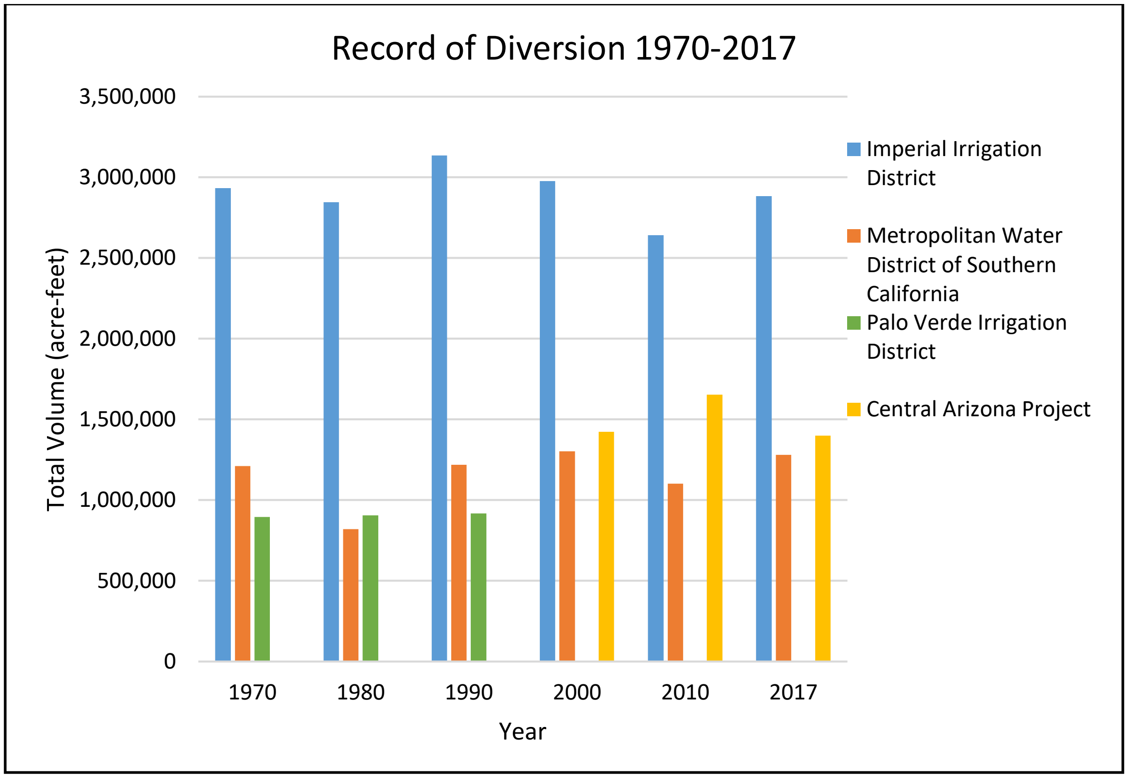


Figure 2-6. Record of diversion from largest users (1970–2017) (Reclamation 2017e,g,h,i).

Table 2-2. Four Largest Diversions in the LCR

Entity	Total Volume (Acre-Feet)	Contract Number	Supply	Date
Imperial Irrigation District	2,461,562	I1r-747 I1r-781	Diversion at Imperial Dam	12/1/1932
Central Arizona Project	1,493,151	14-06-W-245	Pumped from Lake Havasu	12/15/1972
Metropolitan Water District of Southern California	999,819	I1r-645 supplemented	Pumped from Lake Havasu	4/24/1930
Palo Verde Irrigation District	775,220	PVID020733C	Diversion at Palo Verde Dam	2/7/1933

2.3.8.1 *Colorado River Aqueduct*

Operated by MWD, the Colorado River Aqueduct is a 242-mile-long aqueduct system that imports water from the Colorado River at Lake Havasu to metropolitan areas of southern California. The Colorado River Aqueduct, completed in 1941, is composed of “two reservoirs, five pumping stations, 63 miles of open canals, 92 miles of tunnels, 55 miles of concrete pipe and 28 miles of pressurized siphons, with a delivery capacity of over 1.2 million acre-feet a year” (MWD 2017). Today, the Aqueduct delivers over one billion gallons of water a day to southern California (MWD 2017).

2.3.8.2 *Central Arizona Project*

Central Arizona Project
Source: Reclamation, 2015.

Established in the early 1970s, the Central Arizona Project (CAP) did not become a main diverter until nearly 2000. The CAP, constructed from 1970 to 1996, is 336-mile-long canal that conveys water from Lake Havasu to metropolitan areas in central (Phoenix) and southern (Tucson) Arizona. The CAP delivers approximately 488 billion gallons a year of Colorado River water to Arizona. The CAP system consists of pumping plants, hydroelectric pump/generating plants, radial gate structures to control the flow of water, and more than 50 turnouts to deliver water. The system also consists of municipal water treatment plants and a storage reservoir north of Phoenix (CAP 2018). Water delivered through CAP supports "cities, industries, Indian communities and agricultural interests" (Reclamation 2013c).

2.3.8.3 *Tribal Diversions*

Tribes are among many claimants in the Lower Colorado River Waters Rights Adjudication and have rights to the LCR and its tributaries (Table 2-3). Tribes residing within the reservations in the Colorado River Basin have quantified rights to divert nearly 20% of the basin's average annual water supply. Currently, there are more than a dozen Tribes with outstanding claims. Several court cases have recognized tribal rights and have paved the way for Tribal quantified rights. The Court has "directed that water consumed under tribal rights be counted as part of the allocation made to the state in which the reservation is located" (Reclamation 2016:1). The decision has gained momentum with other tribes in the basin, and they continue to work to get their rights quantified and find the means to be able to put the rights to good use (Reclamation 2016).

Table 2-3. Diversion Rights of Tribes of the Colorado River Mainstream Stem Reservations, 2015

State	Reservation / Tribe	Diversion Right (acre-feet per year)	Estimated Use in 2015 (acre-feet per year)	
			Diversions	Consumption
California	Chemehuevi	11,340	221	119
Arizona	Cocopah	10,847	2,569	1,684
Arizona	Colorado River	662,402	595,889	300,860
California	Colorado River	56,846	5,095	2,970
Arizona	Ft. Mohave	103,535	69,515	37,275
California	Ft. Mohave	16,720	15,164	8,157
Nevada	Ft. Mohave	12,534	4,683	3,137
California	Ft. Yuma / Quechan	71,616	96,403	47,621
Arizona	Ft. Yuma / Quechan	6,350	1,286	1,017
Total		**952,190**	**790,825**	**402,840**

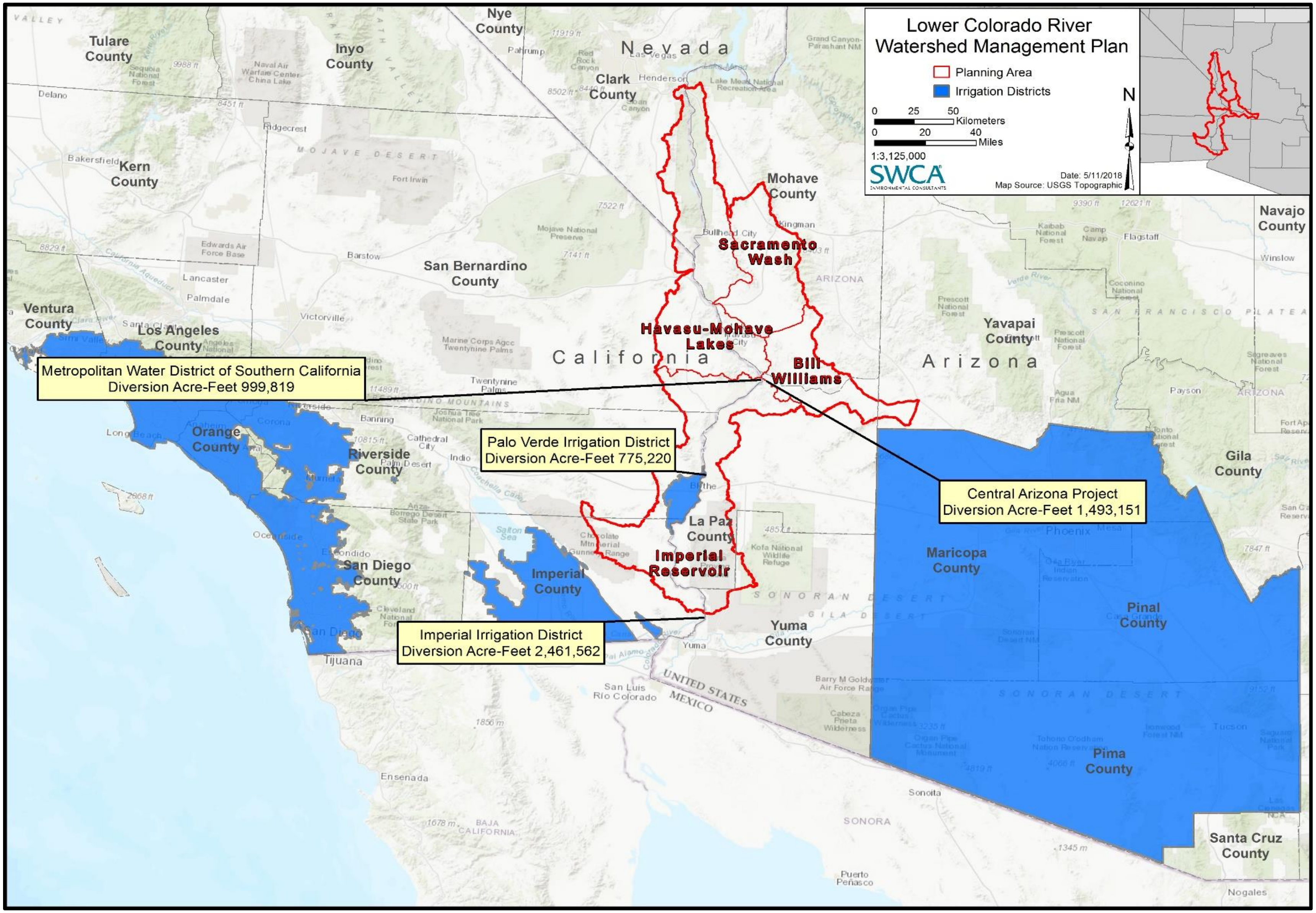


Figure 2-7. Water District consumption and diversion points.

2.3.8.4 *Water Entitlements*

Community water systems in the planning area are described in Table 2-11.

Table 2-11. Water Systems and Annual Water Entitlement in the Planning Area

State	Water User	Annual Water Entitlement (acre-feet)
NWR		
Arizona	Cibola NWR	16,793
	Havasu Lake NWR	37,399
	Imperial NWR	23,000
Federal Establishments		
Arizona	Bureau of Reclamation (Davis Dam)	100
	Department of Army (Yuma Proving Ground)	1,129
	Department of Navy (MCAS)	3,000
	Bureau of Land Management	4,010
California	Bureau of Land Management	2,150
Nevada	Bureau of Reclamation (Includes Sportsman Park)	300
	Lake Mead National Recreation Area	2,000
State and Local Establishments		
Arizona	Bullhead City	17,349
	Lake Havasu PWS	21332
	Town of Parker Municipal System	1,030
	Town of Quartzsite PWS	1,070
	City of Somerton	750
	Arizona Game and Fish Commission	2,838
	Salt River Pima – Maricopa Exchange	48,522
	Yuma Mesa Division Gila	250,000
	Wellton-Mohawk Irrigation and Drainage District	278,000
	Mohave County Water Authority (MCWA)	18,500
	Gila Monster Farms	1,435
	Arizona State Land Department	8,141
California	City of Needles	12,760
	City and/or County of San Diego	112,000
Nevada	Boulder City	5,876
	City of Henderson	15,878
	Southern Nevada Water Authority (U.S. Department of the Air Force)	4,000
Water Districts		
Arizona	Golden Shores Water Conservation District	2,000
	Mohave Valley Irrigation and Drainage District	35,060
	Mohave Water Conservation District	1,800
	Cibola Valley Irrigation and Drainage District	9,126
	Central Arizona Water Conservation District	1,415,000
California	Palo Verde Irrigation District	219,780

	Imperial Irrigation District	2,900,000
	Metropolitan Water District	1,100,000
	The Metropolitan Water District of Southern California	180,000
	Coachella Valley Water District	100,000
Nevada	Las Vegas Valley Water District	15,407
	Big Bend Water District	10,000
Miscellaneous Establishments (Demands greater than 1,000 acre-feet)		
Arizona	University of Arizona	1,088
	Gila Monster Farms	6,285
	EPCOR Water Arizona, Inc.	1,434
	Beattie Farms Southwest	1,110
	ChaCha, LLC	2,100
	GSC Farm, LLC	2,913
	JRJ Partners, LLC	1,080
	Rayner Ranches	4,500
Nevada	Basic Water Company	8,208
	Southern Nevada Water Authority	322,950
Tribal Establishments		
Arizona	Ak-Chin Indian Community	50,000
	Salt River Pima-Maricopa Indian Community	22,000
	Cocopah Indian Reservation	2,026
	Hopi Tribe	4,278
	Colorado River Indian Reservation	56,846
	Fort Yuma Indian Reservation	71,616
	Fort Mojave Indian Reservation	16,720
California	Chemehuevi Indian Reservation	11,340
Nevada	Fort Mojave Indian Reservation	12,534

Source: Reclamation (2017g, 2017h, 2017i)

In 2008, the Cibola Valley IDD volume was adjusted to transfer water back to the Bullhead and Lake Havasu increasing their water entitlement by 2,139 ac-ft.

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Chapter 3 Watershed Conditions

3.1 WATER QUALITY STANDARDS

3.1.1 Designated and Desired Uses

According to the EPA, the primary criterion for water quality is whether the waterbody meets designated uses. The Water Quality Standards Regulation (40 CFR 131) "established the requirements for states and tribes to review, revise, and adopt water quality standards. It also establishes the procedures to review, approve, disapprove and promulgate water quality standards pursuant to section 303 (c) of the Clean Water Act (CWA)" (EPA, 2018). Each state must specify appropriate water uses to be achieved and protected. Arizona, California, and Nevada water quality programs established designated uses of water. The goal of CCRSCo is to have all waters of the area meet all designated uses. Not all uses are attainable, but they can serve as water quality goals.

Table 3-1 through Table 3-3 show designated uses for Arizona, California, and Nevada surface waters in the Planning Area.

Table 3-1. Designated Uses and General Definition for Arizona Surface Water Standards

Designated Use	Abbreviation	General Definition
Full-body contact	FBC	Use of surface water for swimming or other recreational activities that cause the human body to be completely submerged.
Partial-body contact	PBC	Use of surface water for swimming or other recreational activities that cause the human body to be exposed to water not to the point of complete submergence.
Domestic water source	DWS	Surface water used for potable water.
Fish consumption	FC	Humans using surface water to harvest aquatic organisms for consumption.
Aquatic and wildlife (cold water)	A&Wc	Surface water used by animals, plants or other cold-water organisms occurring in elevation greater than 5,000 feet.
Aquatic and wildlife (warm water)	A&Ww	Surface water used by animals, plants or other cold-water organisms occurring in elevation less than 5,000 feet.
Aquatic and wildlife (ephemeral)	A&We	Animals, plants or other organisms that use ephemeral water.
Aquatic and wildlife (effluent-dependent water)	A&Wedw	Effluent-dependent waters used by plants, animals or other organisms for habitation, growth, or propagation.
Agricultural irrigation	AgI	Surface water used for crop irrigation.
Agricultural livestock watering	AgL	Surface water is used as a water supply for consumption by livestock.

Source: (ADEQ 2009)

Table 3-2. Designated Uses and General Definition for California Surface Water Standards

Designated use	Abbreviation	General Definition
Municipal and domestic supply	MUN	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
Agriculture supply	AGR	Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
Aquaculture	AQUA	Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.
Industrial service supply	IND	Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
Ground water recharge	GWR	Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting salt water intrusion into fresh water aquifers.
Water contact recreation	REC I	Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs.
Non-contact water recation	REC II	Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Warm freshwater habitat	WARM	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Cold freshwater habitats	COLD	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Wildlife habitat	WILD	Uses of water that support terrestrial ecosystems including, but not limited to, the preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
Hydropower generation	POW	Uses of water for hydropower generation.
Freshwater replenishment	FRSH	Uses of water for natural or artificial maintenance of surface water quantity or quality.
Preservation of rare, threatened, or endangered species	RARE	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

Source: CWB 2018

Table 3-3. Designated Uses and General Definition for Nevada Surface Water Standards

Designated use	Abbreviation	General Definition
Watering of livestock	Livestock	The water must be suitable for the watering of livestock without treatment.
Irrigation	Irrigation	The water must be suitable for irrigation without treatment.
Aquatic life	Aquatic	The water must be suitable as a habitat for fish and other aquatic life existing in a body of water. This does not preclude the reestablishment of other fish or aquatic life.
Recreation involving contact with water	Contact	There must be no evidence of man-made pollution, floating debris, sludge accumulation or similar pollutants.
Recreation not involving contact with water	Noncontact	The water must be free from: (1) Visible floating, suspended or settled solids arising from human activities; (2) Sludge banks; (3) Slime infestation; (4) Heavy growth of attached plants, blooms or high concentrations of plankton, discoloration or excessive acidity or alkalinity that leads to corrosion of boats and docks; (5) Surfactants that foam when the water is agitated or aerated; and (6) Excessive water temperatures.
Municipal or domestic supply	Municipal	The water must be capable of being treated by conventional methods of water treatment in order to comply with Nevada's drinking water standards.
Industrial supply	Industrial	The water must be treatable to provide a quality of water that is suitable for the intended use.
Propagation of wildlife	Wildlife	The water must be suitable for the propagation of wildlife and waterfowl without treatment.
Water of extraordinary ecological or aesthetic value	Aesthetic	The unique ecological or aesthetic value of the water must be maintained.
Enhancement of water quality	Enhance	The water must support natural enhancement or improvement of water quality in any water that is downstream.
Marsh	Marsh	Maintenance of freshwater marsh

Source: NDEP 2018

Additionally, designated uses are uses of the watershed that are desired by local residents that have not been achieved. Desired uses of water in the LCR watershed are as follows:

- Stormwater Management – Infrastructure exists that regulates flow of stormwater throughout the LCR area and protects against flooding downstream. To better manage the runoff, increased structural and vegetative options must be analyzed.
- Native Vegetation – Native plants, shrubs, grasses, and trees have adapted to the soils and other natural resources in the LCR area. These species contain extensive, deep root systems that prevent erosion. The watershed is in need of native landscape restoration and preservation of what remains in the watershed.

3.1.2 Numeric Criteria State Standards

Water quality standards for the Arizona, California, and Nevada states within the planning area are presented in Table 3-2.

Table 3-2. Arizona, California, and Nevada Water Quality Standards or Criteria

Water Quality Parameter and Unit	Units	Arizona Water Quality Standard or Criteria	California Water Quality Standard or Criteria	Nevada Water Quality Standard or Criteria
Dissolved Oxygen (DO)	Milligrams per liter (mg/L)	Cold water aquatic resources: 6.0	Warm: 5.0	Livestock, Aquatic, Contact, Noncontact, Municipal, and Wildlife:
		Warm water aquatic resources: 7.0	Cold: 8.0	Max: >6.0
			Warm and Cold: 8.0	
Temperature (T, Temp)	Celsius (°C)	Cold water aquatic resources: not to increase 1.0	Not to be altered by discharges of wastewater	Aquatic and Contact:
		Warm water aquatic resources: not to increase 3.0		Max: <2
		Effluent-dependent water aquatic resources: not to increase 3.0		
Turbidity (Turb)	Nephelometric Turbidity Unit (NTU)	Full-body contact: Not to exceed 50 NTU in streams or 25 NTU in lakes	Waters shall be free of changes in turbidity	Aquatic and Municipal:
		Aquatic and wildlife cold: not to exceed 10 NTU in rivers, streams other flowing waters, lakes, reservoirs, tanks and ponds		Max: <10
		Aquatic and wildlife warm: not to exceed 50 NTU in rivers, streams, and other flowing waters. Not to exceed 25 NTU in lakes, reservoirs, tanks and ponds		
pH	Standard Units	Domestic water source: max: 9.0 and min: 5.0	Max: 9.0	Livestock, Irrigation, Aquatic, Contact, Municipal, Industrial, and Wildlife:
		Full-body contact, Partial-body contact, Aquatic and Wildlife: max: 9.0 and min: 6.5	Min: 6.0	Max: 9.0
		Agricultural livestock watering: max: 9.0 and min: 6.5		Min: 6.5
		Agricultural irrigation: max: 9.0 and min: 4.5		
E. coli	(/100 milliliters (mL) or Maximum probable number/100 mL)	Full-body contact:	REC I:	Contact and Noncontact:
		Geometric Mean: 126	Geometric mean: 126	Geometric mean: 126
		Single sample max: 235	Max: 235	Max: 235
		Partial-body contact:	REC II:	

Water Quality Parameter and Unit	Units	Arizona Water Quality Standard or Criteria	California Water Quality Standard or Criteria	Nevada Water Quality Standard or Criteria
		Geometric mean: 126	Geometric mean: 630	
		Single sample max: 575	Max: 1175	
Salinity	mg/L	Below Hoover Dam: not to exceed 723	Same as Arizona	Same as Arizona
		Below Parker Dam: not to exceed 747		
		At Imperial Dam: not to exceed 879		
Sedimentation	mg/L	Aquatic and wildlife cold: 25	Suspended sediment load and suspended discharge rate to surface waters shall not adversely affect beneficial uses.	Same as California
		Aquatic and wildlife warm: 80		
Chlorophyll a	Microgram per liter (μg/L)	Low: <10	Same as Arizona	Same as Arizona Low
		Moderate: 10-15		
		High: 50-5,000		
		Very High: >5,000		
Total dissolved solids (TDS)	mg/L	500 mg/L	Avg: 4000	Irrigation and Municipal:
			Max: 4500	Max: $\leq$1000
Total suspended solids (TSS)	mg/L	Aquatic and wildlife cold: 25		Aquatic:
		Aquatic and wildlife warm: 80		Max: $\leq$25
Alkalinity (Alk)	mg/L (as calcium carbonate)	The CCC of 20mg/L is a minimum value except where alkalinity is naturally lower, in which case the criterion cannot be lower than 25% of the natural level	Same as Arizona	Same as Arizona
Total phosphorus (P, TP)	μg/L	0.10 for marine or estuarine water		Aquatic, Contact, Noncontact, Municipal:
				Max: $\leq$0.05 (mg/L)
Total nitrogen (N, TKN)	mg/L	2 to 6 mg/L	Same as Arizona	Same as Arizona
Nitrate (NO_3)	mg/L	10.0 mg/L	Same as Arizona	Same as Arizona
Ammonium (NH_4)	mg/L	Aquatic and wildlife (cold)	FRESH:	Same as Arizona
		Acute: 24.1 at pH 7.0	4-day average: 0.49	
		Chronic: 4.15 at pH 7.0 an 20ºC	1-hour average: 1.77	
		Aquatic and wildlife (effluent-dependent, warm)		
		Acute: 36.1 at pH 7.0		

Water Quality Parameter and Unit	Units	Arizona Water Quality Standard or Criteria	California Water Quality Standard or Criteria	Nevada Water Quality Standard or Criteria
		Chronic: 4.15 at pH 7.0 an 20ºC		
Sulfate (SO_4)	mg/L	250 mg/L	Recommended level: 250 mg/L	Same as Arizona
			Upper level: 500 mg/L	
Chloride (Cl)	mg/L	250 mg/L	FRESH:	Same as Arizona
			4-day average: 230	
			1-hour average: 860	

Source: ADEQ (2009), California Water Board (2016), and Nevada Legislature (2018)

3.1.3 Antidegradation Policies/Procedures

The antidegradation policy (40 Code of Federal Regulations 131.12) is a vital component of water quality standards, and has important management implication throughout the LCR. Antidegradation does not mean "no degradation" can or may happen. Degradation is permitted in the most pristine waters for various pollutants as long as it is temporary and short-term in nature (ADEQ 2009). Antidegradation regulations help to ensure the following in three tiers:

Tier 1 – The level of water quality necessary to support an existing use shall be maintained and protected. Degradation is prohibited of existing water quality is permitted in a surface water where the existing water quality does not meet the applicable water quality standards.

Tier 2 – Where existing water quality in a surface water is better than the applicable water quality standard the existing water quality shall be maintained and protected. Degradation to waters may be allowed if the Director finds all of the following:

a. The water quality necessary for existing uses is fully protected and water quality is not lowered to a level that does not comply with applicable water quality standards;
b. The highest statutory and regulatory requirements for new and existing point sources are achieved;
c. All cost-effective and reasonable best management practices for nonpoint source pollution control are implemented; and
d. Allowing lower water quality is necessary to accommodate important economic or social development in the area where the surface water is located.

Tier 3 – Existing water quality shall be maintained and protected in a surface water that is classified as an Outstanding Arizona Waters, Outstanding California Waters, or Outstanding Nevada Waters.

3.2 AVAILABLE MONITORING / RESOURCE DATA

Multiple entities that monitor water quality within the watershed are summarized in Table 3-3.

Table 3-3. Available Water Monitoring Data

Watershed	Survey Years	Monitoring Organization
Havasu-Mohave Lakes	1977–2015	ADEQ, California State Water Resources Control Board (CSWRCB), Nevada Division of Environmental Protection (NDEP), EPA, National Park Service Water Resources Division (NPSWRD), MWD, Chemehuevi Tribe, Reclamation, and CAP
Imperial Reservoir	1989–2015	ADEQ, CSWRCB, Reclamation, and EPA
Detrital Wash	1977–1989	ADEQ and NPSWRD
Sacramento Wash	1977–2013	ADEQ, NPSWRD, and Hualapai Tribe
Yuma Desert	1985–2014	ADEQ, Cocopah Tribe, Reclamation, and Quechan Indian Tribe
Bill Williams	1989–2007	ADEQ, North American Lake Management Society, and EPA
Lower Gila	1988–2012	ADEQ and EPA
Tyson Wash	1988–2016	ADEQ

Source: EPA (2017f)

From 2003 to 2005, ADEQ analyzed wells in the Lake Mohave groundwater basin (MHV) extending over 1,000 square miles along the Colorado River from Hoover Dam south to Topock. Forty-three sites were sampled and nine (21%) met all federal water quality standards, established under the Safe Drinking Water Act. ADEQ determined 15 sites (35%) had exceeded maximum contaminant levels (MCL) of contaminants that affect health-based standards (ADEQ 2005). Based on the analysis of MHV by ADEQ, the groundwater appears to be suitable for domestic use, though drinking water concerns may arise in all basins and recharge sources (Tietjen 2014).

Lake Havasu has been monitored for water quality, by ADEQ, from 1991 to 2009 and then again from 2015 to present. Reclamation and MWD continue to monitor Alamo Lake water quality today. The Chemehuevi Tribe began monitoring Lake Havasu around 2010 and continues through today (Reclamation 2017j).

3.2.1 Water Quality Data (Impairments/Threats)

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters that do not meet state standards for water quality. ADEQ compiles the 303(d) list from existing scientific data and best professional judgement to assess water quality and decide which waters to list. Table 3-4 shows the Section 303(d) waters in the LCR.

Table 3-4. Listed Impaired Waters

Subwatershed	State	Location	Causes of Impairment	Waterbody Type	Date
Bill Williams	AZ	Bill Williams River, From Alamo Lake to Castaneda Wash	Ammonia	River	2006
	AZ	Alamo Lake	High pH, ammonia and mercury in fish tissue	Freshwater Lake	2010
Colorado-Lower Gila Watershed	AZ	Lake Mohave	Selenium	Freshwater lake	2010
	AZ	Colorado River, From Hoover Dam to Lake Mohave	Selenium	River	2004
	AZ	Colorado River, Main Canal to Mexico border	Selenium	River	2006
	NV	From Lake Mohave to NV-CA State Line	Temperature	River	2012
Imperial Reservoir	CA	Colorado River, Imperial Dam to California-Mexico border	Selenium	River	2006
	CA	Colorado River, Lake Havasu Dam to Imperial Dam	Toxicity	River	2006
	CA	Colorado River, CA-NV State line to Lake Havasu	Toxicity	River	2010
	CA	Palo Verde Outfall Drain and Lagoon	DDT	River	2006

Source: ADEQ (2014), CWB (2018)

3.2.2 Flow Data

The lower Colorado River is a highly regulated system. Flow fluctuations are a result of changes in reservoir operations related purposes outlined by the Boulder Canyon Operations Act for the operation of Hoover Dam: Flood control/river regulation and/or water conservation/to meet downstream water orders.

As of 2016, over 40 gaging stations monitor the flow of the LCR region stretching along the Colorado River between Hoover Dam and the Southern International Boundary with Mexico. Water demand in the Colorado River Basin has continually increased since the early 1900s while water supply has decreased. According to the DOI's Open Water Data Initiative report "Drought in the Colorado River Basin – Insights Using Open Data (DOI 2017a), flow has declined in the last decade due to consumptive use, drought, delivery, and climate change, concerning many communities in and around the planning area. The river continues to decline from daily loss of flow regimented by Reclamation. Less flow makes it harder for aquatic species to survive and the flow has declined so much that AGFD no longer conducts surveys with Parker Planning Division. Average annual natural flow has decreased narrowing the difference between water supply and water demand. The decrease in flows and increase in water use of the Colorado River system is over-used according to Reclamation. Flow fluctuations are projected from climate change that could have potentially longer, more severe wet and dry periods.

During the past 20 years, average water use and average water supply have been nearly equal, leading to reservoirs' refilling more slowly (USGS 2017c). The reservoirs of Lake Mead and Lake Powell have continually declined, affecting other resources like recreation, hydropower, and water quality (see Table 3-5). Between 2001 and 2015, Lake Mead's elevation dropped from 1,196 to 1,080 feet, a 116-foot decline (Reclamation 2015). As Lake Mead declines, the Lower Basin of the Colorado River gets closer to water shortage conditions.

Reclamation publishes The Lower Colorado Historical River Stream Flow Records for Calendar Years 2008 through 2015 (https://www.usbr.gov/lc/region/g4000/PubStreamFlow/index.html, accessed June 26, 2018). During the record, diversions at the Fort Mojave Tribe – Refuge – Fort Mojave Tribe and Vanderslice Pumps (decreased over 42% and Fort Mojave Tribe – Cimarron decreased by 21%. Over the same period diversions at MWD —Lake Havasu increased by over 68% and Fort Mojave Tribe – South Casino by over 51%. Records of annual discharge and percent change is presented in Table 3-6. Gaging and pumping station locations are depicted in Figure 3-1, below.

There are many factors contributing to water users taking more or less water in any given year. An example to illustrate these factors is the change in MWD diversions between 2015 and 2017. Due to severe drought in 2015, MWD increased diversions and their ability to take delivery of water they stored in Lake Mead. Diversions decreased in 2017 because conditions were met in California and water could be stored in Lake Mead again.

Table 3-5. Mean Reservoir Levels in Feet, 1990–2015

Reservoir	1990	2000	2010	2015
Lake Powell	3646.14	3678.11	3628.63	3601.47
Lake Mead	1,183.24	1,204.22	1,091.56	1,080.48
Lake Mohave	638.37	640.32	640.72	641.1
Lake Havasu	447.36	447.16	448	447.83

Source: Reclamation (2015)

Table 3-6. Gaging and Pumping Stations Discharge and Percent Change, 2011 to 2015

Type	Gaging/Pumping Station Name	Annual Mean Discharge (cfs) (2011)	Annual Mean Discharge (cfs) (2015)	Change (%)
Colorado River Gaging Stations	Colorado River Below Big Bend	13,230	13,300	0.53%
	Colorado River Below Needles Bridge	11,060	11,780	6.51%
	Colorado River at River Section 41	12,770	12,800	0.23%
	Colorado River Parker	8,457	7,810	−7.65%
	Colorado River Water Wheel	8,285	7,893	−4.73%
	Colorado River Below Palo Verde Dam	7,061	N/A	N/A
	Colorado River Below Interstate Bridge	7,648	6,918	−9.54%
	Colorado River Below McIntyre Park	7,747	7,024	−9.33%
	Colorado River at Taylor Ferry	7,812	7,313	−6.39%
	Colorado River Below Oxbow Bridge	7,789	7,159	−8.09%
	Colorado River Cibola	8,109	7,459	−8.02%
	Colorado River at Picacho Park	N/A	7,599	N/A
	Colorado River at Martinez Lake	N/A	7,538	N/A

Type	Gaging/Pumping Station Name	Annual Mean Discharge (cfs) (2011)	Annual Mean Discharge (cfs) (2015)	Change (%)
USGS Gaging Stations	Palo Verde Irrigation District (PVID) C Canal	N/A	N/A	N/A
	PVID D23 Spill	N/A	N/A	N/A
	PVID F-Canal Spill	N/A	N/A	N/A
	Palo Verde Canal	N/A	N/A	N/A
	Palo Verde Drain	N/A	N/A	N/A
	Poston Wastewater	N/A	N/A	N/A
	Gardner Lateral Spill	N/A	N/A	N/A
	Colorado River Indian Reservation Main Canal	N/A	N/A	N/A
	Bill Williams River below Alamo Dam	N/A	N/A	N/A
Lake Gaging Stations	Lake Mohave at Davis Dam	N/A	N/A	N/A
	Lake Havasu at Parker Dam	N/A	N/A	N/A
Diversion and Return Gaging Stations	Fort Mojave Tribe - Nevada	4	4.3	7.5%
	Fort Mojave Tribe - North Casino	15.9	15.8	−0.6%
	Fort Mojave Tribe - North Casino - North Event Center	1.6	2.6	62.5%
	Fort Mojave Tribe - South Casino	7.4	11.2	51.4%
	Fort Mojave Tribe - California 2 - North, South and West Pumps	1.7	2.3	35.3%
	Fort Mojave Tribe - California 1	12	13.5	12.5%
	Fort Mojave Tribe - Cimarron	11.2	8.8	−21.4%
	Fort Mojave Tribe - Willow	40.2	39.1	−2.7%
	Fort Mojave Tribe - Barrackman	13	11.9	−8.5%
	Fort Mojave Tribe - Refuge - Fort Mojave Tribe and Vanderslice Pumps	2.6	1.5	−42.3%
	USFWS - Inlet Canal	5.2	N/A	N/A
	USFWS - Farm Ditch	11.2	8	−28.6%
	USFWS - South Dike	-11.4	-0.8	−93.0%
	Metropolitan Water District at Lake Havasu	969	1,630	68.2%
	CAP at Lake Havasu	2,236	2,090	−6.5%
	PVID - Main Canal	1,156	1,161	0.4%
	PVID - Outfall Drain	487	490	0.6%

Source: Reclamation (2015)

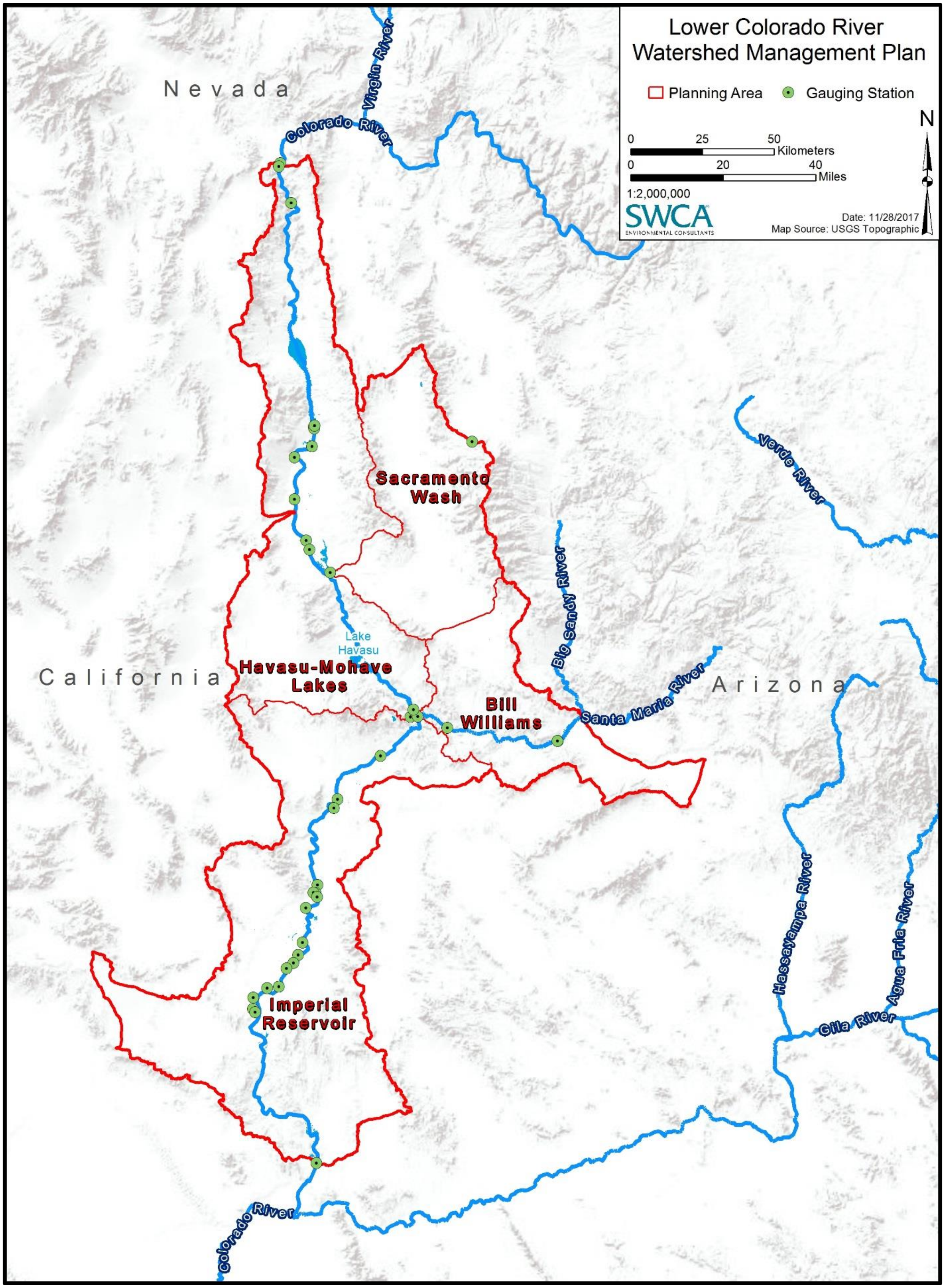

Figure 3-1. Gaging stations along the Lower Colorado River.

3.2.3 Biological Data

Aquatic species in the LCR help gauge in determining stream water quality. Macroinvertebrates, including insects, crustaceans, and mollusks, are used most to determine water quality with biological monitoring and bioassessment. ADEQ manages the Bioassessment Program by evaluating the various fish and macroinvertebrate populations within polluted streams to provide useful comprehensive data on health of the overall watershed and provide water quality details not easily detected via chemical means (National Water Quality Monitoring Council 2017). A water's true health is determined by the biology of the stream both before and after restoration.

There were no areas bioassessed in the LCR watershed, but three lie directly outside the area. Trout Creek, Burro Creek, and Santa Maria River have completed bioassessments but Burro Creek was the only station that had current Index of Biological Integrity (IBI) data. To give an idea of what the bioassessed water was like flowing into the LCR, Burro Creek reported an IBI score of 25.8, which is in violation (ADEQ 2017c). Table 3-7 exhibits the standards for IBI scores of streams through EPA.

Table 3-7. IBI Standard Scoring for Streams

Macroinvertebrate Bioassessment Sample Results	Index of Biological Integrity Score		
	Cold Water	Warm Water	Status
Greater than the 25th percentile of reference condition	$\geq$ 52	$\geq$ 50	Meeting
Greater than the 10th and less than the 25th percentile of reference condition	46 - 51	40 - 49	Inconclusive
Less than 10th percentile of reference condition	$\leq$ 45	$\leq$ 39	Violating

Source: ADEQ (2009)

There are community concerns regarding chemicals and pollutants found in fish tissue along the LCR. In 1996, a study determined various contaminants in fish populations along the LCR. The study concluded that each fish sample detected dichlorodiphenyldichloroethylene (DDE) residues with some populations containing twice the national mean. DDE was highest in fishes near agricultural drainage areas (USFWS 1996). All trace metals were detected in some fish to include arsenic, cadmium, copper, lead, mercury, selenium, and zinc.

Recent data suggest pesticide residues continue to be detected throughout the LCR. Fish tissues collected and analyzed exceeded California's maximum tissue residue level for several pesticide constituents. Mercury, selenium, chlordanes, dichloro-diphenyl-trichloroethanes (DDTs), dieldrin, polychlorinated biphyls (PCBs), and toxaphene have been found in fish tissue samples in 2014 at various levels (California Office of Environmental Health Hazard Assessment [COEHHA] 2017). Table 3-8 lists contaminants found in fish samples in Lake Havasu.

In a study from 2015, researchers assessed biotic condition from lakes Mead and Mohave. Overall, the lakes' conditions warrant concern for native fish populations, yet sport fish populations were sufficient to support recreational fishery. In 2014 and 2015, angler catches were higher than historic rates (NPS 2017). Native fish populations have not seen the same success and neither lake supports self-sustaining populations of native species. Increased non-native species continue to warrant concern on benthic macroinvertebrates. Various native populations have declined dramatically i.e., native razaorback sucker populations in Lake Mohave once numbered over 60,000 individuals in the 1980s to nearly 5,000 individuals in 2015 (NPS 2017).

Alamo Lake was listed as impaired in 2002 due to high levels of mercury in fish tissues (see Table 3-8). AGFD and ADEQ issued a fish consumption advisory in mid-2003; therefore, total maximum daily loads (TMDLs) were calculated for the lake and its watershed. TMDLs refer to the total load of a pollutant that can be discharged to a body of water on a daily basis. The biggest contribution of mercury to the LCR is associated with the delivery of large amounts of suspended sediment during large runoff events (ADEQ 2012b). There was a large runoff event in 2004/2005 that increased mercury levels in the Lake. ADEQ's efforts to mitigate these inputs requires locating point sources (e.g. old mining developments) or implementing sediment runoff control measures. To date, the maintenance on the issue continues. Researchers examine water elevation, alternative discharge elevations, aeration, and pump-back, which could have the potential to break stratification and reduce mercury loads (ADEQ 2012b).

Table 3-8. Fish Samples Evaluated for the Lake Havasu Advisory Committee

Species Name	Number of Samples	Total Number of Fish	Year	Contaminants Analyzed
Bluegill (*Lepomis macrochirus*)	4	20	1987, 2014	Hg, Se
Channel Catfish (*Ictalurus punctatus*)	5	40	2014	Hg, Se
Common Carp (*Cyprinus carpio*)	5	40	2007	Hg, Se, chlordanes, DDTs, dieldrin, PBDEs, and PCBs
Largemouth Bass (*Micropterus salmoides*)	40	75	2014	Hg, Se, chlordanes, DDTs, and dieldrin
Redear Sunfish (*Lepomis microlophus*)	2	15	2014	Hg, Se
Striped Bass (*Morone saxatilis*)	41	60	2014	Hg, Se, chlordanes, DDTs, dieldrin, PCBs, and toxaphene

Source: USFWS (1996)
DDTs = dichlorodiphenyltrichloroethane (DDT), dichlordiphenyldichloroethane (DDD), dichlorodiphenyldichlorothylene (DDE)
Hg = Mercury
PBDEs = polybrominated diphenyl ethers
PCBs = polychlorinated biphenyls
Se = Selenium

3.2.4 Foam

Foam on surface water of a waterbody is mostly produced naturally and is not an indicator of pollution. Naturally formed foam is not a health hazard, but its formation eradicates dissolved oxygen in the water, and can lead to fish deaths. Often times, however, naturally occurring foam in pools offers protection for fish and other aquatic species (New Hampshire Department of Environmental Services [NHDES] 2001). Foam is created when the surface tension of the water (attraction of surface molecules to each other) is reduced and air is mixed in, forming bubbles.

Water bodies throughout the planning area contain organic matter, like algae and plants. Once these decompose, they release cellular products, lowering surface tension. The agents on the surface of the water are blown in the wind, agitating them, thus transferring into a sudsy white foam (NHDES 2001). Boats and currents have the ability to produce foam by mixing air with organic products present in the lake.

Community members in the LCR have concerns with sightings of lake foaming. Foam in the LCR has been observed on Lake Havasu, below Parker Dam, and below Headgate Rock Dam in Parker, Arizona. In 2011, large amounts of foam occurred in these areas for two to three days. The foam was collected and tested, resulting in no unusual concentrations of surfactants, phosphates, or dissolved organic carbon.

The cause of the increased foam levels was suspected to come from the turnover of water as Lake Havasu destratified from its summer condition (CCRSCo 2017). Since the unusually high foam formed in 2011, only minor foam events have occurred in localized areas within the LCR.

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Chapter 4 Pollutant Source Assessment

Pollutants transported in runoff, including stormwater, agricultural and urban runoff are categorized as either point source or nonpoint source.

4.1 NONPOINT SOURCES

Nonpoint source pollution is the primary path that contaminants enter the Lower Colorado River and its tributaries. Nonpoint source pollutants come from various origins like streets, parking lots, agricultural fields, forested lands and other areas within the watershed. Nonpoint source pollutants travel through watersheds via surface and groundwater and each substance is transported differently at various rates. These pollutants increase stressors on biotic organisms, impair water quality, cause water to become unsafe for human consumption, and alter trophic level functions. Nonpoint source pollutants nutrients, bacteria, and total suspended sediments (TSS) have been identified to be impairing various waterbodies in the LCR watershed.

4.1.1 Agriculture

The leading source of water quality impacts to rivers and lakes comes from agricultural nonpoint sources. Nonpoint source pollution from agricultural practices include runoff from barnyards, feedlots and cropland carrying away manure, fertilizers, ammonia, pesticides, livestock waste, oil, toxins from farm equipment, soil, and sediment.

Fertilizers, manure and waste produce nitrogen, which, at high levels, can deplete the oxygen in water and can potentially kill off fish and wildlife inhabiting the water system. Nitrates from agricultural runoff can soak into the ground polluting groundwater, and pesticides, ammonia and other toxins from farm equipment impair or kill aquatic life (EPA 2018). The majority of toxicity data produced in the planning area are influenced primarily from agricultural runoff because there are few major urban areas in the planning area (Anderson, et al. 2012).

Agricultural field in LCR.
Source: Reclamation, 2015c.

4.1.2 Grazing

Grazing livestock and pasture production affects water quality both negatively and positively. Good management practice for forage production protect soil surfaces from erosion, compared with traditionally produced crops. Grazing animals and pasture production can affect water quality negatively by means of erosion and sediment transport into surface waters, by way of nutrients from urine and feces dropped by the animals and fertility practices associated with production of high-quality pasture, and through pathogens from the waste. Refer to Section 4.1.2.1.1 for information on wild horse and burro grazing.

4.1.2.1 ***Cattle***

Currently, there are 53 grazing allotments in the vicinity of the LCR. Table 4-1 represents the 10 largest grazing allotments in the planning area; see Figure 4-1. The remaining 43 allotments not listed represent less than 0.5% of land in the LCR.

Domestic livestock grazing is permitted on BLM and U.S. Forest Service lands. Overgrazing has resulted in loss of habitat to big game species, declines in small game and nongame wildlife, and significant declines in water quality in streams.

Livestock grazing has affected the planning area by altering and reducing vegetation along stream banks or by eliminating riparian areas by channel aggradation, lowering the water table, or channel widening (Armour et al. 1990). For various aquatic species, this reduces food, shade, and cover increasing stream temperature.

Considerable documentation indicates that cattle grazing increases sedimentation along stream channels due to soil erosion (Leopold 1975). These practices may affect the water quality of runoff by increased aquatic vegetation contamination, additional nutrient inputs, depleted oxygen levels through biological decay, and increased turbidity and sedimentation (Armour et al. 1990). Increased sedimentation, from grazing, is expected to affect the macroinvertebrate community by providing spawning habitat, new food locations, and protection from predation (Wiitala, 2013). Immediate effects of overgrazing are streambed trampling and loss of vegetation along stream bank.

Table 4-1. Grazing Allotments in LCR

Grazing Allotment Name	Total Acres in LCR	Percent of Acres in LCR
Planet	297,633.39	4.32%
Big Ranch Unit B	250,049.00	3.63%
La Cienega	240,877.00	3.50%
Crossman Peak	200,720.20	2.91%
Primrose	156,403.57	2.27%
Chicken Springs	134,939.40	1.96%
Ganado	130,436.70	1.89%
Walnut Creek	125,953.00	1.83%
Black Mountain	120,457.10	1.75%
Ehrenberg	113,108.00	1.64%

Source: Armour et al. (1990)

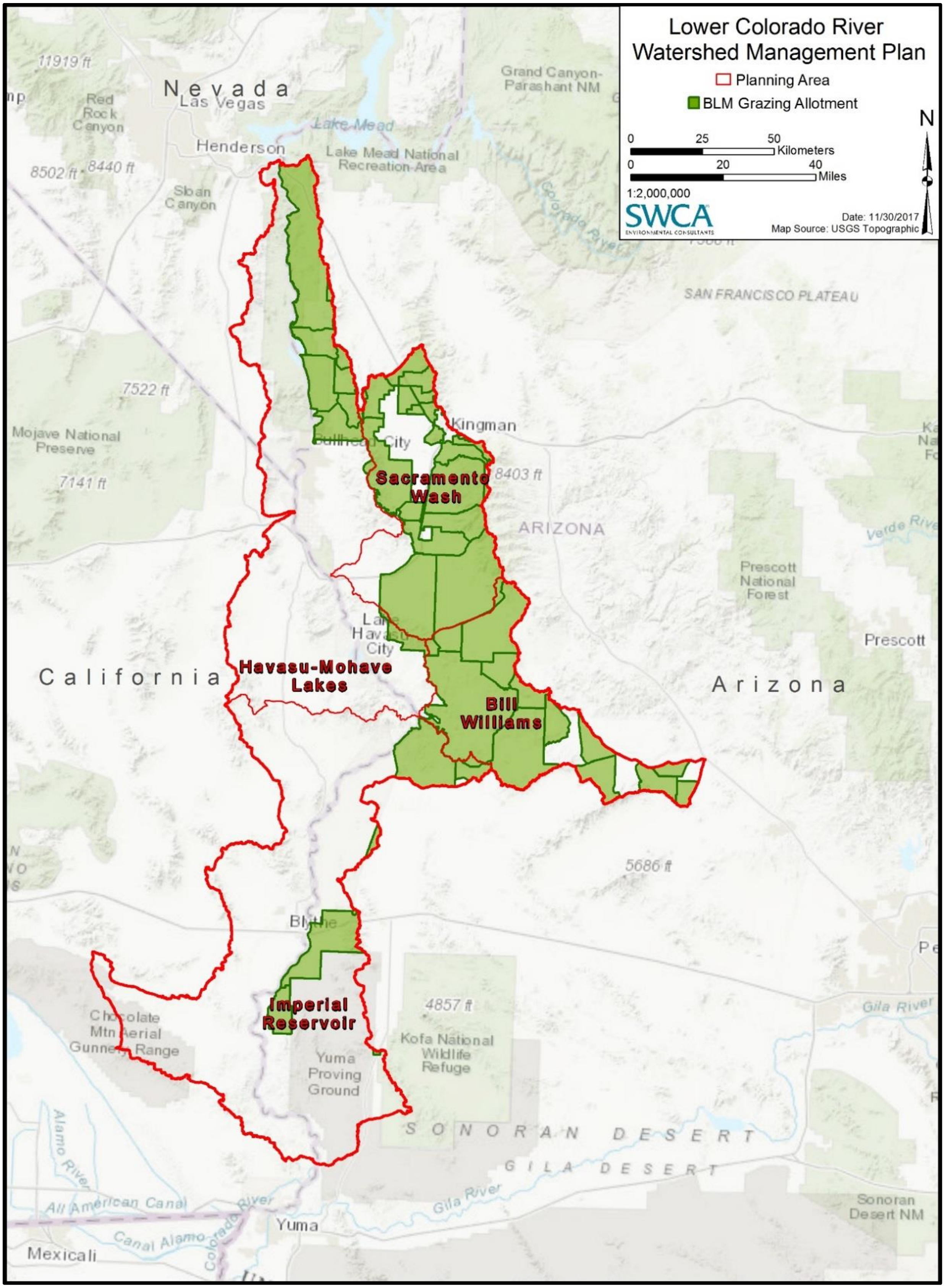

Figure 4-1. Grazing allotments in the planning area.

4.1.2.1.1 FERAL HORSES, BURROS, AND HOGS

Feral horses and burros are invasive species, but many consider them native because they were introduced to the Southwest in the 1600s. These species have no natural predators and if not managed effectively can overpopulate, potentially destroying an ecosystem.

Wild burros are widespread along the Colorado River, where populations have not been efficiently managed to limit damage to the ecosystem. Herds are over-populated in areas ranging from Bullhead City to Lake Havasu City. Burros also occur in a variety of topographic areas. Today there are roughly 540 burros (240 in Arizona and 300 in California). The burros are managed in an ecological balance within their habitat to protect forage plants. If the vegetative monitoring sites show that burro populations are exceeding the Appropriate Management Level, currently at 320 individuals BLM will remove some of the individuals and/or offer them to the public through an adoption program (BLM 2018)

Wild burro in LCR
Source: Swanberg, 2013

Wild horses are not common in the planning area region (Phillips, et al. 2015). Figure 4-2 depicts the wild horse and burro herd areas and herd management areas. The most active populations are near Parker, Arizona.

Feral hogs, another issue in the LCR, were introduced to North America over 300 years ago and are considered an invasive species by Executive Order 13112 (USFWS 2016). Feral hogs are destructive to wild lands and agriculture, and can transmit diseases and pathogens such as E. coli, Salmonella, and Giardia to domestic livestock, wildlife, and humans (University of California Agriculture and Natural Resources [UCANR] 2018). Due to their dependence on water and dietary preference for a number of riparian plants, feral hogs have caused considerable damage to riparian areas, especially the wildlife refuges. It is difficult to determine the population size and range of feral hogs due to their nocturnal nature, but they are an especially big issue in Havasu NWR (USFWS 2016). A Draft Environmental Assessment (EA) was prepared in September 2016 for a feral swine eradication plan in the Havasu NWR and implemented in February 2018 (UCANR 2018).

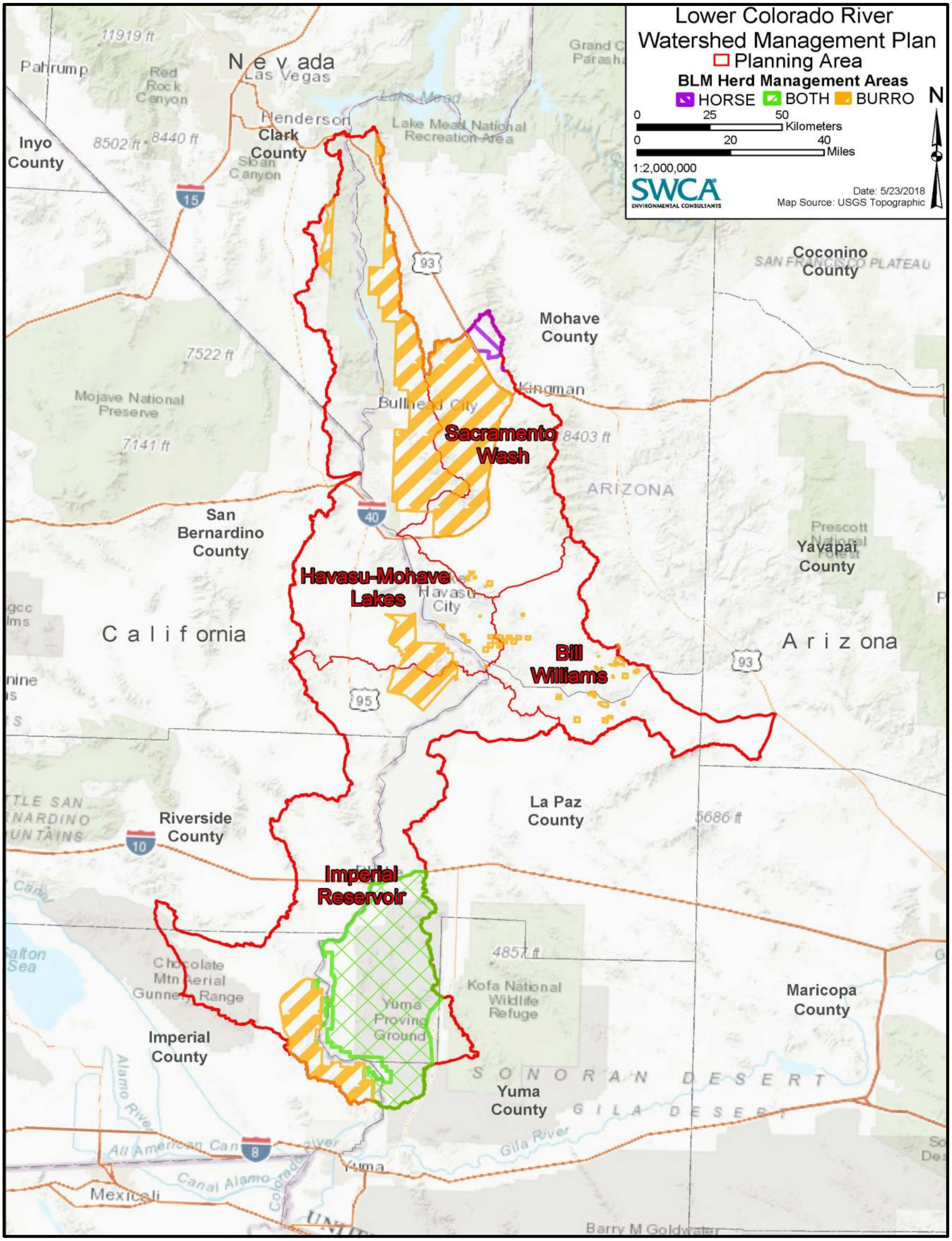

Figure 4-2. Wild horse and burro herd areas and herd management areas (BLM 2017)

4.1.3 Septic Systems

Septic tanks are used frequently in homes not connected to large sewage treatment facilities and are used throughout the LCR watershed. If properly maintained, these systems can be a safe option for domestic sewage treatment. The system consists of an underground watertight container that collects household wastewater. Solids collect at the bottom, while other wastes such as grease and soap float to the top. Anaerobic digestion decomposes the organic matter as long as it stays in the tank, partially treating the wastewater. When property maintained, septic tanks can reduce the pollutant load of effluent water.

In 1999, there were over 20,000 septic tanks within a 1-mile radius of any monitoring well in Lake Havasu City; increasing nitrate levels in the LCR (Wilson 2009). Septic tanks have potential to produce threats to water quality if not managed or maintained properly. Increased influent liquid volumes in combination with lower retention times reduces treatment, causing flooding of the leach field. For example, nitrate leaking from a septic tank can pose significant threats to human health. If ingested, nitrogen interrupts the blood's ability to carry oxygen, causing "blue baby" syndrome. Other threats from inadequately treated septic system include hepatitis, dysentery, acute gastrointestinal illness, and typhoid fever. As of 2011, over 90% of Lake Havasu City's septic tanks have been decommissioned, replaced with the Lake Havasu sewer expansion program (Wilson 2009).

4.1.4 Urban/Suburban Runoff

Developed areas make up less than one percent (0.96%) of the watershed. However, U.S. Census data show that the population is increasing in all but one of the counties in the planning area. Surface runoff and stormwater drainage systems from urban/suburban areas carry various pollutants into the watershed. Pollutants can originate from fertilizer and pesticide use, automobiles, animal farming, pet waste, failing septic systems, heavy metals from roof shingles and cars, etc. (Dressing, et al. 2016). Some of the most common pollutants in urban runoff are sediment, pathogens, nutrients, metals, and thermal pollution. Table 4-3, below, provides information about contaminants of emerging concern originating from both nonpoint and point sources that have been detected in the LCR.

Urbanization converts much of the natural landscape into an impervious surface, which reduces the absorption and filtration that typically happens to rainfall and runoff before entering a body of water. Poor infiltration rates of desert soils also contribute to this lack of filtration (Dressing, et al. 2016). Several studies have examined contaminants flowing into the LCR from runoff in suburban and urban areas. In 2017, researchers evaluated stormwater runoff from Lake Havasu City into Lake Havasu from various drainages. Fifteen sites were evaluated over 5 years and concentrations of pollutants in the area did not exceed EPA or ADEQ surface water quality standards (Wilson 2018).

Table 4-3. Present Emerging Contaminants in the Colorado River and Common Uses

Present Emerging Contaminants in the Colorado River	Common Uses
Organic Chemicals	
Acesulfame-K	Artificial sweetener
Albuterol	Bronchodilator
Atenolol	Treats angina and high blood pressure
Atrazine	Triazine class herbicide
Azithromycin	Antibiotic
Bromochloromethane (Halon 1011)	Formerly used in fire extinguishers
Butalbital	Used with acetaminophen and aspirin for headaches and pain

Present Emerging Contaminants in the Colorado River	Common Uses
Organic Chemicals	
n-Butylbenzene	Medical - induce cell death in vitro and for bioconversion
Caffeine	A psychoactive central nervous system stimulant
Carbamazepine	Treats seizures, nerve pain, or bipolar disorder
Carisoprodol	Muscle relaxant
Chlorpyrifos	Insecticide
Cotinine	An alkaloid found in tobacco; a metabolite of nicotine
Cyanotoxins	Natural group of cyclic heptapeptides produced by aquatic cyanobacteria
DEET	Insect repellent
Desethy-desisopropyl atrazine (DiA)	Herbicide - metabolite of atrazine
Diamino-s-chlorotriazine (DACT)	Herbicide
Diazinon	Insecticide
Dichlorodifluoromethane	Formerly used as an aerosol
2,4-Dichlorophenoxyacetic acid	Herbicide
Diclofenac	Nonsteroidal anti-inflammatory drug (NSAID)
Dilantin (Phenytoin)	Anticonvulsant
Diuron	Herbicide
Erythromycin	Antibiotic
Estradiol (17β-estradiol, E2)	Natural human sex hormone and steroid used to treat symptoms of menopause, osteoporosis, cancer
Estrone	One of several natural estrogens
Fluoxetine	SSRI that treats depression and obsessive-compulsive disorder
Gemfibrozil	Lowers high triglyceride and cholesterol levels
Ibuprofen	Nonsteroidal anti-inflammatory drug (NSAID)
Iohexal	Medical contrast agent
Iopromide	Medical contrast agent
MDMA (Ecstasy)	A phenethylamine and amphetamine classes of drugs widely known as Ecstasy
Meprobamate	Tranquilizer

Present Emerging Contaminants in the Colorado River	Common Uses
Organic Chemicals	
Methamphetamine	A neurotoxin and potent psychostimulant used to treat attention deficit hyperactivity disorder and helps with weight loss in obese patients
Naphthalene	Moth balls, used to make dyes, concrete, and plasterboard
Naproxen	Nonsteroidal anti-inflammatory drug (NSAID)
Nifedipine	Calcium channel blocker for chest pain and high blood pressure
4-nonyphenol	An alkyphenol ingredient of antioxidants, lubricating oil additives, detergents
4-Octylphenol	Manufacture of nonionic surfactants, plasticizers, antioxidants, fuel oil stabilizer, intermediate for resins, fungicides, bactericides, dyestuffs, adhesives, rubber chemicals octyl phenol isomers.
Oxybenzone	Ingredient in sunscreens
Polychlorinated Naphthalene	Used in insulating coatings for electrical wires, in wood preservatives, as rubber and plastic additives, and in lubricants.
Primidone	Anticonvulsant
Progesterone	Natural steroid hormone
Prometon	Herbicide
Propylparaben	Natural plant ester and synthetic cosmetic, pharmaceutical, and food additive
Quinoline	Chelating agent, used in the production of dyes
Simazine	Triazine class herbicide - inhibits photosynthesis
Sucralose	Artificial sweetener
Sulfamethoxazole	Antibiotic
Tris(2-carboxyethyl)phosphine (TCEP)	Flame retardant
Tris (1-chloro-2-propyl) phosphate (TCPP)	Flame retardant
Testosterone	A male steroid hormone used to treat breast cancer in women
Triclocarban	Antibacterial agent in personal care products
Triclosan	Antibacterial and antifungal agent in personal care products
Trimethoprim	Antibiotic

Present Emerging Contaminants in the Colorado River	Common Uses
Inorganic Chemicals	
Chromium	Natural element geologically leached and mined for use in multiple manufacturing systems
Cobalt	Natural element geologically leached and mined for use in multiple manufacturing systems
Hexavalent chromium (Chromium-6)	Used in the manufacture of paints, stainless steel, textile dyes, and wood preservatives
Microorganisms	
Cryptosporidium	N/A
Cyanobacteria (blue-green algae)	N/A

Present Emerging Contaminants in the Colorado River	Common Uses
Inorganic Chemicals	
Molybdenum	Natural element geologically leached and mined for use in multiple manufacturing systems
Perchlorate	Ingredient of explosives and fertilizers
Strontium	Natural element used in multiple manufacturing systems
Microorganisms	
Mycobacterium avium	N/A
Naeglaria fowleri	N/A

Source: ADEQ (2016b)

Pesticides

Any substance or mixture of substances intended for the destruction, prevention, and/or mitigation of any pest is considered a pesticide. They also are used as a plant regulator, desiccant, and/or defoliant and as a nitrogen stabilizer.

In a groundwater assessment of the LCR, 62 pesticides including herbicides, insecticides, and fungicides were analyzed. Five of these were detected in groundwater samples but all were below health-based thresholds. The herbicides atrazine, simazine, and deethylatrazine (degradant of atrazine) were discovered and among the most commonly found in groundwater nationally. Terbuthylazine and prometryn were also detected but at low levels. Overall, one or more pesticides were detected in 20% of the study area (USGS 2010).

In a study from 1996, Dichlorodiphenyldichloroethylene (DDE) was discovered in all fish and bird samples along the LCR and in agricultural drains near Yuma, Arizona. The DDE levels in the organisms was two times as high as studies completed in 1984–1985, and over 20% of the fish contained three times the national mean for DDE concentrations (King, et al. 1996). The DDE found in fish and bird carcasses and eggs was above background levels but residues were generally below thresholds associated with reproductive issues and chronic poisoning in fish and wildlife (King, et al. 1996).

Volatile Organic Compounds (VOCs)

Roadways and parking lots carry VOCs and gasoline oxygenates and degradants. VOCs come from various sources like paints, fuels, solvents, fuel additives, fumigants, refrigerants, and disinfected water and are characterized by their evaporation rates. The compounds persist longer in groundwater than surface water since groundwater is isolated from the atmosphere. In 2007, the USGS (2010) analyzed 85 VOCs throughout the LCR. Four were detected in the LCR: 1,2- dichloropropane (fumigant), chloroform (byproduct of disinfecting water), 1,2,4-trimethylbenzene (a constituent of gasoline), and MTBE (constituent of gasoline). All VOCs discovered were below the health-based thresholds set by EPA and were detected throughout 35% of the study area from Needles, California, to Winterhaven, California (USGS 2010). Eight gasoline oxygenates and degradants were analyzed in the LCR, and there were no detections in the study area.

In a 2017 Lake Havasu City report, small concentrations of hydrocarbons (oil, grease, and polycyclic aromatic hydrocarbons (PAHs)) were detected in stormwater runoff, most likely from deposits on the streets and parking lots, which are flushed during rain events (Wilson 2018).

Perchlorate

Perchlorate is an inorganic compound found in the environment from natural and human-made sources. It is primarily produced for use as an oxidant in solid rocket propellant, explosives, pyrotechnics, dry batteries, blasting operations, and auto airbag inflators. It also has non-industrial uses as a therapeutic drug and in fertilizers (CCRA 2006). The compound is found throughout the United States, but some locations, like the LCR, have had higher exposures than others have.

In Nevada, ammonium perchlorate manufacturing activities contaminated ground and surface waters that eventually spilled into Lake Mead and the Colorado River (English, et al. 2011). The contamination was discovered in 1997, and was determined to be from an aerospace- and defense-related fuel facility, Tronix, a part of Kerr McGee Chemical Company in Henderson, Nevada (CCRA 2006; Sanchez, et al. 2008). Results of an investigation suggested that of 68 water samples taken, two had detectable levels of perchlorate yet each was well below the criterion set by California. Produce was also sampled and found to contain more perchlorate than water samples. The highest levels of perchlorate were found in cacti (English, et al. 2011).

Clean-up efforts are ongoing, reducing perchlorate from contaminating the LCR from the Las Vegas Wash (Reclamation 2010). An alliance made up of EPA, Nevada Division of Environmental Protection, and Kerr McGee maintain and manage cleanup operations (CCRA 2006). These efforts have reduced perchlorate levels substantially. Current levels in the LCR are below current health standards and have no potential threat to public health, provided remediation activities continue (CCRA 2006).

Heavy Metals

Heavy metals can potentially cause adverse impacts on the LCR. They can accumulate in the fatty tissues of aquatic organisms and disrupt their physiology. Heavy metals are common byproducts of manufacturing establishments and the urban environment, but are also found in agricultural, mine, and road runoff. For example, work on metal content in sediments at Lake Havasu wash mouths and on the reservoir bottom (Wilson 2018) has not revealed concentrations above MCLs in either environment, yet local arsenic levels ranged upward in fine-grained wash mouth sediments (to 12.7 mg/kg) that exceed the ADEQ Tier 1 clean-up soil remediation level (10 mg/kg) for residential soils (ADEQ, 2002) and the 2017 USEPA Regional Screening Level (RSL) Resident Soil guidelines (0.68 mg/kg carcinogenic soil level) (EPA, 2018). Although the planning area has concerns regarding many heavy metals, this WMP focuses on selenium, cadmium, and chromium because of research availability and recent spikes in the LCR. Descriptions of selenium and cadmium are below and more information regarding chromium impacts within the LCR can be found in Section 5.1.4 Hexavalent Chromium.

Selenium

In the Colorado River, selenium originates naturally from shale sediment deposits along river tributaries. Lake Powell has the highest annual loading of dissolved selenium where the majority of selenium is believed to come from above Lake Powell. As the river flows through Lake Powell passing through downstream reservoirs selenium loads drop; therefore, researchers have not found evidence that selenium is being added to the system within the Lower Basin (LCR MSCP, 2004). Unlike the Upper Basin, agricultural practices along the Lower Basin do not contribute to increased selenium levels. Selenium concentrations in biota in the Lower Basin were equal or exceeded selenium guidelines for reproductive impairment of biota. Therefore, researchers recently determined that selenium is a constituent of concern in the Lower Basin aquatic system and continued selenium loading could severely affect important components of the ecosystem (LCR MSCP, 2004).

Scientists investigated selenium in sediment and fish from Imperial, Cibola, and Havasu NWRs in 1988 and 1989. Selenium levels were similar in each of the three refuges but selenium levels in sediments increased three to five times from 1986 to 1989 (King, et al. 1993). In another analysis, concentrations of the trace element were found in fish tissue sampled indicating widespread selenium contamination throughout the LCR backwater habitats (King, et al. 1993).

Researchers found that selenium concentrations in the sediment of the Bill Williams River NWR occur below detection limits (Ruiz 1994) and range to just above detection limits in Lake Havasu sediment (Wilson 2018). Conversely, scientists analyzed sediment samples from Topock Gorge and Topock Marsh and determined that five of six sediment samples extracted detected the heavy metal in the mid-1990s (Andrews, et al. 1997). Additional research was completed on aquatic birds in Imperial NWR and indicated acute exposure to elevated selenium levels. Concentration levels in herbivorous species were not at levels of concern however, fish-and-invertebrate-eating birds had selenium levels that concerned researchers (Martinez 1994; King, et al. 2003).

Bioaccumlation of the trace element was found in water birds, grackles, swallows, fish, clams, sediment, and vegetation inhabiting the LCR from a study completed in 2001, near Havasu NWR (Andrews, et al. 1997). Bird eggs are most sensitive to selenium poisoning and often contribute to abnormalities and even death; therefore, egg selenium levels give the best measure for scientist to evaluate selenium levels in bird populations. King’s 2003 study indicated that 94% of bird eggs, from various species on the LCR, had selenium, and 8% had toxic concentrations (King, et al. 2003).

Of the top 10 highest selenium concentrations nationwide, five were found in the Colorado River: Lake Martinez, Arizona; Lake Powell, Arizona; Lake Havasu, Arizona; Colorado River, Yuma, Arizona; and Lake Mead, Arizona (Andrews, et al. 1997). Recent studies indicate large areas of farmland in the Colorado River Basin produced salinized drainage water with much higher concentrations of selenium and concluded that concentrations of selenium have declined over time, but bioaccumulation of the element continued in crayfish and fishes, and the heavy metal remains a contaminant of great concern in Lake Havasu (Marr, et al. 2005).

As of 2016, selenium levels continue to cause impairments at several locations along the LCR. Impaired waters from selenium can be found from Hoover Dam to Lake Mohave, Main Canal to Mexican Border, and Lake Mohave. Though not pervasive, selenium concentrations in shallow groundwater at several wash mouths by Lake Havasu City ranged to elevations above ADEQ drinking water quality standards (Wilson 2018). Lake Powell became impaired in 2016 due to selenium (see Table 3-4). Although it is not in the planning area, it is important to address selenium concerns in the Upper Colorado River because it will eventually flow downstream (ADEQ 2016a).

Cadmium

Cadmium acts as a cumulative poison and is toxic to various fish and wildlife, accumulating primarily in clams. Predators that feed on various species of plants and animals could experience cadmium toxicity potentially causing growth, behavioral, and physiological problems. Sediment samples from Andrews’ 1997 study revealed that all sites in the Havasu NWR had concentrations of the trace element specifically in clams. The clam samples that contained the highest levels of cadmium were found near Winterhaven in the planning area; therefore, researchers determined that there was a point source for cadmium input into from Yuma Valley (Andrews, et al. 1997; King, et al. 1996).

Sediment, invertebrates, and fish samples collected from various points within the Bill Williams River NWR were analyzed and researchers found little evidence of cadmium concentrations. The heavy metal levels do not appear to be high enough to cause environmental degradation (Ruiz 1994). In a Yuma Valley study area, cadmium was not recovered in any egg samples but was present in various bird species livers (King, et al. 1996).

In the area around Topock Marsh, fish tissue sampled did not exceed the 0.5 ug/g threshold that is considered harmful to fish and other predatory species. Concluding their study, scientists determined that although there were cadmium concentrations above background levels, in the past, current concentrations are not determined to be toxic; therefore, cadmium is not a contaminant of concern at Havasu NWR (Andrews, et al. 1997). In King's study from 1996, cadmium was recovered only in clams and bird tissue, suggesting that there is a point source for the trace element input into the Colorado River upstream from Laguna Dam (King, et al. 1996).

4.1.5 Streambank Erosion

Streambank erosion is the wearing away of the banks of a stream. This is distinguished from erosion of the bed of the watercourse. Streambank erosion is accelerated by livestock grazing, certain agricultural practices, streamside recreation, and land use that increases impervious surfaces or decrease the landscape's infiltration capacity. Streambank erosion adds to the sediment load carried in the stream. Excessive sedimentation can be harmful to aquatic life and habitat and can increase nutrients in the water.

Community members have noticed a significant loss of wetlands replaced with armored banks (protective covering such as rocks, vegetation, or engineering materials used to protect stream banks). Stream bank replacement has resulted in wetlands no longer being able to filter water, hardened soils along the banks, and loss of aquatic species (microflora/microfauna) that absorb carbon, produce oxygen, and eliminate contaminants.

Non-native species have increased streambank erosion. These invaders are able to grow at faster rates, outcompeting native vegetation, and can use and colonize armoring structures that native species are not able to use.

4.2 POINT SOURCES

Point sources release pollutants from discrete conveyances, like a discharge pipe, are regulated by local, state, and federal agencies. Mostly, point source dischargers are sewage treatment plants, releasing treated water, and factories.

4.2.1 NPDES Permitted Facilities

The National Pollutant Discharge Elimination System (NPDES), authorized by the Clean Water Act, permit program manages water pollution by regulating point sources that release pollutants into waters of the United States. Individual homes connected to a municipal system, facilities that do not have a surface discharge, or septic systems do not require an NPDES permit. However, permits are required if industrial, municipal, and other facilities discharge directly into surface waters (EPA 2017k).

Stormwater runoff, generated from land and impermeable areas like paved roads, parking lots, and rooftops during rainfall and snow events may contain pollutants in quantities large enough to affect the water quality. Coverage by an NPDES is required for most stormwater release because they are considered point sources of pollution. NPDES Permitted facilities are listed below in Table 4-4.

Table 4-4. NPDES Permitted Facilities in Planning Area

NPDES	Site Name	City	State	Pollutants
AZ0110248	Reclamation	Bullhead City	AZ	Ammonia, tribromomethane, silver
AZ0023523	National Park Service Katherine Landing WTP	Bullhead City	AZ	Total Residual Chlorine
AZ0025160	Reclamation	Colorado River	AZ	Copper, nitrogen, total dissolved solids, total suspended solids
AZ0022756	Petro Shopping Center	Kingman	AZ	E. coli, hardness, nitrogen
AZR051305	Evoqua Water Technologies	Parker	AZ	Ammonia, silver, lead
CAL000372	City of Blythe WWTP	Blythe	CA	N/A
CA0104205	City of Needles	Needles	CA	N/A
CA7000016	PG&E	Needles	CA	N/A
NVCS06698	Isaac House	Laughlin	NV	N/A
NVCS03148	Laughlin Bay Marina	Laughlin	NV	N/A
NVCS19144	Laughlin Regional Heritage Greenway Trail	Laughlin	NV	N/A
NCL021563	Laughlin Water Reclamation Facility	Laughlin	NV	N/A
NVCS14523	Mohave Generating Station	Laughlin	NV	N/A
NVCS28070	River Palms Laughlin	Laughlin	NV	N/A
NVIS06064	Riverside Resort Maintenance Facility	Laughlin	NV	N/A
NVCS02534	Tropicana Laughlin LLC DBA Tropicana Express Hotel and Casino	Laughlin	NV	N/A

Source: EPA (2017b)

4.2.2 Wastewater Treatment Plants

Wastewater treatment plants (WWTPs) receive intake from sanitary sewers via connection pipes from commercial, residential, and industrial sites where treatment is applied prior to release. Improperly functioning plant systems may have dangerous impacts on water quality because nutrients (phosphorus and nitrogen), bacteria, pharmaceutical drugs, and other contaminants are carried throughout various waterbodies without treatment.

Facilities that discharge wastewater are required to obtain a NPDES permit. Roughly, 30 NPDES municipal WWTPs are located within the LCR watershed boundaries. Treatment effluent from these facilities is discharged mostly to the Colorado River. WWTPs within the LCR boundaries are noted in Table 4-5, below.

North Regional Wastewater Treatment Plant began treating wastewater in Lake Havasu City in 2008. Treated water from the plant was used for wastewater storage and planned to be seasonally recovered throughout the drier summer months (Wilson 2013). The city took a proactive measure and looked into monitoring pharmaceuticals and other emerging contaminants (PECs).

Adjacent to Lake Havasu a horizontal collector well's samples contained six of the PECs tested, some of which were tested at higher concentration level than in the River. Eighteen PECs were recorded in the wastewater but concentrations were ultra-low in the Colorado/Lake Havasu area, most likely originating from up-river and local aquatic activities (Wilson 2013). Samples recovered did not contain concentration levels high enough to have any adverse effect on municipal water use. WWTPs can be a large source for PECs to enter the Colorado River; therefore, extensive water management is needed in the region (Jones-Lepp, et al. 2012).

Table 4-5. Wastewater Treatment Facilities in Planning Area

City	Facility Name
Blythe	Blythe Regional WW Reclamation Facility
Bullhead City	Katherine Heights WTP
	Section 10 WWTP
	Section 18 WWTP
	Reclamation - Davis Dam Evaporation Ponds
Cienega Springs	Buckskin/Sandpiper WWTP
Detrital Valley	Temple Bar WWTP
Franconia	Arizona Gateway WWTP
	Pilot Travel Center #211 WWTP
Hoover Dam	U.S. Department of Interior BR - Hoover Dam WWTP
Katherine	U.S. Department of Interior NPS - Lake Mead NRA - Katherine Landing WWTP
Kingman	Golden Valley Temporary WWTP
	Hilltop WWTP
	Downtown WWTP
City	**Facility Name**
Lake Havasu City	Mulberry WWTP
	Island WWTP
	North Regional WWTP
	Sunlake Village WWTP
	Vadose Zone - VW-1
	Desert Skies RV Estates Water Reclamation Facility
Laughlin	Laughlin Water Reclamation Facility
McConnico	Walnut Creek WWTP
Mohave Valley	Epcor Water AZ Inc. - Wishing Well WRF
Needles	Needles WWTP
	Park Moabi Wastewater Treatment Facility
Parker	Joint Venture Wastewater Treatment Facility
	Mountain View Estates WWTP
	Castle Rock Shores WWTP
	Golden West Project

4.2.3 Phase I and II Stormwater Permits

Populations located within urbanized areas, based on the 2010 U.S. Census Bureau, (see Chapter 2)require stormwater discharge permits under Phase II of NPDES. The 1999 Phase II law requires small Municipal

Separate Storm Sewer Systems (MS4) to obtain an NPDES for their stormwater discharge, including non-traditional MS4s like departments of transportation, public universities, prisons, and hospitals. Phase I of NPDES refers to Municipal Separate Storm Sewer Systems MS4 and populations larger than 100,000 requiring NPDES permits (ADEQ 2017e). Phase II permits cover the next tier of communities with MS4s. Table 4-6 illustrates the number of Phase I and Phase II stormwater permits have been issued per city.

Table 4-6. Stormwater Permits per City in Planning Area (2017)

State	City	No. of Permits
Arizona	Bullhead City	6
	Ehrenberg	1
	Golden Shores	1
	Kingman	7
	Lake Havasu City	9
	Parker	2
	Topock	2
California	Blythe	8
	Earp	1
	Needles	6
	Riverside	2

Source: ADEQ (2017e) CWB (2018)

4.2.4 Concentrated Animal Feeding Operations Permits

There are no Concentrated Animal Feeding Operations (CAFOs) in the project area.

4.3 HAZARDOUS WASTE SITES

4.3.1 Superfund: CERCLA Sites

In an effort to clean up lands contaminated by hazardous waste and identified by EPA as candidates for cleanup because of potential human health and environmental risks the Federal government established the Superfund program. EPA assists communities, researchers, scientists, government authorities, and contractors to identify hazardous waste sites, examine the conditions of the site, develop plans for cleanup, and complete site reclamation.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) created a tax on chemical and petroleum industries and provided broad federal authority to respond directly to releases or potential releases of hazardous material that can endanger public health or the environment (EPA 2017e). CERCLA of 1980:

- Established prohibitions and requirements concerning closed and abandoned hazardous waste sites;
- Provided for liability of persons responsible for release of hazardous waste at these sites; and
- Established a trust fund to provide cleanup when no responsible party could be identified.

CERCLA authorizes two types of response actions:

- Short-term removals, where action may be taken to address releases or threatened releases requiring prompt response.
- Longer-term remedial response actions, that permanently and significantly reduce the dangers associated with releases or potential releases of hazardous material that may be serious, but not necessarily life threatening.

There are no CERCLA sites within the planning area; however, Yuma Marine Corps Air Station is on the National Priorities List and is located approximately 17 miles south of the planning area. Water Quality Assurance Revolving Fund (WQARF) Registry Sites are the equivalent of federal Superfund sites but at the state level. There is one WQARF site listed within the planning area, depicted below in Table 4-8.

Table 4-8. WQARF Sites in Planning Area

Facility Name	WQARF ID No.	County	State
Lake Havasu Avenue and Holly Site (former McCulloch manufacturing plant)	AZD041458555	Mohave	Arizona

Source: ADEQ (2018)

4.3.2 Resource Conservation and Recovery Act Sites

The Resource Conservation and Recovery Act (RCRA) authorizes the EPA to control hazardous wastes for its lifetime to include transportation, generation, storage, treatment, and disposal of hazardous waste. Additionally, the regulation provides a framework for managing non-hazardous solid wastes.

RCRA developed three distinct, unrelated, regulatory programs:

Hazardous Waste Management Program (RCRA Subtitle C): Sets national standards for:

a. Hazardous waste management
b. Provides for EPA authorization and oversight of state implementation in RCRA
c. Includes corrective action authorities to address releases to the environment

Solid Waste Management Program (RCRA Subtitle D): Sets national standards for the management of solid waste.

Underground Storage Tanks Program (RCRA Subtitle I):

a. Protects groundwater from leaking underground storage tanks
b. Requires owners and operators of new tanks and tanks already in the ground to prevent, detect, and clean up releases
c. Banned the installation of unprotected steel tanks and piping (EPA 2017a)

Four sites within 5 miles of the planning area are regulated under RCRA, listed in Table 4-9.

Table 4-9. RCRA Sites in Planning Area

Facility Name	EPA ID No.	County	State
Evoqua Water Technologies	AZD982441263	La Paz	AZ
Woten Aviation Services Inc.	CAD085595551	Riverside	CA
Topock Compressor Station	CAT080011729	San Bernardino	CA

Source: EPA (2017d)

4.3.3 Brownfields

A brownfield is a property intended for redeveloped, expansion, or reuse that can be complicated by the existence or potential existence of a hazardous pollutant, contaminant, and/or substance. The program is designed to promote states, communities, and other stakeholders in economic improvement by working together in a timely manner to assess, safely clean up, prevent, and reuse brownfields sustainably (EPA 2017f). There are six Brownfield sites in the LCR watershed, mostly in Arizona (Table 4-10).

The Parker Civic Buildings brownfield site consists of three buildings, built between 1960 and 1983; the Program funded the asbestos abatement activities in 2010 clearing the way for the Town to complete their Barrier Removal Project. The Colorado River Indian Tribes Dump is a 50-acre property along the Colorado River that has been used as an illegal dumpsite where portions of the property were used for auto maintenance. Tribal members are concerned with old transformers buried on the property (EPA 2017d). After completing a geophysical survey, no abnormalities or evidence of buried transformers was found.

The City of Lake Havasu site is 10 acres located at the intersection of Highway 95 and Kiowa Boulevard. A Phase II Environmental Site Assessment was completed here in May of 2000. Arnold Plaza has asbestos, lead-based paint and mold on the interior of the facility, a leaky roof, and several sinking air conditioners. The Old Yucca Fire Station One does not meet current building codes creating safety risks for severe mold contamination. The building has been assessed for asbestos and lead-based paint prior to demolition. The Chemehuevi-North Dumpsite 1 brownfield is a former residential property, abandoned for more than 10 years. The site has been used as a burn area, fire pit, and illegal waste dumping (EPA 2017d).

Table 4-10. Brownfields in Planning Area

Site Name	County	State
Parker Civic Buildings	La Paz	AZ
Colorado River Indian Tribes Dump at 11th and McCabe Road	La Paz	AZ
Arnold Plaza	Mohave	AZ
City of Lake Havasu	Mohave	AZ
Yucca Fire District Old Station One	Mohave	AZ
Chemehuevi-North Dumpsite I	San Bernardino	CA

Source: EPA (2017d)

4.3.4 Underground Storage Tanks/Leaking Underground Storage Tanks

An underground storage tank (UST) is defined by the EPA as “a tank and any underground piping connected to the tank that has at least 10% of its combined volume underground” (EPA 2017c). These regulations only apply to UST systems that store either petroleum or certain hazardous substances.

Leaking underground storage tanks (LUSTs) usually involve the release of a petroleum product from an UST. The LUST can contaminate the surrounding groundwater, surface waters, soil, or affect indoor air spaces (EPA 2017c). A LUST can present various health and environmental risks.

As of 2017, there are roughly 130 UST sites and 49 LUST sites in the LCR watershed. The majority of USTs are located in Kingman, Lake Havasu City, and Bullhead City, Arizona. LUST sites are located primarily in Blythe, California, and Kingman and Bullhead City, Arizona (EPA 2017d). Most of the LUST sites listed have been or are in the process of remediation. Tables 4-11 and 4-12 list UST and LUST facilities in the planning area.

Table 4-11. Number of UST Facilities in Planning Area

State	City	Number of UST Facilities
Arizona	Bullhead City	20
	Ehrenberg	1
	Golden Shores	2
	Golden Valley	3
	Kingman	36
	Lake Havasu City	29
	Mohave Valley	7
	Parker	3
	Topock	1
	Valle Vista	1
	Yucca	1
California	Needles	13
	Parker Dam	2
	Big River	1
	Blythe	7

Source: EPA (2017d)

Table 4-12. Number of LUST Facilities in Planning Area

State	City	Number of LUST Facilities
Arizona	Bullhead City	6
	Ehrenberg	1
	Kingman	9
	Lake Havasu City	4
	Parker	5
	Yuma	1
California	Blythe	18
	Needles	3
	Parker Dam	2

Source: EPA (2017d)

4.4 MINES AND OTHER POLLUTANT SOURCES

4.4.1 Mining

More than a century of copper, gold, and silver mining has affected the water quality of the Colorado River in various ways. Water polluted from contact with mining activities refers to abandoned mine drainage (EPA 2017g), which is a common water pollutant in heavily mined areas. Abandoned mine water quality issues include:

- Acid mine drainage (the most dominant)
- Alkaline mine drainage (occurs when calcite or dolomite is present)
- Metal mine drainage (high levels of lead or other metal drainage)

The creation and movement of highly acidic water abundant with heavy metals refers to acid mine drainage. Chemical reactions of surface water (snowmelt, stormwater, pond water) and shallow subsurface water containing rocks with sulfur-bearing minerals could result in acidic water (EPA 2017g). Rocks that come into contact with the acid may leach heavy metals that may be enhanced from bacterial action. The effects on humans, animals, and plants may be harmful when highly toxic fluids mix with groundwater, surface water, and soil (EPA 2017g).


View of Mineral Park Mine
Source: ADMMR, 2018.

Roughly, 30% of the total national uranium ore production is mined in the Colorado River Basin. Concentrations of uranium, a runoff contaminant, increased significantly downstream in 2007 and 2008. (U.S. Department of Health, Education, and Welfare 1963). The Upper Colorado River uranium loads were less than 0.05 ppb at the headwaters in Northern Colorado. As the river flowed downstream uranium levels increased to 3 ppb, and when it entered the LCR uranium concentrations were between 3 and 5 ppb, which are the same levels as today (McGinley 2009; National Institute of Environmental Health Sciences 2017). Other metals studied include copper, cadmium, arsenic, manganese, lead, and mercury, which were all below maximum thresholds set by EPA.

The largest mining concentration exist southeast of Bullhead City, Arizona, with smaller pockets near Kingman, Arizona, and the southern portion of the Bill Williams watershed. Refer to Table 2-9 in Chapter 2 for a list of active mines in the project area.

4.4.2 Landfills

Landfills are facilities managed for the disposal of solid waste and designed, located, monitored, and operated to ensure compliance with federal, state, and local regulations. The facilities are constructed to protect the environment from contaminant permeation. The facilities avoid being built in environmentally sensitive areas and are constructed on environmental monitoring systems (EPA 2017h). The monitoring systems look for any signs of groundwater contamination and landfill gases, and provide additional safety measures. Landfills must meet strict operation, closure, and design requirements under RCRA. There are 11 active landfills in the LCR (Table 4-13).

Table 4-13. Landfills in Planning Area

Name	County	State
Mohave Valley Landfill	Mohave	AZ
BLM-Golden Valley Landfill	Kingman	AZ
Colorado River Tribes Landfill	Parker	AZ
La Paz County Landfill	Parker	AZ
Lake Havasu City Landfill	Lake Havasu City	AZ
Cerbat Landfill	Cerbat	AZ
BLM-Needles Landfill	Needles	CA
Blythe Landfill	Blythe	CA
Needles WMF 03-046	Needles	CA
Blythe Class III WMF	Blythe	CA
Laughlin Landfill	Laughlin	NV

Source: EPA (2017d)

4.4.3 Pesticide-Producing Facilities

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires facilities that produce pesticides, active ingredients, or devices be performed in a registered pesticide-producing or device-producing facility. Registration and reporting includes registering the facility and file initial and annual production reports with EPA (EPA 2017i). Seven pesticide-producing facilities are located in the Planning Area (Table 4-14).

Table 4-14. Pesticide Producers in the Planning Area

Name	EPA ID	County	State
Wilbur-Ellis Co	002935AZ007	La Paz	AZ
Crop Production Service 617	051896AZ003	La Paz	AZ
Global Chem Tech	089461AZ001	Mohave	AZ
Lico Industries LLC DBA American Towelette Company	091883AZ001	Mohave	AZ
Riverside Manufacturing, LLC	071885AZ001	Mohave	AZ
Compton Ag Services LLC	083273CA001	Riverside	CA
Helena Chemical Co.	0059055CA023	Riverside	CA

Source: EPA 2017i

4.4.4 Contaminants in Point Source Pollutants

Industrial waste facilities commonly discharge pollutants to near-by water sources and are highly regulated by EPA. Pollutants listed in Section 4.1.4 Urban and Suburban Runoff can be released at point source locations via multiple pathways (e.g. wastewater treatment plants). Three pollutants attributed to point source locations are Endocrine-Disrupting Compounds (EDCs), Personal Care Products (PCPs), and Pharmaceutical and Personal Care Products (PPCPs), discussed in further detail below.

Endocrine-Disrupting Compounds (EDCs)

Human activities and wastewater discharge contribute various compounds that can alter animal's endocrine systems and have been detected in the LCR (Reclamation 2010). Substances like these are referred to as endocrine-disrupting compounds (EDCs) and can be linked to various adverse effects in wildlife and humans such as reproductive tract disorders, reduction of reproductive fitness, and hormone-dependent cancers. Antibiotics, anti-seizure medications, and heart medications are metabolites found in pharmaceutical compounds in the LCR (Lower Colorado River Water Quality Partnership [LCRWQP] 2017). Small traces of several pharmaceuticals have been found in surface waters and even detected in finished drinking water. Table 4-15, below, provides details of types and potential sources of EDCs.

Additional information on EDCs can be found at https://ac.els-cdn.com/S0378427413013659/1-s2.0-S0378427413013659-main.pdf?_tid=c2a220da-5fec-4c9e-b5ce-fa24dd470353&acdnat=1527695262_2c2d9771a0d2d5205037ce35a85f05ab

Table 4-15. Types and Potential Sources of EDCs

EDC Sources	EDC Category	EDCs
Landfill	Polychlorinated compounds	Polychlorinated dioxins and biphenyls
Agricultural runoff	Organochlorine pesticides	DDT, dieldrin, lindane
Industrial effluent	Alkylphenols and Phthalates	Nonylphenol, dibutyl phthalate, butylbenzyl phthalate
Municipal effluent	Natural hormones, synthetic steroids, pharmaceuticals	Estradiol, estrogen, testosterone, ethynyl estradiol
Atmospheric/Combustion Emissions	Androgenic	Oxygenated organic species

Source: Clean Colorado River Alliance (CCRA) (2006)

In 2000–2001, USGS studied EDCs along the Colorado River (mainly in Lake Mead) and reported that EDC levels were low enough not to cause any immediate threats. The study focused on 13 compounds found in pharmaceuticals and food derivatives. All 13 compounds were present in the Las Vegas Wash near Lake Mead at least once during a 6-month sampling period (Clean Colorado River Alliance [CCRA] 2006). Six of the 13 compounds were found in Lake Mead during sampling periods in the spring and summer. The most widespread EDCs detected were caffeine, cotinine, and 1,7 dimethylxanthine. Other detected compounds were predominately antibiotics, prescription drugs, human waste, and pesticides (CCRA 2006). Long-term exposure to low levels of EDCs is currently being researched, because very few long-term studies have been performed. EDCs have multiple pathways of entering a water system. A more recent study along the entire Colorado River indicated that many EDE concentrations were generally either below detection limits or at levels of least health concern (ng/L to tens of µg/L) (Jones-Lepp et al. 2012)

Personal Care Products (PCPs) and Pharmaceutical and Personal Care Products (PPCPs)

Shampoos, perfumes, and antibacterial soaps are all examples of personal care products (PCPs) creating an additional class of emergent contaminants that have been found in ground and surface waters of the LCR. When pharmaceuticals and PCPs (PPCPs) are extremely persistent in the environment they can function as EDCs (LCRWQP 2017). The scientific knowledge on this subject is relatively new and continually evolves, although these compounds have been detected in surface waters for years.

Most PPCPs are being detected in low levels in surface water particularly near the Las Vegas Wash (NPS 2017). In the LCR, very low (parts per trillions) concentrations of PPCPs have been discovered and most are unregulated by the EPA. Conventional wastewater treatment methods have difficulty removing the compounds, and in extremely low concentrations they can be highly persistent in the environment. Some technologies have proven to be useful at removing these compounds (such as advanced drinking water systems with ozonation) but can be extremely costly. The effects of PPCPs on human health is still unknown at current concentrations in the LCR, yet these compounds continue to receive attention from the media negatively effecting community members' understandings of local drinking water supplies (LCRWQP 2017). Scientific research on the occurrence and potential effects of these developing compounds is ongoing.

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Chapter 5 Primary and Secondary Priority Issues and Concerns

In recent years, the LCR has shown signs of trending toward less stable conditions through various indicators. Stakeholders were invited to meet on June 26, 2017, to discuss the state of the LCR and to identify various issues that may affect the planning area negatively. In the April 25, 2018 meeting, stakeholders then narrowed these preliminary issues to eight priority issues four primary issues and four secondary issues.

The eight priorities are organized in two categories: Primary and Secondary Issues. Primary Issues are: 1) c*yanobacteria blooms* 2) drought, 3) aquatic invasive species, and 4) hexavalent chromium. Secondary Issues include: 5) mining, 6) agricultural runoff, 7) hydrocarbons, and 8) land development.

These priority issues are the focus of monitoring and research efforts across the planning area. Preliminary goals were guided through a collaborative effort of knowledge development for each priority issue. Watershed management planning is a continual process with an important role of intermunicipal, stakeholder, and interagency collaborations providing recommendations and implementation strategy. The sections below present background information for each priority issue, threats posed to the LCR, and preliminary goals.

5.1 PRIMARY PRIORITY ISSUES

Primary Issues are issues where active programs have been implemented and where CCRSCo can effect change. Primary Issues include cyanobacteria blooms, water resiliency, aquatic invasive species, and hexavalent chromium.

5.1.1 Cyanobacteria Blooms

Issue: Annual cyanobacteria (*Microcystis* sp.) and associated cyanotoxin issues.

Problems from cyanobacterial blooms have increased for many aquatic areas of the LCR, producing a potentially serious threat to public health. *Microcystis* sp. is a common bloom-forming genus that can occur from disseminated individual colonies to wave-controlled concentrations to massive “pea-soup” blooms of lakes, rivers, and streams. Some of the 70 known species of *Microcystis* are capable of producing microcystins. These toxins, produced within the organism, may be expelled into the water column either while the organism is alive or after death when the cell decomposes (World Health Organization 2003).

The most widespread cyanobacterial toxin is microcystin, with over 80 variants, which can bioaccumulate in various vertebrates and invertebrates living in aquatic ecosystems. Microcystins affect the liver mostly, but can damage the kidney and reproductive system in a variety of aquatic organisms and may be a possible carcinogen to humans. Data from the World Health Organization (2003) suggests there are correlations between tumor promoters and microcystin. Other types of cyanotoxins include cylindrosperopsin, anatoxins, and saxitoxins. Cylindrospermosin damages the liver and kidneys of living

Cyanobacteria bloom in California
Source: CDWR, 2016

organisms, anatoxins affect the central nervous system, and saxitoxin refers to as Paralytic Shellfish Poisoning and is passed on through shellfish consumption (World Health Organization 2003).

In 2009, the EPA through its National Lake Assessment on Lake Mead and Reclamation water quality monitoring in Lake Havasu, both discovered elevated populations of *Microcystis*, which occurred at disseminated colonies and wave-formed concentrations until the mid-winter. The populations were on the low end of "moderate risk" levels and until 2015, the cyanobacteria species associated with Lakes Mead, Mohave, and Havasu did not produce algal toxins (*Microcystis wesenbergii*) (Ryan et al. 2015). Interagency monitoring was continued, and populations remained consistent until the winter of 2014–2015.

In 2015, *Microcystis aeruginosa* was identified in all three reservoirs, which can produce one of the most potent microcystic toxins, LR. Later that year another species, *Microcystis novacekii*, was discovered in Lake Havasu, but produced toxins at low levels (<1 μg/L). The magnitude of the toxin concentrations may have been dictated by the species present and their response to environmental factors. Ryan et al. (2015) reported that the cause of the increased *Microcystis* activity is speculative, yet may be a combination of the lack of competitors of nutrients (ultimate cause may be selective quagga mussel feeding habits), the warmer-than-normal winters, and the low nutrient requirements needed for *Microcystis* growth.

5.1.1.1 *Preliminary Goals for Toxic Cyanobacteria Blooms*

During the stakeholder meeting on June 26, 2017, preliminary goals were set to reduce and monitor cyanobacteria algal blooms occurring in the LCR. These are listed below:

- Reduce watershed phosphorus loading in an effort to reduce cyanobacteria blooms;
- determine styles (point and non-point sources) of phosphorus loading in the LCR to better forecast *Microcystis* population growth patterns;
- investigate water quality data and the relationship to observed *Microcystis* accumulations;
- because plankton can be blown around by wind driven surface currents, examine backwaters and wind conditions of the LCR where cyanobacterial blooms have been observed;
- educate and inform the general public about the negative effects associated with harmful algal blooms; and
- protect public health by preventing and minimizing health risks through effective public communication (i.e., educational material) for users of the LCR.

5.1.2 Drought

Issues: Drought issues associated with sediment and salinity.

Persistent drought in the since the early 2000's affect hydrologic conditions in the Lower Colorado River and reservoir operations. Between 2000 and 2004, extreme drought plagued the area, causing below-average streamflow in 2006 and 2007. Storage in the reservoirs dropped from almost at capacity to 54% capacity. Conditions improved, but Lake Powell's water level was at 52% capacity (Udall 2017). Lower water levels have resulted in closure and relocation of boat marinas and other recreational activities.

Drought conditions as Colorado River flows in Lake Mead
Source: Stephens, 2015

Between 2000 and 2018, the LCR had its worst period of drought since 1906 when flow measurement began. Annual flows in the LCR during this period were, on average, 19% below twentieth-century averages. Additionally, higher temperatures have contributed to less-than-average flows (Udall 2017). The 2017-2018 winter produced snow pack 30% below average in most places and subpar runoff for 2018 reflected this situation.

The reservoirs in the Upper Colorado River affect sediment flow in the LCR. Glen Canyon Dam, constructed in the 1960s, traps the vast majority of sediment. The sediment passing through the dam does not increase when the reservoir declines regardless of wet or dry periods. Peak flows from the dam are scheduled for periods of high-energy demand and this pattern holds, in accordance with the Record of Decisions (RODs) dictating releases, regardless of high or low reservoir conditions.

Due to drought and record-setting temperatures, the Upper Colorado River Basin reservoir water surfaces elevations are lower (Figure 5-1). The brown shading represents historical drought impacts on storage volume and pink shading depicts the continued long-term drought trends from 2015 to present day.

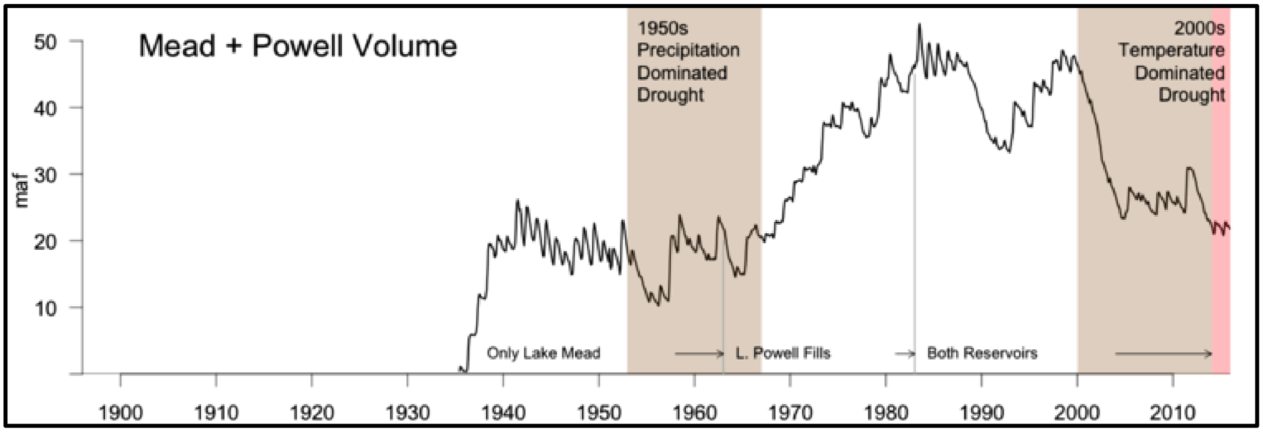


Figure 5-1. Lake Mead and Lake Powell, since initial filling through 2016 (Udall 2017).

5.1.2.1 *Sediment*

Drought conditions in the LCR have had tremendous effects on the sediment dynamics of the river. During drought conditions, greater sediment loads are input into the river (Heritage, et al. 1995). This sediment is unlikely to be transported through the system due to low flow which alters sediment accumulations; therefore, these accumulations of sediment will form at various locations especially in areas where sediment transport capacity is low (Heritage, et all, 1995). High and intermediate flows would be necessary to prevent the stabilization of these sediment traps with riparian vegetation.

Since the late 1800s, the LCR has undergone dramatic changes. Historically, seasonal water fluctuations, drought, and associated high sediment loads contributed greatly to the biological and physical characteristics of the river. Water flows and sediments loads were highly variable, from flows greater than 100,000 cubic feet per second (cfs) between May and July to flows of less than 5,000 cfs during the later fall and winter months, on average. Sediment loads were highest during August and September.

Sedimentation in the Colorado River has been impacted by dam infrastructure and their associated facilities. Dams trap sediment and nutrients, increasing downstream water clarity but possibly lessening downstream productivity due to lack of sediments being naturally replenished (ADWR 2009a). Human activities, in the Colorado River below Hoover Dam, have increased the suspended sediment loads beyond historic records and the cause of excess sediment comes from urban runoff, construction/development, agriculture, drought, and forestry (CCRA 2006).

Existing dams along the LCR have transformed sediment transport characteristics of the river that resulted in lowering the riverbed and water surface, thereby dramatically increasing flows are needed to achieve overbank flooding throughout the LCR (USGS 2004). See Figure 2-2 and Table 5-1a for a map of dams within the planning area and additional dam information. Table 5-1a and Table 5-1b summarize sediment impact from dams and suspended-sediment concentrations.

Table 5-1a. Sedimentation Impacts of Dams within Planning Area

Dam	Watershed	Sedimentation Impacts
Hoover Dam*	Lake Mead	Increased sediment trapping. Hoover Dam traps LCR sediment from the Grand Canyon, leaving the river downstream relatively clear and cooler (ADWR 2009a)

Dam	Watershed	Sedimentation Impacts
Davis Dam	Havasu-Mohave Lakes	Reduced sediment transport in the river. Topock Desilting Basin was constructed in 1956 to reduce the flow of sediment into Topock Gorge and is periodically dredged (ADWR 2009b). Refer to Section 2.1.2.2 for more information about Topock Marsh.
Parker Dam	Havasu-Mohave Lakes	Reduced sediment transport in the river. Formed a delta as sediment deposited near the upstream end of Lake Havasu. In 2018, CCRSCo conducted a topographic survey of the Lake Havasu bottom. The purpose of the study is to characterize bottom sediment surfaces and identify aquatic vegetation distribution, old riparian stands, deployed artificial fish habitats, and historical and indigenous cultural artifacts sites. One finding is a delta was formed near the upstream end of Lake Havasu, the result of sediment deposition (D. Wilson, personal communication, September 5, 2018).
Alamo Dam	Bill Williams	Constructed in 1968 to limit sediment being delivered to the Parker Dam area of Lake Havasu. As a result, the dam altered the dynamics of sediment in the Colorado River between Alamo Lake and Lake Havasu (Gremillion, et al. 2011). Recent bottom mapping of Lake Havasu by CCRSCo indicates significant sedimentation (delta) between the mouth of the river and Parker Dam.*
Gene Wash Dam	Havasu-Mohave Lakes	Trap small amounts of sediment. The All American Canal and Gila Gravity Main Canal move sediment from above Imperial Dam to the Laguna Desilting Basin, built to provide control of river sediment north of Yuma (ADWR 2009b)
Headgate Rock Dam	Imperial Reservoir	
Imperial Dam	Imperial Reservoir	

*Wilson (2017)

Table 5-1b. Suspended-Sediment Concentration (mL/L), 1990–2015

Station Name	State	Year			
		1990	2000	2011	2015
Colorado River below Hoover Dam	AZ - NV	2.5	6	1.5	1
Colorado River below Parker Dam	CA - AZ	4.75	NA	2	1
Colorado River above Imperial Dam	CA - AZ	NA	14.25	5.75	13.5

5.1.2.2 *Salinity*

Salinity is the measurement of the amount of salt in water. Certain salinity levels are healthy for various ecosystems, yet influx of salinity can potentially impact aquatic organisms negatively. Approximately half of the salinity in the Colorado system can be attributed to natural sources; other sources come from irrigated agriculture, development, energy exploration, and industrial facilities such as wastewater treatment plants (CCRA 2006). Salinity standards for surface waters in Arizona, California, and Nevada are described above, Table 3-2.

The Salinity Control Act authorizes the Secretaries of the U.S. Department of the Interior (Interior) and U.S. Department of Agriculture (USDA) to enhance and protect the quality of water available in the Colorado River for use in the United States and the Republic of Mexico. Title II of the Colorado River Basin Salinity Control Act (P.L. 93-320) (1974) (Act), established the Colorado River Basin Salinity Control Program under Title II to address the concerns raised by EPA regarding salinity levels within the Colorado River Basin. The Act also created the Colorado River Basin Salinity Control Advisory Council to advise the federal agencies regarding administration of the Program. P.L. 93-320 has been amended several times since its original enactment.

The increasing frequency of dry periods in the LCR region and the problems associated with salinity in irrigated areas frequently result in consecutive occurrences of drought and salinity on cultivated lands. Salinity and drought stress are similar with respect to physiological, biochemical, molecular and genetic effects (Leksungnoen 2012). Physiological drought occurs when soluble salt levels in the soil solution are high enough to limit water uptake due to low water potential, thereby inducing drought stress to vegetation. Drought and salinity are expected to grow worldwide increasing challenges in ecosystems from stress leading to a reduction in biomass (Leksungnoen 2012).

There are 20 stations throughout the Colorado River Basin monitoring salinity levels using flow records and daily conductivity to calculate salt loads and concentrations. Stream flow, water resource development, reservoir storage, climatic conditions, and natural runoff contribute directly to salinity in the LCR. Historically, annual salinity levels in the Colorado River Basin were below 200 mg/L. Annual salinities in recent years are nearly doubled from natural historic levels to 334 mg/L at Imperial Dam (Reclamation 2005b). Peak salinity occurs downstream where historically it was often calculated well above 1,000 mg/L during low-flow months. However, recent years have seen a decrease in peak salinity (Reclamation 2005b).

A major contributor to salinity in the river system is from drought and irrigated agriculture. Irrigated lands made up 400,000 acres of the Planning Area in the 1980s; by 2000, total irrigated lands totaled over 1.4 million acres (Reclamation 2005b). USGS and Reclamation continually monitor salinity of the Colorado River and in 2004 determined that salinity in the River was below the numeric criteria at the various monitoring stations (Reclamation 2005b).

Salinity control measures are in place as a way to prevent over 1 million tons of salt from entering the Colorado River system. As of 2004, Reclamation's salinity control program has controlled over 569,000 tons of salt, the USDA NRCS program has been able to reduce roughly 405,000 tons salt, and BLM has controlled over 98,000 tons of salt annually from entering the River. Reclamation predicts that by 2025 salinity controls will need to prevent roughly 1.8 million tons of salt per year (Reclamation 2005b). Figure 5-2, below, depicts salinity levels in the Colorado River from 1970 to the mid-2000s at three different sites.

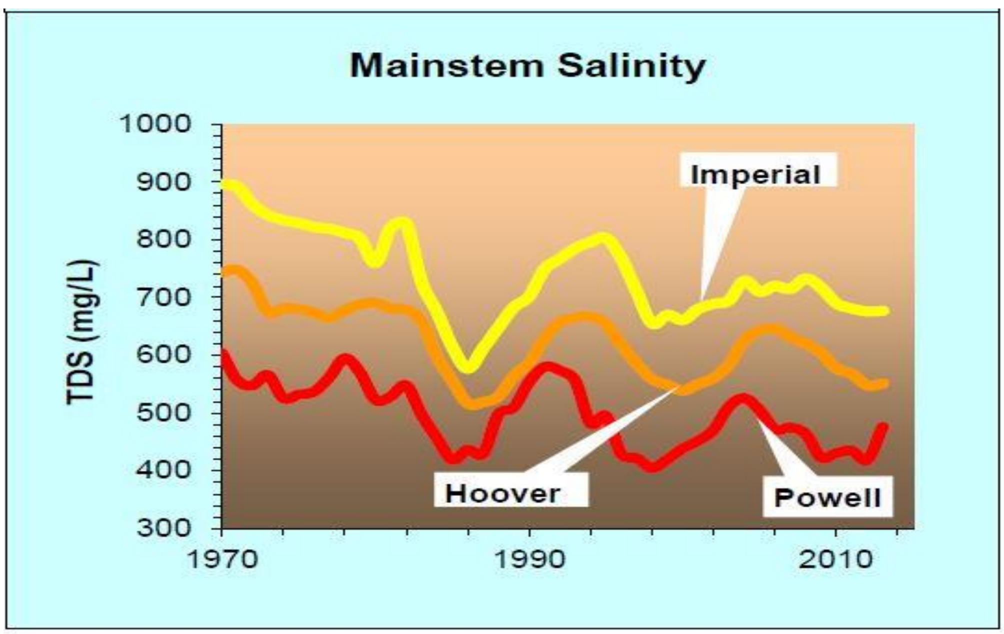


Figure 5-2. Colorado River Salinity Levels.

Source: Reclamation (2017h)

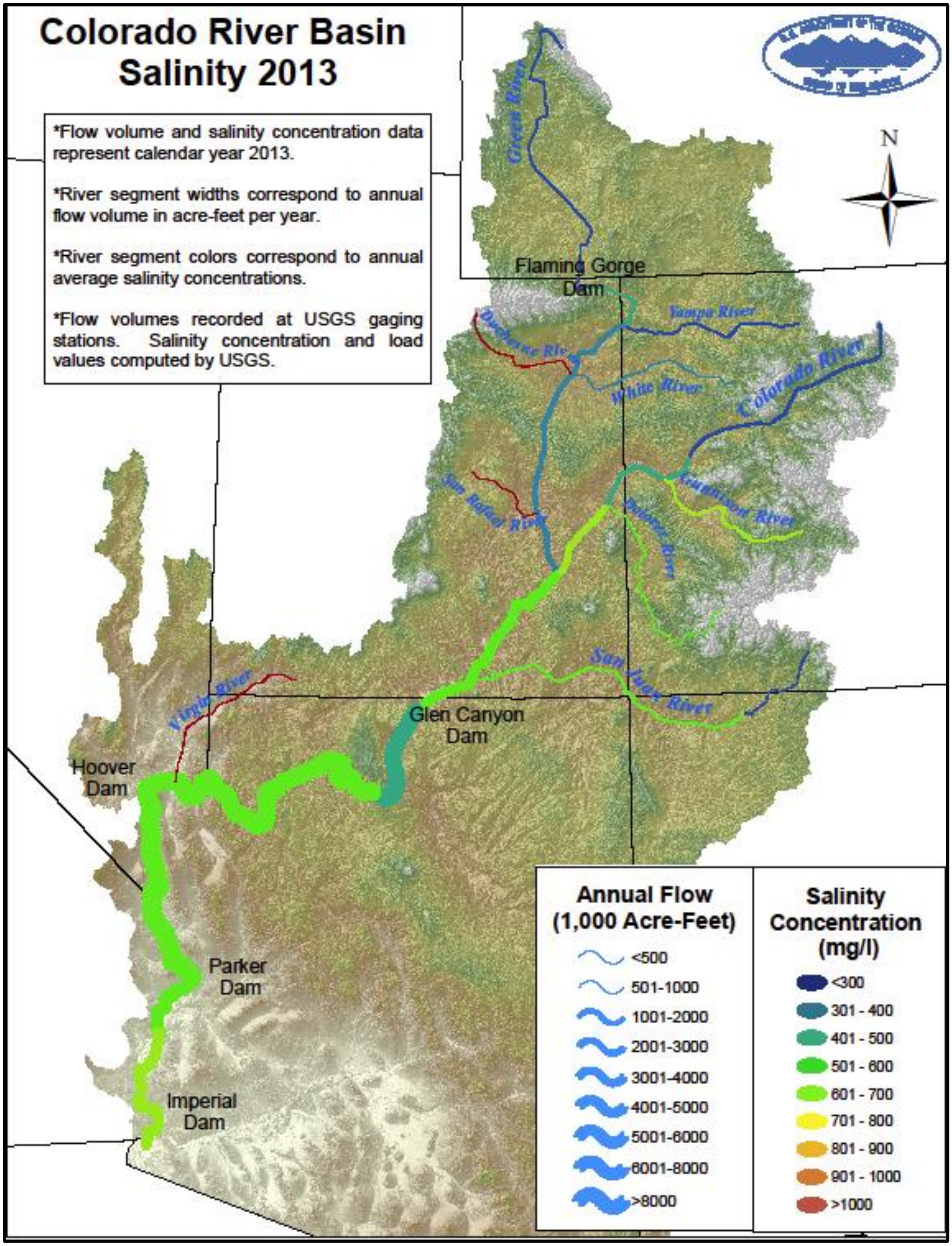


Figure 5-3. Colorado River flows and salinity (2013).

Source: Reclamation 2017h

5.1.2.3 *Drought Preliminary Goals*

At the meeting on October 19, 2017, preliminary goals were set to investigate the effects of long-term drought in the planning area.

- Monitor watershed salinity, reservoir status, and any threats to water supply;
- Identify "safety net" water supplies at a low cost;
- Prepare and deploy a long-term, 5- to 10-year, plan to evaluate long-term infrastructure and opportunities to develop cooperative agreements with various industries;
- Research future anticipated hydrologic and chemical modeling;
- Deploy a short-term, 1-year, plan evaluating current infrastructure and community to combat salinity due to drought; and
- Manage current drought plans to help reduce water loss (City of Phoenix 2015).

5.1.3 Aquatic Invasive Species

Quagga mussels at Parker Dam
Source: Stephens, 2010

Issue: Invasive species in the River, especially quagga mussels and invasive aquatic plants.

Invasive species have become an increasing threat to the LCR's natural ecosystems. Non-native species outcompete and displace native species due to the lack of natural predators and disease, thereby creating a monoculture of the invasive species. Effects can be detrimental on the watershed from non-native species by displacing natural foods and habitat, causing areas to become vulnerable to catastrophic events. Invasive species that are present in the LCR watershed include but are not limited to: rock snot (*Didymosphenia geminata*), quagga mussel (*Dreissena bugensis*), New Zealand mud snail (*Potamopyrgus antipodarum*), northern crayfish (*Orconectes virilis*), apple snail (*Pomacea* spp.), red-rimmed melania (*Melanoides tuberculate*), giant salvinia (*Salvinia molesta*), water lettuce (*Pistia stratiotes*), and water hyacinth (*Eichhornia crassipes*). Table 5-3 presents each invasive species' common name, scientific name, threats posed, and risk to the LCR.

Table 5-3. Invasive Species Threatening the Lower Colorado River

Common Name	Scientific Name	Species' Threats	Invader in Lower Colorado River
Rock Snot (Didymo)	*Didymosphenia geminata*	• Didymo affects the abundance and diversity of benthic macroinvertebrate communities through direct trophic and habitat interactions.[a] • The algae can reduce fish spawning habitat and make recreational activities such as boating, swimming, fishing, etc., unpleasant.[a] • Extensive mats of the algae could modify river hydraulics and foul pipes and underwater surfaces of municipal, industrial, and agricultural water intakes. • The algae is not considered a human health risk.[a]	• Through Arizona Game and Fish Department (AGFD) Directors Order {A.R.S. §17-255.01(B)}, list didymo; a.k.a. Rock Snot (*Didymosphenia geminata)* as an aquatic invasive species in Arizona, with subsequent affected waters listing and mandatory conditions .for movement. • Recently discovered in Arizona, in early 2007. • Didmyo found in the gut of a black fly larva below Lees Ferry in the Colorado River. [a] • A sample of algae was collected in 2009 and a single didymo cell was found associated with the sample in the LCR.[a]
Quagga Mussel	*Dreissena bugensis*	• The species is able to remove considerable amounts of phytoplankton and suspended particulates from the water. In turn, the removal of these organisms depletes food sources for phytoplankton, ultimately negatively affecting fisheries. • The mussel's tissues accumulate organic pollutants more than 300,000 times greater than concentrations found in the natural environment. The organic pollutants can be distributed up the food chain, increasing exposure to wildlife. [b] • Broken shells are very sharp and have caused lacerations to swimmers and anglers. • The organism clogs water intake structures, reducing pumping capabilities for power, agricultural, and water treatment plants. • Various gastropods, native to the LCR, become outcompeted from *D. bugensis*. • Recreational activities and industries have been impacted negatively; docks, boats, beaches, buoys, and break walls have all been colonized heavily. [b]	• Quagga mussels have been found in the Colorado River from Lake Mead downstream to the Mexican border. [b]
New Zealand Mud Snail	*Potamopyrgus antipodarum*	• New Zealand mud snails (NZMS) sequester biomass/nutrients. • Native gastropods are outcompeted. [c] • The snail consumes significant food resources, making the nutrients unavailable to other species in the food chain. • Fish are capable of carrying NZMS through their digestive tract, expelling the snails alive and intact. • As a food source, NZMS offer almost no nutrition to their consumers. With low to no nutrients available, fish populations are reduced. [c]	• NZMS can be found in the Colorado River below Glen Canyon Dam, Lee's Ferry Reach and Grand Canyon, and in Lake Mead. [c] • NZMS have not been discovered below Hoover Dam. • No specifically targeted surveys have been conducted elsewhere in the LCR to determine their distribution. [c]

Common Name	Scientific Name	Species' Threats	Invader in Lower Colorado River
Northern Crayfish	*Orconectes virilis*	• The northern Crayfish can potentially alter and reduce macrophyte biomass and diversity in aquatic ecosystems. • The species has negatively impacted native fish populations throughout Arizona to include desert suckers, the Sonora sucker, and little spinedace due to competition. [d] • The Chiricahua leopard frog has declined due this invasive species, as well as native snails, i.e., Three Forks spring snail in Arizona. • Other impacts associated with Orconectes virilis include the decrease of insects and other macroinvertebrates, the alteration of the structure and composition of lake and river shores, the turbidity increase in water, and irrigation network and levee impacts from their burrowing behavior. [d]	• The species is known to occur along the entire length of Lake Powell on the Colorado River. [h] • The invader inhabits the Santa Clara River and Virgin River, which discharges to the Colorado River. [h]
Apple Snail	*Pomacea* spp.	• The snails exploding population in ephemeral habitats have devastated agricultural crops. • The alien invader has the potential to negatively impact native wetland ecosystems and agriculture, outcompete native species for limited resources, and severely alter freshwater habitats, creating an unbalanced ecosystem. • The species has caused meningitis in humans because it can host the rat lungworm (Angiostrongylus cantonensis), transmitted through the consumption of improperly prepared flesh of escargot. [e] • This snail can decimate native snail populations, introduce parasites, and continually stress native wetland ecosystems. • Apple snails disrupt aquatic plant species by destabilizing the wetland ecosystems and interrupting key roles in nutrient cycling. • After the species become established, there is no effective way to eliminate the snail. [e]	• Apple snails have been found in the Colorado River at Yuma.
Red-rimmed melania	*Melanoides tuberculate*	• The invasive species host various parasites to include Oriental lung fluke (*Paragonimus westermani*), Chinese liver fluke (*Clonorchis sinenesis*) and trematode (*Centrocestus formosanus*) and various other parasites have been found which can infect humans • The species can outcompete and replace native snail populations and will consume benthic fish eggs. • Red-rimmed melania can also have high-density populations.[k]	• In 2018, an established population was found in Lake Havasu, specifically in Cattail Cove State Park • Occurrences were documented in Imperial Reservoir in 2006 at Parker Dam Pond.[k]
Giant Salvinia	*Salvinia molesta*	• Giant salvinia notoriously dominates slow moving or quiet freshwaters. • The species grows rapidly, reproduces quickly, and can withstand a wide range of environmental stressors. [f] • The plant is aggressive, is competitive with native species, and impacts aquatic environments, water use, and local economies. • The plant grows in dense populations, depleting the water of light and oxygen. This results in decomposing matter falling to the bottom, consuming dissolved oxygen imperative to lives of fish and other aquatic organisms. [f]	• The U.S. Fish and Wildlife Service discovered giant salvinia on August 4, 1999, in the Imperial NWR on the Colorado River. [f] • Additional sightings of the non-native species floating down the Colorado River specifically on the Cibola NWR, in Pretty Water and Three Finger Lake have been recorded. • The source of the invasion was linked to the West Side/Outfall Drain of the Palo Verde Irrigation District near Blythe, California. [f]

Common Name	Scientific Name	Species' Threats	Invader in Lower Colorado River
Eurasian Water Milfoil	*Myriophyllum spicatum*	• The species is capable of reducing and displacing native aquatic plant diversity due to its ability to form dense canopies that ultimately prevent light from penetrating the surface of the water. [i] • As a food source, the invader is a less valuable food source, than native aquatic plant species, for a variety of aquatic species. • The dense cover provided by the invasive plant provides sufficient protection for small invertebrates and other organisms, increasing the survival rate of young fish species but decreasing predatory fish populations. [i] • The thick vegetation depletes dissolved oxygen in the water and degrades water quality. • Recreational activities are restricted from the large thick mat of plants. • Irrigation infrastructure and water intakes become clogged from the invader.[i]	• The species has been discovered throughout the LCR. [i] • The species was detected in the LCR in the early 1970s.
Spiny Naiad	*Najas minor*	• Spiny naiad block sunlight from penetrating the surface of the water, destroying or inhabiting growth of native aquatic plant species. • This species has the ability to out-compete native plants for space because of their aggressive growth rate and ability to overtake shallow water ecosystems. • *N. minor* dominated ecosystems can drive out various animals dependent on the displaced native vegetation for survival. • Oxygen in nearby water and sediment can be dramatically decreased because of the dense mats formed from dead and decaying spiny naiad. • Dense stands of the invader may inhibit recreational activities like fishing, boating, and/or swimming. • Discharge capacity on municipal and farming lands may be reduced from the alien species' mats.	• Although native to Arizona, the species was introduced in the LCR in the 1980s.
Water Lettuce	*Pistia stratiotes*	• The invasive plant grows in dense populations, clogging waterways and making fishing, swimming, and boating more challenging to enjoy. [g] • Thick mats of water lettuce block the air-water interaction of the environment and deplete dissolved oxygen in the process, creating less suitable habitat for fish and other aquatic species. • The plants outcompete native vegetation, reduce biological diversity, and alter animal communities that become blocked due to its dense mat. [g]	• In March 2008 and 2010, water lettuce was discovered in the Colorado River in Yuma County, Arizona, most likely from higher water temperatures, allowing plants to sexually reproduce quicker. [g]

Common Name	Scientific Name	Species' Threats	Invader in Lower Colorado River
Water hyacinth	*Eichhornia crassipes*	• Water hyacinth is similar to the effects water lettuce has on aquatic ecosystems. • Recreational activities such as boating and fishing become nearly impossible due to the dense mats formed by the invasive plant. [h] • The plant can also greatly diminish water flow because of the dense mats it produces. • Biological diversity decreases, oxygen becomes depleted and light can no longer penetrate the surface of the water, ultimately eliminating all species in the ecosystem. [h]	• On March 18, 2016, water hyacinth was reported to a California Fish and Wildlife Officer, who reported the invasive species to the Arizona Game and Fish Department. This was confirmed after sampling the plant and observing the species in several patches in the upper end of Ferguson Lake. [h]
Gizzard shad	*Dorosoma cepedianum*	• The species outcompete native fish species and contribute to decreases in growth and size of native species.[j] • The invader is capable of significantly increasing phytoplankton levels, increasing turbidity and potentially impacting visual predators.	• The invasive species was first identified in the LCR in 2007 and by 2008 it was the second most netted fish. • In 2007, gizzard shad invaded Lake Mead and most recently, November 2012, three gizzard shad were found in Lake Mohave. [j]

[a] Dahlberg (2010).
[b] Arizona Game and Fish Department (2012).
[c] Sorensen (2010).
[d] U.S. Fish and Wildlife Service (2015b).
[e] Silverwood (2011).
[f] McMahon (2010).
[g] Florida Fish and Wildlife Conservation Commission (2017a).
[h] Florida Fish and Wildlife Conservation Commission (2017b).
[i] Pfinsgten, Berent, et al. (2017).
[j] Webber, P (2013).
[k].USGS (2018)

5.1.3.1 *Invasive Species Preliminary Goals*

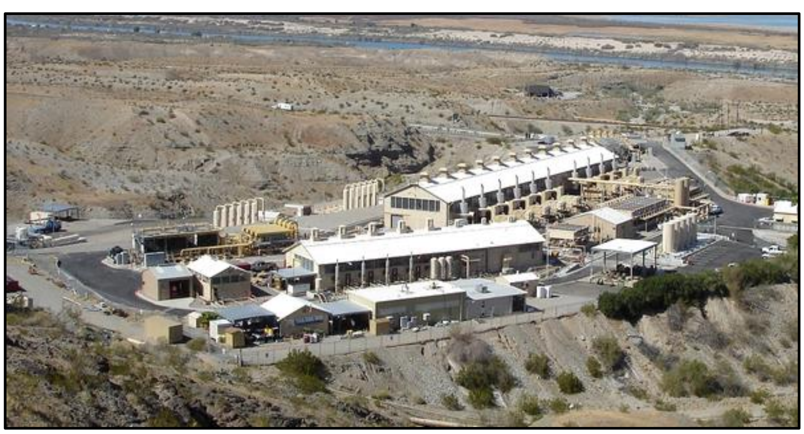
During the stakeholder meeting on June 26, 2017, preliminary goals were set to mitigate invasive species' occurrences in the LCR. These are listed below:

- Work with the AGFD to identify community-based solutions;
- connect with the USFWS, the University of Arizona (i.e., Colorado River Aquatic Invasive Species Task Force), non-governmental organizations (NGOs), and other organizations to investigate invasive species removal options;
- prevent and control the introduction of new and existing invasive species in the LCR region and eradicate the species wherever possible;
- raise awareness among the general public about invasive species and their effects on the watershed through education and literature;
- investigate associations between marine and freshwater non-native species that may be transported from California;
- apply modern invasive species management and habitat restoration techniques to LCR;
- preserve listed species and communities throughout LCR; and
- increase the LCR's natural features, including wetlands, floodplains, woodlands, riparian buffers, and open spaces.

5.1.4 Hexavalent Chromium

Issue: Hexavalent chromium has seeped into the groundwater near the LCR from a Pacific Gas and Electric site and an old plating facility.

Hexavalent chromium is an ionic form of the metallic element chromium used in industrial processes. The compound is a known carcinogen if inhaled, ingested in food and water, or comes in direct contact with skin. In 2007, chromium VI was found in groundwater south of Needles, California, roughly 60 feet from the Colorado River (CAP 2007). The source of pollution came from Bat Cave Wash, a deep ravine northeast of the Colorado River.



Topock Compressor Station, Needles, CA.
Source: CDTSC, 2011

Chromium impacts continue to be evaluated and monitored by ADEQ and California Department of Toxic Substance Control (CDTSC) from the Pacific Gas and Electric Topock compressor station, located in San Bernardino County, California. In the 1950s and 1960s, Pacific Gas and Electric Topock used chromium VI for their natural gas compressor station. For more than 13 years, Pacific Gas and Electric discharged contaminated hexavalent chromium water, over 1 billion gallons, into Bat Cave Wash. The chromium VI-contaminated water eventually seeped into the groundwater, where it remains today, slowly progressing toward the Colorado River (Matson 2015). The State of California and ADEQ have monitored the groundwater in the vicinity and have been successful at removing and treating the compound in various areas. No chromium VI has been detected in the Colorado River downstream of the Topock Site (CDTSC 2005).

An additional chromium VI plume exists approximately 1 mile from Lake Havasu in Lake Havasu City (LCRWQP 2017). The source was identified as a metal plating facility, at a former McCulloch Corporation manufacturing facility that discharged spent chromium waste into an underground tank that leaked into the surrounding subsurface. To help ensure that the Colorado River does not become contaminated with hexavalent chromium, groundwater cleanup from various sources has been implemented (LCRWQP 2017). The State of Arizona and ADEQ are currently evaluating remedial procedures for the contaminated groundwater in the area and have listed the site under the Water Quality Assurance Revolving Fund Registry (1986).

5.1.4.1 *Preliminary Goals for Hexavalent Chromium Containment*

During the stakeholder meeting on June 26, 2017, preliminary goals were set to address hexavalent chromium at the two sites in the LCR. These are listed below:

- Work with ADEQ as appropriate regarding evaluation of the listed Lake Havasu City hexavalent chromium site;
- increase public knowledge about hexavalent chromium and its impacts to water quality in the LCR;
- Research future anticipated hydrologic water modeling;
- Protect public health by preventing and minimizing health risks associated with hexavalent chromium; and
- Reduce the amount of urban-based pollutants from entering surface water.

5.2 SECONDARY PRIORITY ISSUES

Secondary Issues refers to those where issues have been addressed, where there are minimal impacts, or where CCRSCo has minimal ability to address and will likely only be related to a water quality monitoring. Secondary Issues include mining, agricultural runoff, hydrocarbons, and land development, which are discussed below.

5.2.1 Mining

Issue: Mines in the region could potentially introduce hazardous runoff into the Colorado River during flash floods.

Mining has been active intermittently in the surrounding area of LCR for over a hundred years. Unregulated and/or unhealthy environmental practices have had negative impacts on maintaining a diverse and healthy ecosystem in the LCR. The LCR is littered with abandoned surface and underground mining sites, over 1,000, mainly for gold, copper, and silver exploration. Residual effects of pre-law mining have scarred the landscape and negatively influenced water quality from acid mine drainage seeps, mine tailings, and other mining activities (Rosner 1995). Impacts from mining activities include acid drainage and metal leaching, contaminating the water quality and disturbing the various ecosystems within the LCR.

Persistent Bioaccumulative Toxic (PBT) chemicals, used in mining processes, have become a concern because of their toxic qualities and slow degradation process, causing it to remain in the environment for long periods of time. These compounds can build up and accumulate in body tissue and are not destroyed easily. PBT chemicals include mercury, lead, dioxin like compounds, polycyclic aromatic compounds, and a variety of other pesticides and chemicals (Patagonia Area Resource Alliance 2017).

Copper smelter and dust chamber from abandoned mine outside of Parker, Arizona
Source: Totally Trailer, 2018

Refer to Table 2-9 and Figure 2-10 in Chapter 2, which provides a current list of active mines and locations in the planning area.

5.2.1.1 *Preliminary Goals for Mining Activities in the LCR*

During the stakeholder meeting on June 26, 2017, preliminary goals were set to investigate mining activities occurring in the LCR. These are listed below:

- Identify sources of nonpoint source pollution;
- conduct source characterization studies for watershed impacts from mining;
- rank and prioritize individual mining sites for water quality investigation;
- obtain documentation from BLM of known mining operation sites, mine owners, and potential hazards;
- investigate uranium, copper, gold, and arsenic runoff impacting the LCR from mining activities through the Arizona Geological Survey;
- examine Alamo Lake for mercury contamination;
- reduce the effects of acid mine drainage impacts on LCR watershed;
- educate and inform the public regarding all aspects of mining in the LCR area and its potential hazards; and
- reduce/prevent metals and sulfates from acid mine discharge from entering surface water.

Agricultural Runoff

Issue: Impacts to water quality from agricultural and farming activities.

Agricultural land use is the largest user of water in the Colorado River basin, increasing pollutant runoff and salinity. Irrigation development in the Lower Colorado River began around the same time as the Upper Colorado River, but at a much slower pace due to the required river diversions and irregular flow. Development began in the late 1800s and continues today (ADWR 2009b). Currently, the irrigated lands for the entire Lower Colorado River total more than 1 million acres.

Irrigational practices have changed significantly with technological advances and the introduction of canal and lateral lining, sprinkling systems, gated pipe, and tile drains, resulting in less runoff from agricultural practices (ADWR 2009b).

5.2.1.2 *Agricultural Runoff Preliminary Goals*

Preliminary goals for agricultural runoff occurring in the LCR include:

- Work with farmers and applicators to adopt agricultural technology to reduce excess application of nutrients.
- Increase grower participation in NRCS, state and/or local Department of Natural Resources (DNR), and other conservation programs through marketing.
- Reduce pollutants associated with application overlap.
- Promote conservation tillage practices and cover crops.
- Perform training workshops on agricultural practices and cost-share opportunities.
- Promote vegetated filter strips.
- Perform field demonstrations on proper pesticide application procedures.

5.2.2 Potential Hydrocarbon Leaks/Spills

Issues: There is potential for hydrocarbon leaks and/or spills into LCR and adjacent backwaters.

Another secondary issue is potential leaks/spills of hydrocarbons. Stormwater runoff from the surrounding lands in the watershed has the ability to increase hydrocarbon contamination into LCR. These hydrocarbons can be detrimental to water quality, accumulate in aquatic species and through the food chain, lower dissolved oxygen, and affect respiration in aquatic organisms (Todd 1999). Hydrocarbons are considered toxic substances and are defined as organic compounds, containing mostly carbon and hydrogen with other elements such as nickel and detergents. Hydrocarbons occur in coal, crude, oil and natural gas extraction, and plant life (Todd 1999). Benzene, methane, and paraffin are all hydrocarbons and are used as fuels, solvents, and various raw materials for products of plastics, pesticides, dyes, etc., that could contaminate the LCR.

Potential hydrocarbon leaks and spills include oil and grease, gasoline, and polyaromatic hydrocarbons (PAHs). These hydrocarbons are used in various industrial processes, automobile wear, automobile and watercraft emissions, automobile and watercraft fluid leaks, and waste oil (Todd 1999). Boats and jet skis contribute to hydrocarbon emissions in the planning area, however the extent is unknown at this time. Hydrocarbons are usually introduced to a waterbody by inputs from urban runoff and stormwater. Runoff from Lake Havasu City into Lake Havasu analyzed between 2012 and 2016 contained low concentrations of oil, grease, PAHs, and total petroleum hydrocarbons that did not result in detectable quantities in the reservoir water column or bottom sediments (Wilson 2018).

5.2.2.1 *Potential Goals for Hydrocarbon Leaks/Spills*

During the stakeholder meeting on June 26, 2017, preliminary goals were set to manage potential hydrocarbon leaks and/or spills occurring in the LCR. These are listed below:

- Manage urban runoff effectively to reduce the presence of hydrocarbons in LCR;
- develop a monitoring strategy for LCR;
- continue following the Lower Colorado River Geographic Response Plan;
- reduce hydrocarbons in the watershed through public education and outreach on practical knowledge of the issue; and
- develop literature and educational material for the public regarding the negative impacts hydrocarbons have on the LCR.

5.2.3 Land Development

Issues: Increased urbanization, land use, and non-point sources would affect water quality in the LCR.

Land uses in the planning area are expected to change little in the future, but water demand will increase in certain regions due to urbanization, particularly in the growing cities of Yuma, San Luis, and Somerton, Arizona, affecting the water quality in the LCR (Davey 2006). For more information on current land uses in the region, refer to Section 2.4, Land Use and Land Cover, Figure 2-7. To understand better water quality in the LCR, it is important to analyze predictions of future land development. Increased stormwater runoff and non-point sources from urbanization and other land use changes would affect water quality.

Additionally, future risks to water quality from land development could occur from changes in water demand within the planning area. Risks would come primarily from agriculture, and municipal and industrial (M&I) uses as presented in *Colorado River Basin Water Supply and Demand Study* (Reclamation 2012). The purpose of this study was to address the ranges of future potential imbalances in water quality and mitigation measures. The study projected future water supply and demand as it refers to water quality impacts from land development along the Colorado River over a 50-year period (Reclamation 2012).

Agricultural

Approximately 3.8% of the planning area is in agricultural use. In 2015, agricultural water demand made up over 35% of total Colorado River demand in Arizona. This is expected to drop to approximately 20% of total Colorado River demand by 2060. This decrease in agricultural demand across Arizona is mainly from a shifting away from farmlands to urban development in central Arizona (Reclamation 2012). Although water demand for agriculture declines over a broader region, agricultural lands in the planning area would increase to make up for the loss of agricultural lands in central Arizona.

Groundwater use for agriculture has increased due to declines in surface water deliveries and rises in overall water use. As groundwater is depleted, salinity and total dissolved solids (TDS) levels are increased and become more concentrated when applied to agricultural lands (Davey 2006). Decreases in groundwater recharge from river flows would result in increased salinity, as the river flows are of lesser TDS content than agricultural filtration.

Municipal and Industrial (M&I)

Between 1990 and 2000, Mohave County was the fastest-growing county in Arizona, and proposed developments in the northwestern portion of the planning area have caused concern regarding water supplies to meet compliance standards and future needs (ADWR 2009). Population growth is expected in the form of large master-planned communities in Detrital Valley, Hualapai Valley, and Sacramento Valley basins (refer to Figure 2-4 for location) and areas around Yuma are predicted to have increased urbanization.

One of the largest components of Colorado River demand is M&I. In 2015, Reclamation predicted demand would increase from approximately 26% to approximately 45% of total Colorado River demand by 2060, mostly driven by population growth (Reclamation 2012). The increased urbanization demand for Colorado River water is predicted to have a much lesser impact than other planning areas, however, water levels would continue to decline and non-point sources would increase, negatively impacting water quality.

Areas with increased urbanization affect water quality negatively in the following ways: erosion and sedimentation, urban runoff, nitrogen, phosphorus, sewage overflows, pesticides and waterborne pathogens (see Chapter 4, Section 4.1 Nonpoint Sources and Chapter 5, Section 5.1.2 Water Resiliency for additional information).

In summary, urban growth throughout the planning area will increase demands placed on the Colorado River's resources, resulting in changes to future water use. As agricultural lands are being converted into developed land uses, in central Arizona, there would be an increase of agricultural lands along the Colorado River to make up for the loss. Increased urbanization throughout the planning area may have negative impacts on water quality in the LCR from increased stormwater runoff and non-point sources. Additionally, as water demand increases, surface water decreases, lowering groundwater levels, which in turn increases salinity and TDSs concentrations affecting the overall quality of water. Appropriate planning may mitigate changes to the area, allowing land development to thrive for many years into the future.

5.2.3.1 *Potential Goals for Land Development*

Preliminary goals to analyze future land development and its effect on water quality occurring in the LCR are listed below:

- Monitor water levels in LCR as future land development projects increases;
- educate and inform the public about impacts future land developments may have on water quality from increased urbanization and water use efficiency; and
- provide information to Reclamation about increasing upstream water storage capacity so flood events are less frequent.

Chapter 6 Implementation Program Design

6.1 EXISTING MANAGEMENT STRATEGIES

Many federal and local agencies are currently active in management and/or monitoring within the LCR. Activities that are directly related to issues and concerns identified in Chapter 5 are discussed below under three general categories: invasive species, water quality, and drought management/planning.

Invasive Species

Reclamation, USFWS, AGFD, California Department of Fish and Wildlife, and Nevada Department of Wildlife are responsible for the management of wildlife and fisheries, endangered species, and invasive species within the watershed (State of Arizona 2011). Controls currently in place to combat invasive species include:

- A barrier in the Walters Camp old river channel to eradicate and manage giant salvinia.
- Mechanical harvesters and chopping machines that remove water hyacinth and water lettuce from the water and are able to dispose of it offshore.
- Substrate system to the intake towers of Hoover Dam that determine how quickly quagga mussel colonization occurs. This is done in conjunction with increased inspections of exterior structure underwater and replacement of bio-boxes where colonization has shown.
- A strainer and ultra-violet system on each dam's domestic water supply line to monitor quagga mussel colonization (LCR MSCP 2017).
- A Lake Mead NRA Quagga Mussel Response Plan and an Interagency Management Action Plan for Quagga Mussels, developed by NPS in cooperation with its partners. The plan addresses monitoring needs for adults, juveniles, and veligers in order to develop future mitigation measures (NPS 2007).

Quagga mussels on intake towers of Hoover Dam
Source: Reclamation, 2008

- Use of salvinia weevil (*Cyrtobagous salviniae)*. This host-specific biological control will not have direct negative impacts on native plant species. The efficacy of these weevils in the lower Colorado River has been high at suppressing and controlling giant salvinia in California and Arizona (AGFD, 2010).
- Use of Glyphosate 5.4, an herbicide used in the LCR to control water lettuce and water hyacinth.
- In 2003, the Aquatic Nuisance Species Task Force established the New Zealand Mudsnail Management Plan Working Group to create a national management and control plan. Hazard Analysis and Critical Control Point – Natural Resource Management (HACCP-NRM) planning is another general tool for managing invasive species pathways. HACCP-NRM plans to identify

potential pathways of introduction of invasive species and identify how the pathways can be broken to prevent the introduction in the LCR.

- For over 10 years, there have been multiagency quagga mussel meetings for Lake Mead hosted by Southern Nevada Water Authority. The group has expanded to other invasive species at all LCR locations.
- An Aquatic Invasive Species multiagency group headed by University of Arizona meet three times a year, at various locations throughout the LCR, to discuss issues and management strategies to combat invaders.
- The Colorado River Aquatic Biologist (CRAB) group, part of LCR MSCP, meets in Laughlin, NV annually to discuss invasive and endangered species.
- Arizona enacted "Don't Move a Mussel" program to combat the invasive quagga mussel. New regulations were enacted in 2010 to prevent the spread of quagga mussels.
- Nevada Department of Wildlife has implemented a watercraft inspection and decontamination program to prevent the spread of quagga mussels. The program also prevents the spread and introduction of other undesirable non-native species.
- California Department of Fish and Game manage the Dreissenid Mussel Prevention Program Development and Requirements. The code requires any managers of the reservoir to develop and implement a program to prevent the spread of the invaders.

Water Quality

The EPA, ADEQ, California Environmental Protection Agency, and NDEP regulate the treatment and discharge of wastewater, monitor and assess the quality of surface water and groundwater, identify water pollution problems, and issue permits to protect water from point source pollution in the LCR watershed (ADEQ 2017d). This includes the oversight of pollution from mining operations, hexavalent chromium, and potential hydrocarbon leaks and spills. Current controls used to manage these pollutants include:

- Land manipulation or structures have been developed to channel runoff away from pollution sources at mining operations to minimize acid mine drainage.
- Installation of groundwater monitoring wells in Arizona to monitor the levels and geographic extent of hexavalent chromium from the Pacific Gas and Electric (PG&E) releases near Needles (ADEQ 2017d).
    - August 1, 2005: PG&E installed IM-3 groundwater extraction and treatment system (pictured on the right). The system has treated more than 825 million gallons of water and removed approximately 7,300 pounds of chromium from August 2005 through December 2017 (CDTSC 2018a).

Source: CDTSC, 2005b

    - DOI accepted PG&E's Biological Assessment (as revised) on July 7, 2014, to address remedial activities for groundwater improvement. To date, mesquite trees have been planted by PG&E for habitat improvement on the Havasu NWR and drip irrigation was installed to ensure their survival (CDTSC 2018b).

- The McCulloch manufacturing site (located in Lake Havasu City, Arizona at Lake Havasu Avenue and Holly Avenue) was added to the Water Quality Assurance Revolving Fund (WQARF) Registry on December 4, 2017. ADEQ has developed a fact sheet, a community involvement plan outline, and scope of the remedial investigation and feasibility study (ADEQ 2017f).

- BLM provided necessary funding to correct impacts from abandoned mines at the Swansea Mine located approximately 16 miles from Parker, Arizona. As of May 2010, eight deep, open, abandoned mine shafts were filled in or had bat-friendly enclosures installed, providing a safer environment for public and wildlife areas (BLM 2013).

- Ongoing multiagency/multi-tribal LCR water quality monitoring and the development of a publically accessed, LCR water quality database housed by SNWA beginning in 2009 through an intergovernmental agreement between Reclamation and CCRSCo.

Drought Planning and Management

Reclamation is responsible for managing water use in the LCR. The agency supports a proactive approach to drought by assisting water managers to develop and update comprehensive drought plans, and implement projects that will build long-term resiliency to drought. Current controls in place to manage drought include the following.

- In 2008, Reclamation established a means by which operating water systems within the Colorado River Basin must submit a System Water Plan. Plans must be submitted every 5 years and consist of three components: a Water Supply Plan, a Drought Preparedness Plan, and Water Conservation Plan.

- On December 13, 2007 the Department of the Interior and Reclamation approved the 2007 Interim Guidelines (2007 Interim Guidelines) for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead with a Record of Decision based on the 2007 Final Environmental Impact Statement for the 2007 Interim Guidelines. The 2007 Guidelines were developed to improve management of Colorado River water supplies; provide water users a greater degree of predictability with respect to the amount of annual water deliveries, particularly under drought and low reservoir conditions; and provide additional mechanisms for the storage and delivery of water supplies in Lake Mead.
- The USGS installed over 200 USGS wells through 2009 to electronically measure water levels 4 times a day. The devices were installed at locations based on growth, subsidence, type of land use, proximity to river/stream channels, proximity to water contamination sites or other areas affected by drought.

- Local Tribes have adopted several ordinances to protect water resources, including Drought Contingency Plans that establish drought declaration criteria and identify response actions.

- *Colorado River Basin Ten Tribes Partnership Tribal Water Study* is a collaborative study involving 10 Tribes in the LCR and Reclamation partnership. The study was performed to determine tribal water supplies, document current Tribal water use, project future water demand, document uses of Tribal water by others, and identify Tribal opportunities and challenges associated with LCR water supply (Reclamation 2016).

- In June 2014, LCR was named a Critical Conservation Area under the NRCS Regional Conservation Partnership Program. Grants have helped irrigators use water more effectively and reduce the amount of salts and selenium carried into the LCR and its tributaries. Efforts for water efficiency include coordinating canals, ditches, and pipes that deliver water to farms with improvements in the way water is delivered to crops, and eliminating flood irrigation via replacement with sprinklers and other irrigation systems (Reclamation 2016).

- Reclamation is currently collaborating with Arizona, California, and Nevada to determine proactive steps to lower the risk of reaching critical elevations at Lake Mead. A Memorandum of Understanding was drafted for Pilot Drought Response Actions outlining a commitment from Reclamation and several water agencies throughout the LCR to use best efforts to produce between 1.5 and 3.0 million acre-feet of additional water through 2019 (Reclamation 2016). The pilot report evaluating the effectiveness of the program is due to Congress in 2018 (Reclamation 2017j).

- In July 2014, $11 million was allocated for system conservation for Reclamation, Central Arizona Water Conservation District, MWD of Sothern California, Denver Water, and Southern Nevada Water Authority (Reclamation 2016). The Pilot System Conservation Program invites water users to participate in pilot projects that establish temporary, voluntary, compensated programs to conserve and/or reduce the use of water, and increase storage levels in reservoirs to benefit the River. Implementation agreements were established in 2015, and proposal requests have been received from potential program participants (Reclamation 2016). Ten projects have been implemented in the LCR resulting in nearly 117,000 acre-feet of system water with additional agreements being implemented in 2018 (Reclamation 2017j).

- WaterSMART Grants are being utilized in Southern California by municipal water agencies to provide rebates for turf replacement, installation of meters for residential and commercial customers, and construction of recharge basins to create groundwater storage and various other conservation projects (Reclamation 2016).

- The University of Arizona is developing a geospatial database of environmental flow needs and responses in order to deliver water and land managers easy access to the best techniques available for determining the amount of water needed in the ecosystem, funded by Desert LLC (Reclamation 2016).

- Since 2015, Reclamation has been working with partners to develop a Drought Contingency Plan. More detail is available in Section 2.4.6 Relevant Authorities.

- In 2017, Minute 323 amended Minute 319 mandating Lake Mead's elevation be used as an indicator for water delivery reductions. Refer to Section 2.4.6 Relevant Authorities for more information.

- Reclamation and non-federal partners have initiated a Basin Study in southern Arizona to evaluate the impacts of climate change and ensure sustainable water supplies. Part of the study provides incentives to improve understanding groundwater supplies with future uncertainties in Colorado River water supply. To date, Reclamation and non-federal partners will both contribute $680,000 to update existing models, bring together various stakeholders and local communities, and develop adaptation strategies to improve management of groundwater supplies (Reclamation 2018).

6.2 ADDITIONAL MANAGEMENT STRATEGIES AND PRACTICES

Additional management strategies will focus on public education, water quality monitoring, and research. The strategies include best management practices (BMPs) that will contribute to achieving water quality goals set forth in the WMP. BMPs include programs and practices designed to improve water quality and identify resource concerns, or affect changes to human behavior, attitudes and value perceptions.

The intended audience for this WMP is local agencies, watershed managers, and community members supporting the decision-making and planning process. Best management practices listed in Appendix A represent tools to help achieve the goals set forth in this WMP. These BMPs would be best implemented by landowners, producers, and local conservation professionals. Community-based, grassroots efforts prove to be one of the most effective and successful ways to obtain real and significant water quality improvements.

In order to achieve the goals of the WMP, it will be important for CCRSCo and member organizations to identify appropriate BMPs. When selecting and implementing BMPs, consideration will be given to the feasibility of the BMP in a given location and to those that are most acceptable for stakeholders of the watershed. It will also be important to analyze and evaluate the effectiveness of the practice at achieving specific goals, targets, and objectives within the watershed.

Appendix A summarizes BMPs for consideration to address further issues and concerns presented. These BMPs are presented by priority issues (primary then secondary), then further organized by the three management strategies: education, monitoring, and research.

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Chapter 7 Watershed Goals

7.1 MANAGEMENT OBJECTIVES AND INDICATORS

Watershed improvements in the LCR and implementation of BMPs are an essential component to obtaining the desired water quality improvements identified in this WMP. Active engagement from community stakeholders will be vital, as will participation from state and federal agencies. Continuation of monitoring will be needed, along with implementation of BMPs (see Section 6.2). Monitoring is an important component in assessing attainment of water quality standards and designated uses. Monitoring is necessary to determine whether water quality has improved, degraded, or is unchanged. This helps to determine the effectiveness of the newly implemented programs and projects and identify any need for more resources or additional BMPs.

The final element in the planning process, implementation of the WMP, begins once goals, action statements, and objectives have been determined. Plan implementation relies on adherence to the goals, objectives, and action statement. However, these goals are not permanent and can evolve throughout the implementation process. Community members and stakeholders have identified the specific concerns in the LCR and specific goals, objectives, and action statements based on the best available information. The needs of the WMP change constantly, and needs and desires within the watershed community may mean these goals will need to be reevaluated. Needs and conditions change; therefore, the plan must remain flexible enough to respond to any of these changes and, at the same time, provide strong guidance for future work.

7.2 EDUCATION, MONITORING, AND RESEARCH INDICATORS

Throughout the entire implementation process, several monitoring indicators will be used to understand and determine whether water quality improvements have been attained. Documentation of successful indicators is key. Indicators are classified into three categories: education, monitoring, and research.

Education Indicators

Education indicators complement other monitoring and research indicators to illustrate the project and management strategy effectiveness. These indicators focus on maintaining information regarding attitudes, awareness, capacity, and behaviors that may lead to improvements and/or protections of the water quality in the watershed. Educational indicators will be used to monitor:

- Increase in awareness of watershed concerns, accomplishments, and activities
- Increase in public participation in activities for watershed improvement
- Educational teachings of conservation land practices as related to watershed health
- Increase in knowledge of public concerns in the watershed issues
- Improvement in community attitudes toward actions to improve watershed health.

Education indicator monitoring will be accomplished through various resources such as workshops, participation in watershed programs, and distribution of education fliers on the issue. Using these forms of monitoring will allow stakeholders to identify if more community members and stakeholders are becoming more involved and/or educated about watershed protection activities.

Monitoring Indicators

Monitoring indicators for determining watershed health are measurements of water quality, habitat, or other information provided about watershed health. These indicators will track and aid in the determination of changes in water quality. Examples can be in the form of chemical and biological monitoring of pollutants in the watershed, species health and population status, and habitat assessments. Monitoring indicators will be used to measure and monitor:

- Changes in the biological integrity of the watershed
- Habitat quality changes
- Changes in pollutant loads in surface water and groundwater
- Success of BMPs

BMPs can be evaluated on their effectiveness using these indicators. To ensure monitoring is effective, a protocol for minimum sampling needs to be established (e.g., water samples need to be tested quarterly, macroinvertebrates populations need to be sampled annually). Additionally, annual assessments of existing sample sites need be completed, as well as analysis of before and after samples at various points throughout the watershed.

Research Indicators

Research indicators provide tracking information about task completion and needs, program participation, and objective attainment. Examples of these types of indicator are participation numbers in cost-share programs, data gaps in research, and acreage of implemented BMPs. Research indicators provide information about:

- government guideline changes,
- data gaps determined in analysis,
- new technologies and future hydrological modeling, and
- funding opportunities.

Research indicators will ensure stakeholders can identify trends in planning future activities/projects promoting the most interest and highest level of positive impact from various programs.

As part of the research program, a database will be established to track development and maintain a record of educational, monitoring, and research indicators. Following community/stakeholder workshops/events and sampling events, the database will be updated in a timely manner; for example, quarterly for non-time specific measures such as requests for educational material.

7.2.1 Lower Colorado River Objectives and Indicators

Throughout this WMP development process, stakeholders and community members identified concerns they have regarding the LCR. Preliminary goals, as laid out in Chapter 5, were set for each concern with identifying measures that could be implemented to improve water quality in the LCR. Following are objectives and management strategy indicators: education, monitoring, and research.

7.3 PRIMARY PRIORITY ISSUES

7.3.1.1 *Cyanobacteria Blooms*

Objective: Determine cyanobacteria and associated cyanotoxin issues, where "hot spots" are, and implement control mechanisms.

Objective indicators:

<u>*Education*</u>

Develop outreach and education to community members regarding harmful cyanobacteria blooms. Volunteers would survey for cyanobacteria blooms in various areas quarterly for a minimum of 5 years to monitor sources of blooms; indicators include number of workshops developed and number of participants at each.

<u>*Monitoring*</u>

Survey blooms using various technologies, e.g., satellite imagery, drones, etc.; use information for predictive modeling applications and develop a database of blooms; indicators are number of blooms, and number of successful predictive modeling applications.

<u>*Research*</u>

Investigate biological, physical, and chemical controls (refer to Appendix A for specific BMPs) to reduce blooms. CCRSCo and stakeholders would analyze and implement successful controls to vulnerable areas, and monitor number of blooms following implementation of control programs; indicators include number of effective control(s) implemented, and number of blooms before and after control(s) implementation.

Work with Reclamation and state environmental departments to identify where blooms are most common, vulnerable areas, evaluate water quality in the area, and continue to monitor until cyanotoxins fall below normal levels. Surveys would be completed when blooms are found and/or quarterly, data would be analyzed to determine any correlation between blooms and other natural and/or human-made occurrences. Indicators include number of blooms, and number of monitoring surveys completed.

7.3.1.2 *Drought Response*

Objective: Determine and evaluate the effects long-term drought has on sediment yield and salinity in the LCR.

Objective indicators:

<u>*Education*</u>

Educate and develop water conservation and drought preparedness workshops for community members, at least two programs once a year for 5 years. Measure effectiveness of workshops by documenting participation and post-workshop surveys; indicators include number of workshops performed, and number of participants at each workshop.

<u>*Monitoring*</u>

Evaluate community Water Use Reports (WUR), System Water Plans (SWP), Drought Preparedness Plans (DPP), and Water Conservation Plans (WCP) and water reducing technologies for agricultural lands. Examine WUR and/or Plans submitted or implemented, promote communities to implement WUR and/or Plan, and evaluate WUR and/or Plan effectiveness annually. Review and consider

Drought Contingency Planning efforts that address water sharing when the reservoir levels reach identified elevation threshold. Indicators include number of WUR and Plans submitted or implemented, the effectiveness of WUR and Plans, and the number of efficient water-saving technologies for cultivated lands.

Research

Investigate other water conservation programs to address drought issues (e.g., energy saving technologies, rainwater harvesting, ADWR's Agricultural Water Conservation Program) and technologies. Document successfully implemented programs and provide community surveys to determine if other drought issues have been addressed; indicators would be number of water conservation programs implemented, number of available new technologies, and number of drought issues addressed from community surveys.

7.3.1.3 ***Aquatic Invasive Species***

Objective: Continue aquatic invasive species controls to determine if populations have decreased specifically quagga mussels and invasive aquatic plants.

Objective indicators:

Education

Develop education materials and workshops for stakeholders and community members about the identification and eradication of invasive species. Surveys would be distributed before and after each workshop to understand if there is an increase in public knowledge. Once completed CCRSCo would analyze the data to determine the effectiveness of the workshop. A spreadsheet would be used to keep track of participants at each workshop, location, type of workshop, pre- and post-survey results, and overall control effectiveness; indicators would be the number of workshops completed, number of participants, and overall perception of public awareness.

Monitoring

Monitor BMP effectiveness through recordation of various sampling techniques used via CCRSCo-managed spreadsheet. Evaluate the movement of invaders and continue to monitor herbicide/pesticide applications. The spreadsheet would include sampling locations, dates of sampling, and targeted invasive species; indicator would include the number of effective techniques to control targeted species.

Research

To determine BMP efficiency, CCRSCo and other stakeholders would be responsible for tracking and analyzing new control programs in a spreadsheet; indicators would include the number of additional programs enacted annually, and number of successful programs eradicating non-native species.

7.3.1.4 ***Hexavalent Chromium***

Objective: Monitor and manage hexavalent chromium from two sites in the LCR watershed.

Objective indicators:

Education

Develop outreach and education to community members regarding improper disposal of waste and form "clean-up" groups. Inspections would be completed in various areas quarterly for a minimum of

5 years; indicators include number of improper waste sites identified, number of "clean-up" groups formed, and number of businesses participating in such programs.

<u>*Monitoring*</u>

Work with state and federal agencies to continue monitoring the progress made at each site in regards to the reduction and long-term neutralization of hexavalent chromium in the groundwater; indicators would include number of water quality and biological surveys completed, and amount of hexavalent chromium in water before and after surveys.

<u>*Research*</u>

CCRSCo and various other stakeholders would research developing technologies and/or potential study needs. State and federal agencies have continuously worked to clean up this site for years with considerable progress; therefore, CCRSCo would work with these agencies to develop a spreadsheet of current and prospective BMPs to assess efficiency and accuracy of the BMP. Indicators include increased BMP selection for chromium control, research needs, cost of potential BMP, and effectiveness of BMP.

7.4 SECONDARY PRIORITY ISSUES

7.4.1.1 *Mining*

Objective: Analyze and reduce potentially hazardous runoff from mining activities into the Colorado River.

Objective indicators:

<u>*Education*</u>

Develop outreach and education to community members regarding hazardous runoff from active and abandoned mining sites; indicators include number of mining waste sites identified, stakeholder participation, and other participating entities in such programs.

<u>*Monitoring*</u>

Identify and analyze abandoned mine sites in the area, document cleanup/remediation activities, focus on areas where mining runoff is most prolific, determine site remediation techniques, programs and projects with stakeholders, evaluate each site biannually for a minimum of 5 years or until site has been remediated. CCRSCo would document outcomes of every phase at every site; indicators include number of cleanup/remedial projects, and number of pollutants in mining runoff.

Monitor waterbodies to meet water quality standards and attain warm water habitat: pH 6.5 to 9.0, net alkalinity 20 mg/L, and total dissolved solids 1,500,000 μg/L. Researchers would perform compliance inspections quarterly for a minimum of 5 years. CCRSCo and/or other stakeholders would keep record of monitoring and what technologies were enacted; indicators would be number of sites if, when, and where water quality has improved and the number of overall improvements before and after implementation of remedial techniques.

<u>*Research*</u>

Determine pollutants, if any, in the runoff from active and closed mines in the LCR area. Sample and record identified pollutants. Identify water quality treatment projects (e.g., Research and Demonstration Programs, Education and Information Programs, etc.) to reduce pollutants in the runoff; indicators would include number of treatment projects enrolled, and number of overall pollutants over time.

Develop target requirements for each project site that will be maintained and tracked during and after any human activity in the watershed. A spreadsheet will provide CCRSCo with up-to-date data regarding mining disturbances; indicators would be number of target requirements set per site, number of pollutants in runoff pre- and post-targeted requirement implementation.

7.4.1.2 *Agricultural Runoff*

Objective: Analyze impacts on water quality from agricultural and farming runoff and determine control measures.

Objective indicators:

Education

Encourage farmers to enroll in grower programs in NRCS, local and/or state DNRs, water conservation workshops, and other conservation programs. CCRSCo would document enrollee participation on a biannual basis to determine whether participation in program decreases pollutants in agricultural runoff; indicators include number of programs and workshops enacted, number of participants per program, and change in pollutants in runoff samples before and after program enrollment and workshops.

Monitoring

Continue to monitor and regulate the turbidity and sediment levels from agricultural operations. It would be up to local farmers to complete water quality sampling at various sites to determine vulnerable areas, work with stakeholders to implement remedial technologies, monitor remedial activities, and evaluate if pollutants in agricultural runoff have declined; indicators would include number of vulnerable sites, number of remedial activities, and number of pollutants in runoff before and after remedial activities.

Research

Determine efficiency of farming irrigation systems that have BMPs implemented. Partner with the state extension service (University of Arizona) and other agencies to put sampling plans and BMPs in place for farmers and provide technical support. Conduct quarterly water quality sampling to determine runoff pollutant reductions through efficient and effective BMPs; indicators include number of systems with implemented BMPs, number of pollutants in runoff before and after BMP implementation, and number of systems needing BMPs.

7.4.1.3 *Potential Hydrocarbon Leaks/Spills*

Objective: Control and analyze potential hydrocarbon leaks/spills in the LCR and adjacent backwaters.

Objective indicators:

Education

Implement and encourage safe recycling practices for hydrocarbons to community members and monitor participation activity regularly. CCRSCo would provide educational materials to the public regarding the dangers of hydrocarbon leaks/spills and responsible recreational uses. Indicators would be number of participants at educational events, and the number of hydrocarbon leaks/spills in the LCR annually.

Monitoring

Document the number of facilities with cleanup plans and facilities needing to implement cleanup plans. CCRSCo to maintain program to track progress of ongoing cleanups, new remediation plans, and to determine the effectiveness of each cleanup. Indicators include number of cleanup plans, number of cleanup plans needed, and change in number of hydrocarbon leaks/spills before and after cleanup plan implementation.

Evaluate BMPs (refer to Appendix A for BMP details) annually to determine effectiveness and costs. CCRSCo and other stakeholders would document progress of each BMP; indicators would include number of BMPs implemented, and number of spills/leaks reported before and after BMP implementation.

Research

Determine number of large hydrocarbon polluters in region and work with local governments to manage cleanups. Document successful remedial programs/projects and cleanup status biannually for a minimum of 5 years; indicators include number of rectified and ongoing cleanup sites, and number of large hydrocarbon polluters.

7.4.1.4 *Land Development*

Objective: Evaluate impacts on water quality from future land development.

Objective indicators:

Education

Develop education materials for stakeholders and community members about the land use changes and future development and impacts these changes may have on water quality; indicators include number of programs and workshops conducted, number of participants per program, and number of potential land development projects per year.

Monitoring

Identify and analyze future land use changes and land development sites in the area, document type of activities the new development will conduct, focus on areas where development is most prolific, and evaluate each site biannually until project completion. CCRSCo would document outcomes of every phase at every site; indicators include number of land development projects, and number of pollutants in water quality.

Research

Identify susceptible areas in the LCR, particularly the planned communities in Detrital Valley, Hualapai Valley, and Sacramento Valley basins, and around the City of Yuma. Identify types of future land development projects to evaluate potential water quality effects. Determine changes in water quality by analyzing government and non-government water records over time as land development increases in and around the planning area. Indicators include any increases in salinity and TDS levels from urbanization, increase in the number of point and non-point sources, and the number of land development projects per year.

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Chapter 8 Implementation Schedule and Costs

8.1 MANAGEMENT STRATEGIES OVERVIEW

This WMP supports the Lower Colorado River planning area in an effort to identify water quality impairments and is in accordance with the EPA's Nine Key Components for Watershed-Based Plans. The approach for this WMP is to coordinate with various stakeholders to develop a framework for environmental management that focuses on public- and private-sector efforts to address the highest concerns within the hydrologically defined geographic areas. The plan takes into consideration both groundwater and surface water flow and identifies measures that may help improve water quality and restore uses of these waters negatively impacted by various pollutants in the LCR.

This WMP promoted community input from residents living in and near the planning area. The interaction between various stakeholders is an important learning opportunity to discussing water resource problems. These meetings were another way to understand the interface between humans, their activities, and the impacts they have on the watershed. Participants developed an awareness due to the interconnectedness of all of the systems in the watershed, whether it be social, cultural, or ecological, and provided residents and other stakeholders with tools for beginning the process of identifying concerns in the planning area and developing solutions.

Once issues were identified, WMP team members focused on addressing local community concerns to determine priority issues (see Chapter 5). The WMP characterized the general watershed conditions with an emphasis on the sources, transmission, and fate of land-based pollutants of the four watersheds draining into the LCR. Characterizing the watershed involved collecting and analyzing existing data and documenting existing watershed conditions. This information formed the basis for identifying issues and concerns and determining the best way to remediate pollutants.

The next steps for implementation of this plan will begin after additional community meetings are held, existing research is analyzed, and funding sources have been determined and secured. Securing funding is required in order to implement the activities to reach the goals and objectives of this WMP. Funding research needs to be on a continual basis with the activity timelines in mind to prevent delays and keep the projects on track.

Monitoring the WMP (as identified in Chapter 7) is one of the most important steps in a watershed management plan. Key stakeholder groups and individuals need to be involved as well as community residents to evaluate the WMP's progress.

Depending on resource availability, achieving goals and objectives occurs in the following manner:

- The plan will be subject to continual review by community members, stakeholders, and governmental agencies. When modification is necessary, the plan may be amended and public participation may be required.
- Annual information meetings will determine necessary revision of the plan, and citizens will be able to contribute their concerns. Surveys will be distributed to community members and other stakeholders to assess knowledge and attitudes regarding completed activities and watershed issues. Local media outlets will provide opportunity for the public to provide review and input.
- Indicators will be used as a way to track the progress and effectiveness of the plan.
  - Updates will be completed on the natural resources inventory and analyze changes over time of water quality in the planning area. These will be completed on an annual basis to determine the success of the plan.

- o The health of the LCR will be determined through water quality sampling data and biological data on a quarterly basis.

8.1.1 Implementation

Implementation of the WMP will initially focus on management actions for Priority Issues, outlined in Chapter 5. In order to determine early success implementation must be focused on specific areas, building momentum, and obtaining new funding sources.

Eight priority issues were addressed in the WMP with a series of structural and non-structural BMPs, implemented through education, monitoring, and research management strategy indicators, as well as broader policy initiatives.

Management actions are associated with each issue and in some cases, similar management actions identified in the WMP support multiple goals. This approach acknowledges that management goals have been set, are related to one another, and implementation actions can have several benefits.

Although full WMP implementation will likely require 20 or more years, this plan emphasizes the use of interim milestones (see Section 8.4) to ensure consistent progress. The first 5-year implementation period will lay the foundation for future success through a combination of education, monitoring, and research designed to test and demonstrate a long-term approach. Implementation of the following recommendations requires additional funding and staff support. Potential funding sources include but are not limited to various grants and other federal and state assistance. Refer to Section 8.2 Potential Funding Sources for more information.

8.1.1.1 *Education*

Education is an essential component to implementing this WMP. Effective outreach and education programs connect water quality issues with residents' quality of life. This management strategy informs residents about the link between their lives and the health of the LCR's water sources, and provides easy steps to make homes and businesses more watershed-friendly.

Educational management strategies for implementation of this WMP can come in a variety of forms. For each priority issue, educational material based on the issue can be developed and distributed, or workshops for community members regarding the specific issue can be provided. Refer to Appendix A for additional educational management strategies.

8.1.1.2 *Monitoring*

Implementing monitoring techniques as a management strategy can be rather tricky (for example, variable weather and other environmental conditions can make it nearly impossible to detect changes in water quality in the LCR). Monitoring water quality through various techniques provides characterization of the chemical constituents present in the surface and groundwater.

Several priority issues can be addressed via natural resource surveys to determine the success of BMPs, such as investigating backwaters of the LCR to determine cyanobacteria blooms, or monitoring irrigation systems to determine which system effectively reduces water loss. Appendix A illustrates the various BMPs implemented using a monitoring management strategy.

8.1.1.3 *Research*

This WMP is intended to be updated and revised as new data are collected and practices are implemented. This plan will be reevaluated on an annual basis and necessary revisions would be made by CCRSCo. Target areas that do not have sufficient data need to be developed. Many of the data requirements involve the expansion of current data collection efforts, while others are new data collection endeavors.

Implementation of the WMP would include data gap analysis, which would determine missing research. For example, analysis is required to determine which algaecide works best to control cyanobacteria. Refer to Appendix A for additional details on BMPs and management strategies.

8.2 POTENTIAL FUNDING SOURCES

Implementation of the following recommendations will require additional funding and staff support. Staff support may be in the form of a designated watershed manager, charged with implementing provisions of this WMP. Potential funding sources include but are not limited to various grants and other federal and state assistance.

CCRSCo has received a Cooperative Watershed Management Program grant through the Bureau of Reclamation's WaterSMART program to help expand and diversify its membership and to develop an EPA-approved watershed management plan for the two Colorado River mainstem HUCs.

The grant covers a 2-year period starting September 2017, with a finalized WMP in September 2018. The WaterSMART program has a provision that at the end of the first year an assessment is made to determine whether to fund the project for the second year.

There are other WaterSMART program grants that could potentially fund implementation of this WMP, listed below:

- Water and Energy Efficiency Grants—provide funding opportunities for projects that result in quantifiable water savings and support broader water reliability benefits.
- Water Marketing Strategy Grants—provide funding to develop water marketing strategies to establish or expand water markets or water marketing activities.
- Small-Scale Water Efficiency Projects—provide funding to support specific small-scale water efficiency projects that have been prioritized through planning efforts.
- Title XVI – Water Reclamation and Reuse—provides funding for the planning, design, and construction of water recycling and reuse projects.
- Basin Studies—provide cost-shared partnership to evaluate water supply and demand and ensure reliable water supplies are available.
- Site-Specific Pilots—financial aid is provided to evaluate reservoir management practices and determine if new opportunities exist.
- Drought Response Program—provides funds and support to water managers for developing drought plans and implementing long-term drought resiliency projects.
- Baseline Assessments—support reservoir operations planning, appraisal and feasibility studies, basin studies, drought contingency planning, and environmental analysis.
- Applied Science Grants—projects are funded to address drought impact and water management, and to develop platforms to improve access to and use of water resources.
- Desalination—provides federal funding to develop a desalination construction program providing paths to ocean or brackish water desalination projects.

- Water Conservation Field Services Program—provides financial assistance for water conservation planning, development of system optimization reviews, designing water management improvements, and demonstration projects.

ADEQ created the Water Quality Assurance Revolving Fund (WQARF) Program to identify, prioritize, assess, and resolve threats of contaminated soil and groundwater sites. The Program uses state funds and privately funded cleanups. California and Nevada have similar programs, Drinking Water State Revolving Fund (DWSRF) Programs that provide financial assistance to repair public water system deficiencies based on a prioritized funding approach. Other potential funding sources from California include:

- Urban Streams Restoration Program—funding is provided to reduce flooding and erosion, restore, protect, and/or enhance the natural ecology of streams.
- Agricultural Water Use Efficiency Grants Program—Proposition 1 – funding is provided for agricultural water management planning and water use efficiency projects and programs.
- Water-Energy Grant Program—financial assistance is provided for water efficiency programs or projects reducing water and energy use.

The NRCS and its partnering agencies administer wide-ranging conservation programs to assist farmers, landowners, and ranchers in conserving natural resources. Community members of the LCR can become involved in any of these programs to promote conservation. The 2014 Farm Bill established several conservation programs:

- Conservation Stewardship Program (CSP)—financial assistance is provided to improve land conditions and wildlife habitat.
- Environmental Quality Incentives Program (EQIP)—funding is provided for implementing conservation practices.
- Agricultural Conservation Easement Program (ACEP)—provides financial and technical assistance to conserve agricultural lands and wetlands and their related benefits.
- Regional Conservation Partnership Program (RCPP)—provides financial assistance to help producers install and maintain conservation activities.
- Conservation Innovation Grants (CIG)—funds are provided to develop the tools, technologies, and strategies to support future-generation conservation efforts and develop market-based solutions to resource challenges.

EPA’s Office of Grants and Debarment established national assistance agreement policies, training, and guidance through environmental grants.

- Environmental Education Grants Program—funds environmental education projects that promote environmental awareness and help provide communities with the skills to take responsible actions to support the environment.
- Urban Water Small Grants Program—provide financial aid to fund, research, train, and demonstrate advances in urban water restoration by improving water quality through various community activities.

Other funding methods for watershed management programs may include the sale of bonds, development impact fees, and the creation of a stormwater utility. In a given area, one method may be preferred because of its potential to generate revenue, its overall suitability, or its public acceptance. These alternative funding approaches are discussed below:

- General Fund

  - General appropriations are a traditional way to fund most government programs and services. The approach represents a stable funding source from local taxes, but there is competition with other local agencies for limited funding.
- General Obligation Bonds
  - The approach would require voter approval and would be subject to local administration policy regarding debt ceiling. Typically, this option has been financed through issuance of 15-year term bonds.
- Development Impact Fees
  - This assessment is determined by the impacts requiring new facilities and/or service levels. This type of funding is usually passed on to the property owner through higher costs.
- Stormwater Utility
  - Stormwater utility fees are another alternative to increasing taxes or impact fees. Fees are assessed on users of the system based on average conditions for groups of customers.

8.3 EVALUATION/MONITORING FRAMEWORK OF INDICATORS

There are various ways to evaluate and measure progress toward meeting the goals of this WMP (refer to Chapter 7 for more detailed information on indicators). Objectives and milestones would be used to track and monitor the progress and efficiency of various BMP management practices in reducing pollutants to the maximum extent possible. The evaluation of the BMP management practices implemented will help establish a baseline for future progress at eliminating pollutants in the LCR that can be measured. EPA measures progress in five general categories:

1. **Tracking implementation over time.** Where projects and programs are implemented, a measurable goal can be created as a way to track where, how often, and the effectiveness of the BMP project or program.
2. **Measuring progress by implementing projects/programs.** Some projects/programs are established over time and a measurable goal can be used to track progress until the implementation of the BMP is completed.
3. **Tracking total numbers of projects and programs implemented.** Program/project implementation can be measured numerically.
4. **Tracking program/project effectiveness.** Program and project goals can be measured to track the effectiveness of BMPs. For example, evaluating a structural control for invasive species or evaluating the effectiveness of the public education and outreach and determine any correlations between program/project effectiveness and pollutant elimination in the LCR. A measurable goal can also be a program/project design objective or a performance standard.
5. **Tracking environmental improvement.** The ultimate goal of the plan is to protect, monitor, and improve the LCR for various pollutants and pollutant sources, a measurable goal. Success of environmental improvement can be assessed and documented through various programs and projects like determining whether state water quality standards are being met or tracking trends or improvements in water quality (physical, biological, and chemical) and other indicators or improvements in habitat within the watershed (Meals, et al. 2014).

8.4 MONITORING/TRACKING EFFECTIVENESS

Monitoring and measuring progress in the watershed will be qualitative and quantitative. Individual communities and agencies will be required to monitor various BMPs on the community and agency levels to determine effectiveness (refer to Chapter 6 and Appendix A for more detail regarding BMPs). Monitoring efficiency and progress would be necessary regionally—subwatershed or watershed level—to assess the ecological effects of the community as a whole and agency actions on the river and its tributaries. The sections below define the various qualitative and quantitative methods to measure BMP effectiveness with education, monitoring, and research indicators.

Stakeholders and community members understand the importance of collaborative, long-term water quality, quantity, and biological monitoring as a way to determine where to prioritize resources to meet collective goals. The monitoring program will be established on a watershed scale since this would be most cost effective. There are multiple entities with surface water quality monitoring programs in place on the river and reservoir and not all water quality data is accessible; therefore, CCRSCo could perhaps be responsible for tracking all of those monitoring efforts.

8.4.1 Qualitative methods

A set of qualitative evaluation criteria can be used to determine whether goals have been accomplished and whether substantial progress has been made toward attaining water quality standards in the LCR. The criteria listed below can be used to determine whether the plan needs more revisions at a future time to meet standards. A summary of the methods is listed in Tables 8-1 and 8-2. The summary provides an indication of how these programs may be measured and monitored to determine success both in the long and short term.

Some evaluations can be implemented on a watershed basis, such as public awareness surveys to evaluate public education efforts, but the majority of these activities will be measured at the local level.
By evaluating the effectiveness of these programs, stakeholders will have more information about public response and success of the various programs. It is fair to assume that the success of these actions and programs are not tied directly to measurements in the River, but will have positive impacts on the conditions of the LCR.

Table 8-1. Summary of Qualitative Evaluation Techniques for the Planning Area

Indicator	Evaluation Method	What is measured	Implementation
Education	Public surveys	Awareness; Knowledge; Behaviors; Attitudes; Concerns	Pre- and post-surveys recommended. By mail, telephone or group setting. Repetition on regular basis can show trends. Appropriate for local or watershed basis.
	Written evaluations	Awareness; Knowledge	Post-event participants complete brief evaluations that ask what was learned, what was missing, what could be done better. Evaluations completed on-site.
	Visual documentation	Aesthetics. Pre- and post- conditions.	Provides visual evidence. Photographs can be used in public communication materials.
	Participation tracking	Number of people participating. Geographic distribution of participants. Amount of waste collected.	Track participation by counting people, materials collected and having sign-in/evaluation sheets.
	Focus groups	Awareness; Knowledge; Perceptions; Behaviors	Select random sample of population as participants. Six to eight people per group. Plan questions, facilitate.

Indicator	Evaluation Method	What is measured	Implementation
Monitoring	Stream surveys	Habitat; Flow; Erosion; Recreation potential; Impacts	Identify parameters to evaluate. Use form, such as Stream Crossing Inventory, to record observations. Summarize findings to identify sites needing observation.
Research	Phone call/ Complaint records	Number and types of concerns of public. Location of problem areas.	Answer phone, letter, emails and track nature of calls and concerns.

8.4.2 Quantitative methods

Quantitative evaluation techniques measure the effectiveness of specific programs and projects within the watershed. It is beneficial to monitor the effectiveness of the cumulative watershed efforts in terms of water quality, water quantity, and biological monitoring and monitor long-term progress. Long-term monitoring throughout the planning area addresses many objectives established to increase water quality in the area.

Table 8-2. Summary of Quantitative Evaluation Techniques for the Planning Area

Indicator	Program	Evaluation Method	What is measured
Education	Public Outreach and Education	Homeowner education about septic system maintenance	Conduct public surveys; Track public participation; Stream surveys
		Provide watershed education materials to residents	Conduct public surveys
		Provide information and education to farmers	Conduct public surveys; Track participation; stream surveys
		Watershed-related articles in community newsletters	Conduct public surveys; Track public participation
		Create and maintain partnerships with institutions, schools, and private sector to promote a collaborative effort in watershed management	Number of partnerships established and maintained; Number of people reached through partnerships; Track BMPs established across partnerships
	Water Quality	Train staff to identify illicit discharges	Number of staff trained; Number of illicit connections identified and corrected
Monitoring	Community Coordination and Funding	Establish and maintain long-term committee of entity representatives to promote implementation of the WMP	Track implementation of WMP; Number of committee meetings; Track consistent participation of representatives
		Secure funding and develop partnerships to conduct monitoring	Implementation of monitoring program
		Develop an environmental information line and pollution complaint hotline	Number of calls
		Promote reporting system for illicit discharges	Number of illicit connections identified and corrected; Number of complaints
		Adopt fertilizer reduction ordinance or policy	Number of fertilizer reduction ordinances/policies adopted
		Adopt no dumping ordinance or policy	Number of no dumping ordinances/policies adopted
		Adopt stormwater management ordinance	Number of stormwater management ordinances adopted
		Adopt wetlands ordinance w/ natural features setback; create local map of wetlands	Number of wetlands ordinances adopted
	Water Quality	Conduct outfall screening program	Number of illicit connections identified and corrected

Indicator	Program	Evaluation Method	What is measured
		Minimize seepage from sanitary sewers	Stream surveys
		Track illicit discharges	Number of illicit connections identified and corrected
	Conservation Practices	Reduce directly connected impervious surfaces	Number of homes with disconnected downspouts
		Practice nutrient management on agricultural land	Number of acres employing practice
	Existing Data and Studies		
		Initiate hydrologic and hydraulic studies	Track data generated from studies; Rating curves developed
		Inventory and stabilize eroding streambanks	Records of all inventoried streambanks; Number of linear feet of stabilized banks and pollutant load reductions calculated
		Inventory areas lacking stormwater management for retrofit opportunities	Track completed inventories and BMP retrofit opportunities identified
		Conduct natural features inventories	Number of inventories
	Vegetation	Create and maintain vegetated filter strips	Stream surveys; Track area of practice throughout watershed
		Plant and maintain riparian buffer with native vegetation	Stream surveys; Track area of practice throughout watershed
		Practice agricultural conservation cover	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficiency
		Practice conservation crop rotation with cover crop and mulch/no-till	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficiency
		Restore wetlands, recreate storage	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficiency
	Structures	Stabilize soils at crossing embankments	Baseline and ongoing embeddedness/stream habitat studies; Track completed road stream crossings; Track stabilized road stream crossings; Pollutant removal efficiency
		Install best available technology to reduce nutrients at permitted point sources	Stream surveys; Number of eligible and participating point sources; Pollutant removal efficiency
		Install sediment traps or basins at construction sites	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
		Repair misaligned/obstructed culverts	Baseline and ongoing embeddedness/stream habitat studies; Track completed culverts; Pollutant removal efficiency
		Stabilize road/bridge surfaces	Baseline and ongoing embeddedness/stream habitat studies; Track stabilized road/bridge surfaces; Pollutant removal efficiency
Research	Existing Data and Studies	Develop and implement a coordinated monitoring strategy to measure water quality, water quantity and biota	Track development of monitoring strategy
		Measure pollutant removal efficiencies of BMPs	Many evaluation methods, depends on type of practice

Indicator	Program	Evaluation Method	What is measured
	Community Coordination and Funding	Conduct work sessions to prioritize specific projects for funding, establish estimated costs, and identify funding mechanisms	Track prioritization for project funding, project cost estimates, and funding mechanisms; Track implementation of WMP; Number of work sessions

8.5 INTERIM MILESTONES

To track progress of this WMP over a 5- to 10-year period, a number of interim measurable milestones will be put in to place to make sure all management measures are being evaluated and to see whether the public is aware of efforts being made to improve water quantity and quality in the LCR. The education and information component of each issue will influence initial implementation measures. The goal is to educate the public on these issues and see improvements throughout the watershed from community members. Another milestone includes evaluation of all priority issue BMPs at the 5-year mark to determine if there has been improvement in the LCR. The ultimate goal is that after 5 years, management measures will be implemented efficiently and effectively and begin to see progress in the quality and quantity of the LCR's waters.

Milestones listed below provide assistance in determining whether nonpoint source management measure or other control measures being implemented are effective. The monitoring component, Section 8.3, evaluates the effectiveness of implementation of this WMP over time, measured against the criteria established.

A designated watershed manager will be in charge of documenting observed and permitted projects and programs on all land. Communication will be facilitated through annual semiannual meetings discussing progress and ensure all parties have proper documentation. Milestones are as follows:

- Updates to Lower Colorado River websites with educational material;
- Watershed photo-documentation (all projects on private and public lands);
- Watershed planning meetings, involving most stakeholders;
- Identification of funding sources for plan implementation;
- Recordation of curation of postings due to harmful cyanobacteria blooms;
- Track progress of BMPs in the watershed using a database (e.g., Excel); and
- Documentation of existing watershed conditions (e.g., photographs).

8.6 SCHEDULE OF ACTIVITIES AND COSTS

Due to the complex ecological nature of the response of a watershed, it is difficult to predict when goals will be accomplished. Some of these goals may realistically be met within a few years; however, some of the watershed goals could require additional studies and improvements that may take decades to accomplish. Predicting when a goal will be completed is nearly impossible; therefore, CCRSCo will continuously strive to meet the goals set forth in this plan. Progress will be monitored to achieve these goals regularly to ensure that the long-term (5–10 years) and short-term (1–5 years) goals are met.

Costs estimates for BMP implementation are provided in Appendix B. Cost estimates are based on current, publicly available information. Appendix B is organized by priority issue (primary and secondary) and presented as a range (low to high) of expenditures associated with each BMP. Cost estimates are based on other WMPs and research of individual BMPs.

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APPENDIX A

Potential Best Management Practices

Cyanobacteria Blooms

Possible BMP options to reduce/eradicate cyanobacteria blooms or reduce health risks in the LCR are listed in Table A-1.

Table A-1. Cyanobacteria Blooms Best Management Practices

BMP	Considerations
Education	Develop and distribute educational materials to the public to explain risks associated with cyanobacteria exposure and BMPs that minimize sources of the pollutant.
Communication	Maintain constant communication with the public, i.e., advisories to prevent hazards and minimize various health risks associated with blooms.
Survey/Compliance	Survey LCR for cyanobacteria blooms on a routine basis to assure residents and visitors that water quality standards are being met.
	Investigate backwaters and wind conditions in the LCR where blooms have occurred because plankton can be blown by wind-driven surface conditions.
	Assure the LCR meets water quality standards for partial body-contact recreational activities throughout the year.
Surface skimming	Research efficiency of oil-spill skimmers to remove cyanobacteria from these surface scums.
Barley straw	Examine barley straw effectiveness, if when exposed to sunlight and in the presence of oxygen, produces a chemical that inhibits algae growth.
Coagulation	Research various coagulant efficiencies and effectiveness that would facilitate the sedimentation of cyanobacteria cells to the anoxic bottom layer of the water column.
Flocculation	Investigate various flocculants to determine which is most productive in facilitating the sedimentation of nutrients to the anoxic bottom layer of the water column, thereby limiting nutrient levels in the waterbody and inhibiting cyanobacterial growth.
Hypolimnetic oxygenation	Research techniques to achieve hypolimnetic oxygenation to include: airlift pumps, side stream oxygenation, and direct oxygen injection.
Floating Treatment Wetlands (FTW)	Determine effectiveness of plants growing on floating mats on the surface water to provide surface area to filter and trap nutrients and encourage biofilm processes that reduce cyanobacteria levels.

Water Resiliency

Possible BMPs for water resiliency in the LCR are listed in Table A-2, below.

Table A-2. Water Resiliency Best Management Practices

BMP	Considerations
Education material and workshop	Develop water conservation workshops and preparedness for communities throughout the LCR annually for 5 years and document participation.
	Prepare information for farmers about plant crops that can withstand dryness, hold water, and reduce the need for irrigation to reduce drought.
Water management	Work with stakeholders to evaluate every type of irrigation system and choose the option that will help reduce water loss to percolation, evaporation, and runoff.
	Routinely maintain and manage existing irrigation systems to be more efficient.

BMP	Considerations
	Monitor and manage available water pumped from deep aquifers and surface water.
Land management	Work with farmers to examine soil moisture regularly to make more strategic water and crop management decisions.
Land management	Investigate construction of a water storage system that holds water for use during irrigation season in storage ponds and tanks for future drought management.
	Research the use of conservation tillage and no-till to minimize disturbing any soils.
	Learn how to maintain and establish riparian buffers, filter strips, grassed waterways, and other types of conservation buffers near streams and other water sources.
Water modeling	Examine future hydrological and water quality modeling.

Invasive species

Additional BMPs to control/eradicate invasive species in the LCR are listed below in Table A-3.

Table A-3. Invasive Species Best Management Practices

BMP	Considerations
Training	Provide training in identification of locally known invasive species to community members and employees.
	Develop program to produce and distribute information to the public on the harmful effects of invasive species on native flora and fauna, methods of control, and support monitoring programs to identify problem species and sources.
Workshop	Conduct soil erosion control workshops for contractors, developers, and excavators.
	Incorporate invasive species control practices in other workshops.
	Develop educational material and workshops to promote the development and use of biological controls or other alternatives to reduce or avoid the use of chemical controls.
Ground disturbance	Monitor ground disturbance in recreation areas and minimize ground disturbance during construction activities. Ground disturbance can uproot existing vegetation and expose soil, creating a seedbed where non-native plants may become established or expand their numbers.
	Inspect areas at highest risk of invasion following soil disturbance activities to help detect new invasions. Early detection will enable control strategies before the new population becomes large, thereby increasing the effectiveness of management activities and reducing costs.
Survey	Survey the movement of invasive plants, insects, and diseases to non-infested areas, especially for sensitive areas surrounding riparian restoration or habitat maintenance projects.
Herbicide/Pesticide	Continue to use and monitor herbicide/pesticide applications in targeted areas to control and/or eradicate non-native species populations.
Boat decontamination	Fully inspect equipment and remove any organisms present.
	To avoid the spread of aquatic invasive species promote AGFD guidelines: • Clean/remove any clinging material like plants, animals, and mud from the boat, anchor, motor, and trailer. • Remove the plug (if applicable) and drain the water from the bilge, live well and any other compartments that may hold water. • Draining water from engine and engine cooling system(s). • Ensure watercraft, vehicle, equipment, or conveyance are allowed to dry completely.*
	Scrub equipment with a stiff-bristled brush and/or wash with soapy water. This simple step will aid in the removal of small organisms and seeds, as well as remove organic materials that make disinfection less effective.

BMP	Considerations
Minimize invasive species from spreading	Analyze associations between marine and freshwater invaders that enter LCR through California.
	Investigate removal strategies for non-native species working with USFWS, University of Arizona, NGOs, and other organizations.
	Study effectiveness of existing efforts for monitoring and removing various invasive species from the LCR.

*AGFD (2014)

Hexavalent Chromium

Table A-4 lists additional BMPs for consideration to further manage and/or reduce the risk of hexavalent chromium in the LCR.

Table A-4. Hexavalent Chromium Best Management Practices

BMP	Considerations
Outreach	Continue to work with other entities on remediation efforts and remain on the Topock site outreach list as a way to stay informed.
Workshop	Distribute media and conduct workshops regarding negative impacts hexavalent chromium has on water quality.
Water modeling	Examine future hydrological water modeling.

Mining

Potential BMPs to reduce runoff from mining activities and abandoned mines in the LCR are presented in Table A-5 below.

Table A-5. Mining Best Management Practices

BMP	Considerations
Educational material	Provide public with educational material and workshops regarding all aspects of mining hazards in the LCR.
	Educate farmers and landowners on the higher susceptibility of mine lands to erosion through outreach campaigns.
Outreach	Develop educational materials about recontouring and revegetating lands on abandoned mines.
Pits/quarries or underground mines	Work with local and federal government agencies to restore abandoned mine lands sites and prevent pollutants from entering surface waters.
	Identify and catalog abandoned mining sites and nonpoint source pollution with operating owner, and potential hazards listed.
	Work with Arizona Geological Survey to investigate uranium, copper, gold, and arsenic runoff entering the LCR.
Overburden, waste rock, and raw materials piles	Research the various water quality structures like check dams, rock outlet protection, level spreaders, stream alternation, drop structures, serrated slopes, benched slopes, contouring, and stream alteration for runoff dispersion to control potential pollutants.
	Work with Arizona Geological Survey to investigate uranium, copper, gold, and arsenic runoff entering the LCR.

Agricultural Runoff

Considerations for agricultural runoff BMPs are listed below in Table A-6.

Table A-6. Agricultural Runoff Best Management Practices

BMP	Considerations
Workshop	Work with and teach farmers to adopt precision agriculture techniques to reduce excess applications of nutrients and reduce nutrient losses through surface runoff or leaching.
Irrigation	Educate landowners on proper maintenance of irrigation systems via webpage, media articles, and workshops.
Educational materials	Develop educational materials on integrated pest management and safe use of pesticides, and provide field demonstrations on proper application of pesticides.
Groundwater uses	Monitor the regulation of new agricultural facilities' groundwater withdrawals/uses to assure there are no significant impacts to the quantity and quality of the groundwater.
Grower programs	Work with landowners to enroll their lands in grower programs and other conservation programs through NRCS, DNR, USFWS, and EPA.
Technical assistance	Develop and implement technical assistance (volunteers) protocol to landowners interested in improving pastureland quality with fertilizer and lime.

Potential Hydrocarbon Leaks/Spills

Potential BMPs to eliminate and manage hydrocarbon leaks/spills throughout the watershed are listed below in Table A-7.

Table A-7. Hydrocarbon Leak/Spills Best Management Practices

BMP	Considerations
Educational material	Develop literature and educational material for public about the dangers of hydrocarbon leaks/spills and provide outreach.
Fueling activities	Inspect the fueling area to detect problems before they occur.

Land Development

Other BMPs to consider for land development are found in Table A-8, below.

Table A-8. Land Development Best Management Practices

BMP	Considerations
Educational material	Develop literature for the public regarding possible impacts future land development and use have on water quality.
Survey	Monitor ongoing land development projects and land use changes for any illegal activity, e.g., illegal dumping, hazardous material waste, etc.
General practices	Analyze future land development projects and land use changes in the LCR.

APPENDIX B

Cost Estimates for Best Management Practices

Invasive Species

Estimated BMP implementation schedule and cost estimate range are described below in Table B-3.

Table B-3. Invasive Species BMPs, Implementation Schedule, and Estimated Costs

Management Strategy	BMP	Implementation Schedule	Estimated Cost (Low)	Estimated Cost (High)
Education	Education/Outreach	Short-term	$8,000	$8,000
Education/Monitoring	Ground disturbance	Short-term	$22,500	$23,500
Monitoring	Road ROWs ($ per acre)	Short-term	$60	$60
	Boat decontamination	Short-term	$830,000	$830,000
Education/Monitoring/Research	Minimize invasive species from spreading	Long-term	$264,000	$1,089,000
	Total		**$1,124,560**	**$1,950,560**

Hexavalent Chromium

Cost estimates and an implementation schedule of BMPs to combat hexavalent chromium are described below in Table B-4.

Table B-4. Hexavalent Chromium BMPs, Implementation Schedule, and Estimated Costs

Management Strategy	BMP	Implementation Schedule	Estimated Cost (Low)	Estimated Cost (High)
Education	Workshop	Short-term	$1,000	$3,000
Research	Water Modeling	Long-Term	$6,000	$8,000
	Total		**$7,000**	**$11,000**

Mining

The implementation and cost estimate ranges for mining BMPs are below, Table B-5.

Table B-5. Mining BMPs, Implementation Schedule, and Estimated Costs

Management Strategy	BMP	Implementation Schedule	Estimated Cost (Low)	Estimated Cost (High)
Education	Education	Short-term	$1,000	$3,000
	Mining reclamation	Short-term	$77,000	$85,000
Monitoring	Pits/quarries or underground mines	Short-term	$129,000	$132,000
Research	Overburden, waste rock, and raw materials piles	Short-term	$95,700	$121,000
	Total		**$302,700**	**$341,000**

Agricultural Runoff

The implementation schedule and cost estimates for agricultural runoff are described below in Table B-6.

Table B-6. Agricultural Runoff BMPs, Implementation Schedule, and Estimated Costs

Management Strategy	BMP	Implementation Schedule	Estimated Cost (Low)	Estimated Cost (High)
Education	Irrigation	Short-term	$7,200	$10,500
	Pesticide application	Short-term	$75,500	$125,500
Education/Monitoring/Research	General practices	Short-term	$88,000	$116,000
	Total		**$170,700**	**$252,000**

Potential Hydrocarbon Leaks/Spills

Hydrocarbon leaks/spills BMP implementation schedule and cost estimates can be found below in Table B-7.

Table B-7. Hydrocarbon Leaks/Spill BMPs, Implementation Schedule, and Estimated Costs

Management Strategy	BMP	Implementation Schedule	Estimated Cost (Low)	Estimated Cost (High)
Education	Education	Short-term	$1,000	$3,000
Monitoring	Fueling activities (refer to Table A-7 for detail)	Short-term	$218,620	$300,550
	Total		**$219,620**	**$303,550**

Land Development

An implementation schedule and cost estimates for diversion BMPs are listed below in Table B-8.

Table B-8. Diversion BMPs, Implementation Schedule, and Estimated Costs

Management Schedule	BMP	Implementation Schedule	Estimated Cost (Low)	Estimated Cost (High)
Education	Education	Short-term	$1,000	$3,000
Monitoring	Survey/Compliance	Short-term	$30,000	$60,000
Research	Land Use	Long-Term	$50,000	$60,000
	Total		**$81,000**	**$123,000**

Total Estimated Costs

The estimated cost of implementing all recommended actions to achieve the watershed plan goals and objectives for the WMP as well as the information and education actions to achieve LCR watershed plan goals ranges between $6.8 million and $8.1 million over a 10-year period.