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# **LITTLE COLORADO RIVER MANAGEMENT PLAN**



**U.S. BUREAU OF RECLAMATION  
UPPER COLORADO REGION  
SALT LAKE CITY, UTAH**



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**May 2009**

**Draft Final**

# **LITTLE COLORADO RIVER MANAGEMENT PLAN**

Prepared for

**U. S. Bureau of Reclamation  
125 South State Street  
P.O. Box 11568  
Salt Lake City, Utah 84138-1102  
(801) 524-5517  
Order No. 98PG40-0069**

Prepared by

**Richard A. Valdez and John Thomas  
SWCA, Inc. Environmental Consultants  
257 East 200 South, Suite 200  
Salt Lake City, Utah 84111  
(801) 322-4307**

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## **PREFACE**

This report addresses the requirement of the 1995 Biological Opinion and is being submitted to the Bureau of Reclamation (Reclamation), Upper Colorado Region, in partial fulfillment of Reclamation Order No. 98PG40-0069. An initial draft of this document was reviewed by the Glen Canyon Environmental Studies (GCES) in October 1995. Substantial changes and improvements were made to the document and it was submitted as a preliminary draft for review by Reclamation in February 1996. The document was updated and a final draft was submitted to Reclamation in November 1998. A revised document that described strategies for developing the Little Colorado River (LCR) management plan was completed in April 1999, recommending that Reclamation establish an interagency partnership as the vehicle for developing the management plan. Draft reports describing a partnership that could form the basis of a plan were completed in October 2001 and October 2007. An Agency Review Draft was submitted in October 2008 in fulfillment of the 1995 Biological Opinion. This Draft Final clarifies the ongoing threats to the humpback chub in the LCR and better defines possible actions that can be taken to minimize those threats.

## **ABBREVIATIONS**

ADEM	Arizona Department of Emergency Management
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
AMWG	Adaptive Management Work Group
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
Reclamation	Bureau of Reclamation
CRF	Code of Federal Regulations (also FR)
cfs	cubic feet per second
CRMP	Colorado River Management Plan
Interior	Department of the Interior
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FOSC	Federal On-Scene Coordinator
GCES	Glen Canyon Environmental Studies
GCMRC	Grand Canyon Monitoring and Research Center
GIS	Geographic Information System
GMP	General Management Plan
gpm	gallons per minute
LCR	Little Colorado River
mg/L	milligrams per liter
MOM	Multi-Objective Management Plan
NEPA	National Environmental Policy Act
NMDGF	New Mexico Department of Game and Fish
NPS	National Park Service
PDC	Phelps Dodge Corporation
PIA	Practicable Irrigable Acreage
PWCC	Peabody Western Coal Company
RM	river mile
RPA	Reasonable and Prudent Alternative
SCS	Soil Conservation Service
Secretary	Secretary of the Interior
Service	U.S. Fish and Wildlife Service
SOSC	State On-Scene Coordinator
SRP	Salt River Project Agricultural Improvement and Power District
TDS	total dissolved solids
U.S.C.	United States Code
USGS	U.S. Geological Survey

## **EXECUTIVE SUMMARY**

The Little Colorado River (LCR) is the most important stream to the federally endangered humpback chub (*Gila cypha*) in the Lower Colorado River Basin. The lower 13 miles of the LCR is perennial from ground water springs. This reach is occupied by the largest self-sustaining population for the species and the lower 8 miles is designated critical habitat. The LCR is the principal spawning area for humpback chub that are resident to the LCR as well as up-migrants from the mainstem Colorado River. Nine aggregations of humpback chub are found in the Colorado River through Grand Canyon with the largest at and near the confluence of the LCR. The humpback chub in the LCR is threatened by streamflow regulation, competition with and predation by a suite of nonnative fish species, possible spills of hazardous materials upstream of critical habitat, and parasitism by the Asian tapeworm (*Bothriocephalus acheilognathi*) and parasitic copepod (*Lernaea cyprinacea*). These threats, individually and collectively, can result in recruitment failure and declines in population numbers of humpback chub.

In January of 1995, the U.S. Fish and Wildlife Service (Service) issued a final biological opinion on the operation of Glen Canyon Dam that contained a reasonable and prudent alternative (RPA) requiring the Bureau of Reclamation (Reclamation) to be instrumental in the development of a management plan for the LCR. The RPA was intended to avoid possible adverse impacts to the humpback chub and its spawning and rearing habitats in the LCR. A review of past and recent studies of surface and ground water hydrology revealed that over the last 60 years (1948-2007), the LCR was dry near Cameron (30 miles upstream from critical habitat) an average of 135 days per year (37% of the time). The decade with the lowest number of no-flow days (109) occurred in 1978-87. However, the third highest decade with no-flow days was the most recent, 1998-2007, with 141 days, likely the result of increasing demand for water in the LCR Basin and regional drought since the mid-1990s. A more striking statistic is the pattern of peak flows in the LCR. High peak flows stimulate food production and scour the stream channel to provide a clean substrate for high hatching success of humpback chub. Average annual peak flow for the 60-year period of record was 4,820 cfs, with most peak flows occurring in August (during monsoonal rainstorms) followed by January and February (snowmelt runoff). In the last two decades

## *Executive Summary*

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(1988-97 and 1998-2007), the magnitude of peak flows has decreased by 35% and 49%, respectively, from the previous decade (1978-1987). Fewer peak flows and a reduced magnitude of peak flows mean that reproductive success of humpback chub is likely reduced and recruitment is lowered.

Ground water flow from a complex of springs maintains perennial surface flow in the lower 13 miles of the LCR and is vital to sustaining the humpback chub population and its critical habitat. The source of this ground water is principally the Coconino (C) aquifer that underlies much of the LCR Basin and mixes with the Redwall-Muav (R) aquifer prior to discharging along the banks of the LCR. The largest of these springs is Blue Springs with a volume of about 95 cfs. The remainder of springs contribute to a base outflow for the LCR of 211-223 cfs (flow varies because evapotranspiration reduces volume in summer), a volume that has not changed over the last 30 years. Streamflow reduction in the lower LCR is considered a serious threat to the humpback chub. The C-aquifer contains an estimated 413 million acre-feet (MAF) of water with the age of water in the aquifer estimated at 7,000 years. Annual recharge of the C-aquifer is estimated at 319,000 AF/year, and most of the aquifer discharges at the Blue Springs complex with a volume of about 164,000 AF/year. Ground water usage in the LCR Basin from the C-aquifer is about 100,000 AF/year, or about 31% of annual recharge. There is uncertainty at this time as to how pumping affects the C-aquifer and eventually discharge at Blue Springs. The complexity of the C-aquifer and how pumping affects the volume of water in the aquifer and eventually discharge at the Blue Springs complex are not well understood and should be the subject of continued investigations. Given the age of water in the aquifer, pumping could continue for many years before discharge is reduced at Blue Springs—or, discharge reduction may become evident soon.

Water management in the LCR Basin consists of a complex and dynamic array of regional, county, and municipal water management groups with the principal purpose of providing water for increasing human development in the basin. Generally, water conservation is urged to maximize water availability for a given area of the basin but not to insure downstream delivery, especially into the lowest 13 miles of the LCR. With over 2,700 reservoirs in the LCR Basin (most less than 2 surface acres) capturing and storing over 252,700 AF/year, perennial surface flow is not likely to be restored to the lower LCR above

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Blue Springs. The LCR Basin is not dominated by a few large reservoirs that control the majority of flow in the system, but rather by a large number of small dams, irrigation diversions, and even earthen berms on dry washes. This complex and large array of facilities with varied ownerships and jurisdictions makes development and implementation of a comprehensive plan for the LCR Basin difficult because of the vast array of interests and water management objectives with little or no federal authority.

The high variability of flow in the LCR Basin, while a problem to water capture facilities will continue to provide the periodic surface and peak flows so critical to the humpback chub and its critical habitat in the lower LCR. The large and sudden late winter snow/rain storms and late summer monsoonal rainstorms in the basin create large amounts of water in the drainage over a short time period that cannot be captured with existing dams and facilities. Most of the largest dams are at high elevations in tributaries that capture snowmelt, but the large storms that hit the central and lower parts of the basin produce floods that are largely unimpeded. This situation is expected to continue and will only be affected if large water capture facilities are constructed in the mid to lower drainage, or if climate change results in fewer large winter storms and monsoonal rain events. A major threat to the humpback chub in the lower LCR would be construction of a large dam and reservoir in the middle to lower reaches of the LCR that would capture these large runoff events. In the late 1950s, a narrow dam (Coconino Dam) was being considered downstream of Cameron to trap sediment coming down the LCR and slow sedimentation of the proposed Bridge Canyon Dam on the mainstem Colorado River. These dams were never built, but the Coconino Dam would have had a large effect on flow in the lower LCR.

Over the course of developing this Plan, Reclamation met with numerous stakeholders in the LCR Basin and concluded that development and implementation of a comprehensive management plan is beyond Reclamation's legal authority and jurisdiction. Hence, Reclamation has developed a plan that identifies threats to the species, strategies and actions that provide protection to the humpback chub, and the stakeholders that could contribute a watershed plan.

## **ACKNOWLEDGMENTS**

This document is the product of an assimilation of relevant literature on the LCR. The extensive database developed by the Navajo Nation was a principal source of information in compiling this plan. All available information was synthesized and presented in this document in order to provide a background of resources in the LCR, identify existing and potential threats to the humpback chub, and develop a management plan. Pertinent information and documents used in this supplement are provided in a consolidated literature cited section.

The following individuals from SWCA, Inc. assimilated information and contributed to this report: Michelle Brink, Howard Gross, Joe Rocchio, and Sharee Moser. Reviews by the following individuals greatly improved this document: Christine Karas, Tony Morton, Mark McKinstry, Dave Speas, and Dennis Kubly of Bureau of Reclamation; Debra Bill and Don Metz of U.S. Fish and Wildlife Service; Dave Wegner of Glen Canyon Environmental Studies.

## 1.0 INTRODUCTION

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### 1.1 Purpose and Objectives

This Little Colorado River Management Plan (Plan) was developed by the Bureau of Reclamation (Reclamation) to comply with the Final Biological Opinion (1995 Opinion; U.S. Fish and Wildlife Service 1995) of the Final Environmental Impact Statement on the Operation of Glen Canyon Dam (FEIS; U.S. Department of the Interior 1995). The 1995 Opinion requires Reclamation to be instrumental in the development of a management plan for the Little Colorado River (LCR). The 1995 Opinion was issued in compliance with Section 7(b) of the Endangered Species Act of 1973, as amended (ESA; Public Law 97-304; 16 U.S.C. 1531 *et. seq.*), for the conservation of the endangered fishes, humpback chub (*Gila cypha*) and razorback sucker (*Xyrauchen texanus*). This Plan outlines and describes threats to the species, strategies and actions that will further conservation of the endangered fish species, and the stakeholders that could contribute to this plan.

The purpose of this Plan is to identify activities that Reclamation believes are necessary to provide compliance with the ESA by minimizing the likelihood of jeopardizing the continued existence of the humpback chub and avoiding the destruction or adverse modification of designated critical habitat in the LCR. The razorback sucker is not specifically addressed in this Plan because of the small numbers found in Grand Canyon and the lack of information linking the species to known life-history attributes in the LCR.

The objectives of this Plan are to:

- Protect the humpback chub spawning population and habitat in the LCR; and
- Provide assistance and guidance for coordinated actions of stakeholders in the LCR Basin to avoid adverse impacts to the endangered humpback chub and its critical habitat in the LCR, while proceeding with necessary and lawful water development.

## 1.0 Introduction

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### 1.2 Background

The humpback chub is a large cyprinid fish species endemic to the Colorado River Basin. The species was first included in the List of Endangered Species issued by the Office of Endangered Species on March 11, 1967 (32 FR 4001), and was considered endangered under provisions of the Endangered Species Conservation Act of 1969 (16 U.S.C. 668aa). It was included in the U.S. List of Endangered Native Fish and Wildlife issued on June 4, 1973 (38 FR No. 106; i.e., the “red book”), and received protection as endangered under Section 4(c)(3) of the original ESA of 1973. A Recovery Plan was approved August 22, 1979, and revised May 15, 1984 and September 19, 1990 (U.S. Fish and Wildlife Service 1990). Critical habitat was designated March 21, 1994 (59 FR 13374) as 174 miles of the Colorado River from Nautiloid Canyon to Granite Park in Grand Canyon and the lower 8 miles of the LCR. Recovery goals that amend and supplement the recovery plan were approved August 1, 2002 (U.S. Fish and Wildlife Service 2002) and withdrawn by a court order on January 18, 2006 (Grand Canyon Trust vs Norton, 04-CV-636-PHX-FJM, U.S. District Court for the District of Arizona) for failure to provide adequate estimates of time and cost. Revised recovery goals are expected to be issued in 2009.

The LCR is the major tributary of the Colorado River in Grand Canyon (Figure 1). The LCR supports one of only six populations of humpback chub and is the primary area in the lower basin where this species spawns successfully. The five other populations are in the upper basin. Nine aggregations of humpback chub in the mainstem Colorado River through Grand Canyon are dependent on the LCR as the primary source of recruitment. Increasing human populations in the LCR Basin continue to deplete surface water flows and have placed an increasing dependence on ground water to maintain the humpback chub population in the lower 13 miles of the LCR. Nonnative fish species, parasites, and potential hazardous-materials spills further place this population at risk. A coordinated effort of LCR stakeholders is needed to manage water resources in a manner that fosters species conservation and allows necessary and lawful water development.



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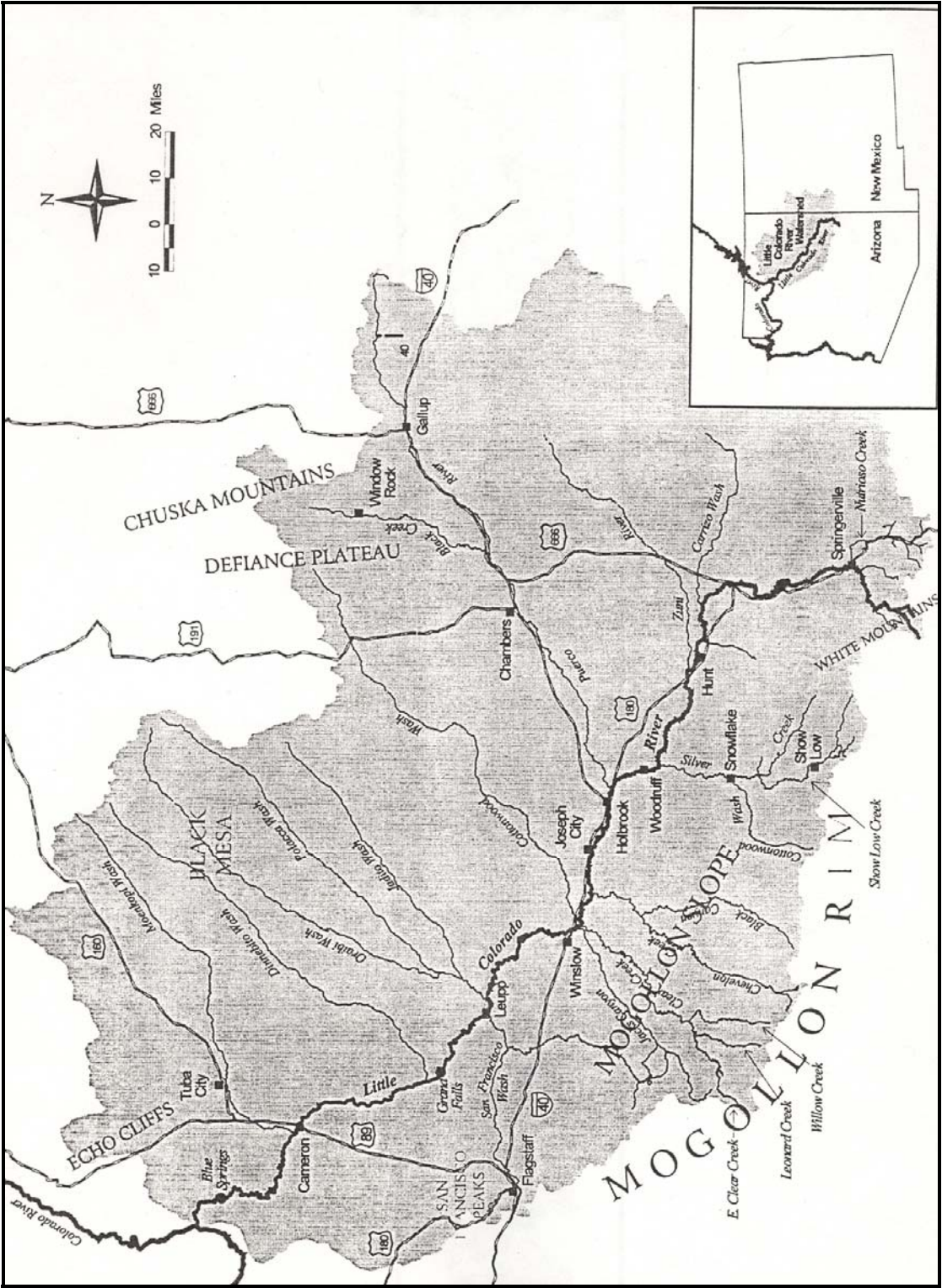


Figure 1. The Little Colorado River Basin.

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### 1.3 Compliance with the Endangered Species Act

#### 1.3.1 History of Consultations

Glen Canyon Dam was authorized in 1956 and completed in 1963, prior to enactment of the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et seq.) and the ESA of 1973. Dam construction and initial operations were not subject to provisions of NEPA or ESA, but because of potential impacts to threatened or endangered species from ongoing operations, Reclamation requested consultation from the U.S. Fish and Wildlife Service (Service) under Section 7 of the ESA. On May 25, 1978, the Service issued a biological opinion on the operation of the dam (U.S. Fish and Wildlife Service 1978), concluding that:

*“...past, present and future proposed operations of Glen Canyon Dam...is [sic] jeopardizing the continued existence of this species [humpback chub] by limiting its distribution and population size.”*

The Service required in the 1978 Opinion that Reclamation conduct studies to: (1) determine the potential impact of warming releases from the dam, (2) identify the ecological needs of the endangered species, (3) develop methods to reduce or eliminate known limiting factors of low temperature and frequent flow fluctuations, and (4) determine the relationships between mainstem and tributary inflow habitats and their use by endangered fish species.

On April 2, 1982, following uprating and rewinding of the hydroelectric generators at Glen Canyon Dam, the Service restated that the jeopardy determination of the 1978 Opinion was still in effect. Before implementing the uprated capacity of the power plant, Reclamation requested additional consultation, and the Service issued a Draft Biological Opinion on August 25, 1987. The 1987 Draft Opinion also determined that dam operations were likely to jeopardize the continued existence of the humpback chub. Although the bonytail (*Gila elegans*) had been recently listed as endangered in 1980 (45 FR 27713) and the Colorado pikeminnow (*Ptychocheilus lucius*) had been listed as

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endangered since 1967 (32 FR 4001), these species were considered extirpated from Grand Canyon and were not included in the 1987 Draft Opinion. The razorback sucker was also not included because it was not listed as endangered until 1991 (56 FR 54957). Critical habitat was not designated for the four big river fishes until March 21, 1994 (59 FR 13374), and the 1978 and 1987 opinions did not contain protection for critical habitat.

As a result of the 1987 Draft Opinion, Reclamation worked with the Service, AGFD, NPS, and Navajo Nation Natural Heritage Program to develop seven conservation measures that, when successfully implemented, would meet Section 7 consultation requirements and NEPA compliance. These conservation measures were:

1. Investigate the taxonomic status of the genus *Gila*.
2. Maintain hatchery stocks of Grand Canyon humpback chub.
3. Ensure that flood releases from Glen Canyon Dam occur with a frequency not greater than one in twenty years.
4. Develop a management plan for the Little Colorado River.
5. Conduct research to identify impacts of Glen Canyon Dam operations on the humpback chub in the mainstem and tributaries.
6. Establish a long-term monitoring program to assess the relationship of project operation to the humpback chub (pending completion of research).
7. Establish a second spawning population of humpback chub in the Grand Canyon (pending completion of research).

Before the 1987 Draft Opinion could be finalized, the Secretary of the Interior on July 27, 1989, directed Reclamation to prepare an Environmental Impact Statement on the operation of Glen Canyon Dam. Once a preferred alternative was developed and selected through the NEPA process, Reclamation determined that dam operations had the potential to affect humpback chub and therefore, reinitiated Section 7 consultation with the Service on February 5, 1993.

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### 1.3.2 The 1995 Biological Opinion

In the Final Biological Opinion, dated December 24, 1994, and issued January 7, 1995, the Service determined that:

*“...the proposed operation of Glen Canyon Dam according to operating and other criteria of the MLFF [Modified Low Fluctuating Flow Alternative], as described in the Draft EIS...is likely to jeopardize the continued existence of the humpback chub and razorback sucker and is likely to destroy or adversely modify designated critical habitat.”*

The 1995 Opinion contained a reasonable and prudent alternative (RPA) designed to: (1) protect endangered and other native fish fauna in National Park Service lands, (2) provide water storage and releases consistent with the primary function of Glen Canyon Dam, (3) ensure compliance with the EIS, and (4) prevent jeopardy to the endangered fish by reducing known limiting factors.

The four elements of the reasonable and prudent alternative were:

1. *“Attainment of riverine conditions that support all life stages of endangered and native fish species is essential to the Colorado River ecosystem. Therefore, Reclamation shall develop an adaptive management program that will include implementation of studies required to determine impact of flows on listed and native fish fauna, recommend actions to further their conservation, and implement those recommendations as necessary to increase the likelihood of both survival and recovery of the listed species.”*
  - A. *“A program of experimental flows will be carried out to include high steady flows in the spring and low steady flows in summer and fall during low water years (releases of approximately 8.23 maf) to verify an effective flow regime and to quantify, to the extent possible, effects on endangered and native fish.”*
  - B. *“Reclamation shall implement a selective withdrawal program for Lake*

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*Powell waters and determine feasibility...*

- C. *“Determine responses of native fishes in Grand Canyon to various temperature regimes and river flows of the experimental flows and other operations of Glen Canyon Dam.”*
- 2. *“Protect humpback chub spawning population and habitat in the LCR by being instrumental in developing a management plan for this river.”*
- 3. *“Develop actions that will help ensure the continued existence of the razorback sucker by first sponsoring a workshop...to enlist the advice of species experts, endangered fish researchers in Grand Canyon, Native Fish Work Group biologists, and others, such as Colorado River Recovery Team members, to develop a management plan for the species in the Grand Canyon.”*
- 4. *“Establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam.”*

Element 2 of the RPA requires that Reclamation shall be instrumental in developing a management plan for the LCR. Element 2 further states that:

*“This element remains very important to the survival of the humpback chub in Grand Canyon. Reclamation has, through contracts with the Navajo Nation, developed an extensive database for use in developing the plan. Reclamation will work with the Service, Navajo Nation, Hopi Tribe, National Park Service, Bureau of Indian Affairs, AGFD, and others to develop a management plan that includes actions to avoid possible adverse impacts to humpback chubs and their spawning and rearing habitats in the LCR. The principle objective of this plan shall be the protection of humpback chub habitat in the Colorado River and LCR. A draft plan will be prepared within two years from the date of this biological opinion and transmitted to agencies, parties, and others having authority to implement the plan.”*

In a memorandum to the Service dated April 6, 1995, Reclamation responded to the 1995 Opinion, and questioned the appropriateness of Element 2 of the RPA and the

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directive to be "*...instrumental in developing a management plan for this river.*" In Reclamation's opinion, threats to the humpback chub and its habitat in the LCR were unrelated to dam operations. Reclamation further stated that a directive to develop a management plan for the LCR was beyond Reclamation's legal authority and jurisdiction, and therefore inappropriate to include as an element of the RPA. It was Reclamation's opinion that development of a management plan for the LCR should be more appropriately included in the 1995 Opinion as a conservation measure rather than a reasonable and prudent alternative. However, in the spirit of cooperation, Reclamation agreed to work toward development of a plan.

### **1.3.3 The 2002 Biological Opinion**

In 2002, Reclamation, NPS, and USGS consulted with the Service on: (1) experimental releases from Glen Canyon Dam, (2) mechanical removal of nonnative fish from the Colorado River in an approximately 9-mile reach in the vicinity of the mouth of the LCR to potentially benefit native fish, and (3) release of nonnative fish suppression flows having daily fluctuations of 5,000-20,000 cfs from Glen Canyon Dam during the period January 1-March 31. Two conservation measures were included in the 2002 Opinion: (1) relocate 300 humpback chub above Chute Falls in the LCR to increase the likelihood of humpback chub surviving a flood in the LCR Basin, and (2) reduce predation and other inclement environmental conditions.

### **1.3.4 The 2008 Biological Opinion**

In 2008, Reclamation consulted with the Service on the proposed adoption of proposed experimental operations of Glen Canyon Dam. The Service issued a biological opinion that concluded that implementation of the March 2008 high flow test and the five-year implementation of MLFF with steady releases in September and October is not likely to jeopardize the continued existence of the humpback chub, and is not likely to destroy or adversely modify designated critical habitat. The opinion also presented a suite of conservation measures to be implemented through the adaptive management program (AMP) and committed to by Reclamation:

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- **Humpback Chub Consultation Trigger.**—A reinitiation trigger was identified as being exceeded if the population of adult humpback chub ( $\geq 200$  mm TL) in Grand Canyon declines significantly, or, if in any single year, based on the age-structured mark recapture model (ASMR; Coggins 2007), the population drops below 3,500 adults within the 95% confidence interval.
- **Comprehensive Plan for the Management and Conservation of Humpback Chub in Grand Canyon.**—Reclamation will continue to work with AMP cooperators to develop a comprehensive approach to management of humpback chub in Grand Canyon. Reclamation has committed to specific conservation measures in this biological opinion, but will also consider funding and implementing other actions not identified here to implement the plan.
- **Humpback Chub Translocation.**—Reclamation will assist NPS and the AMP in funding and implementation of translocation of humpback chub into tributaries of the Colorado River in Marble and Grand canyons. Havasu, Shinumo and Bright Angel creeks will initially be targeted for translocation, although other tributaries may be considered. Reclamation and the AMP will also fund and implement translocation of up to 500 young humpback chub from the lower LCR to above Chute Falls in 2008 if the Service determines that a translocation is warranted.
- **Nonnative Fish Control.**—Reclamation will continue efforts to assist NPS and the AMP in control of both cold- and warm-water nonnative fish species in both the mainstem of Marble and Grand canyons and in their tributaries, including determining and implementing levels of nonnative fish control as necessary.
- **Humpback Chub Nearshore Ecology Study.**—Reclamation will implement a nearshore ecology study that will relate river flow variables to ecological attributes of nearshore habitats (velocity, depth, temperature, productivity, etc.) and the relative importance of such habitat conditions to important life stages of native and nonnative fishes. This study will incorporate planned science activities for evaluating the high flow test on nearshore habitats as well as the 5-year period of

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steady flow releases in September and October. A research plan will be developed with the Service via the AMP for this study by August 1, 2008, and a 5-year review report will be completed by 2013.

- **Monthly Flow Transition Study.**—Reclamation has committed to adjusting daily flows between months to attempt to attenuate transitions that may be detrimental to nearshore ecology, such that they are more gradual, and to studying the biological effects of these transitions, in particular to humpback chub. If possible, Reclamation will work to adjust September and October monthly flow volumes to achieve improved conditions for young-of-year, juvenile, and adult humpback chub, as acceptable to the Service.
- **Humpback Chub Refuge.**—Reclamation will assist the Service in maintenance of a humpback chub refuge population at a Federal hatchery or other appropriate facility by providing funding to assist in annual maintenance. In case of a catastrophic loss of the Grand Canyon population of humpback chub, a refuge will provide a permanent source of sufficient numbers of a genetically representative stock for repatriating the species. This action would also be an important step toward attaining recovery.
- **Little Colorado River Watershed Planning.**—Reclamation will continue its efforts to help other stakeholders in the LCR watershed to develop watershed planning efforts, with consideration for watershed level effects to the humpback chub in Grand Canyon.

The 2008 Biological Opinion acknowledged the efforts by Reclamation in the development of this management plan and recognized that, because of its limited authority in the LCR, Reclamation's most effective role is to help other stakeholders in the LCR to develop watershed planning efforts that best consider conservation of the humpback chub.



### 1.3.5 Critical Habitat

Critical habitat was designated for the four Colorado River endangered fishes (i.e., humpback chub, razorback sucker, Colorado pikeminnow, bonytail) on March 21, 1994 (59 FR 13374). Critical habitat for humpback chub in Grand Canyon includes 174 miles of the Colorado River, from Nautiloid Canyon (RM 34; i.e., distance downstream from Lees Ferry) to Granite Park (208), as well as the lower 8 miles of the LCR. Critical habitat for razorback sucker includes the Colorado River from the confluence of the Paria River through Grand Canyon and Lake Mead to Hoover Dam.

Critical habitat is defined in Section 3(5)(A) of the ESA as:

*“(i) the specific areas within the geographical area occupied by the species, at the time it is listed...on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and*

*(ii) specific areas outside the geographical area occupied by a species at the time it is listed ...upon a determination by the Secretary that such areas are essential for the conservation of the species.”*

Designation of critical habitat, under Section 4(b)(2) of the ESA, identifies habitat features, or primary constituent elements, essential to the conservation of the species. Areas designated as critical habitat receive protection under Section 7(a)(2) of the ESA with regard to actions carried out, funded, or authorized by a federal agency that are likely to adversely modify or destroy critical habitat. Designation of areas as critical habitat affects all entities funded or authorized by a Federal agency, regardless of whether or not these areas are currently occupied by the listed species.

Critical habitat identifies areas that may require special management or protection within existing authority and jurisdictions. The designation of critical habitat will not, by itself, lead to recovery of a listed species, but is one of several measures available to

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contribute to species conservation. In cases where critical habitat has been designated, conservation of a listed species is focused on protecting those areas that contain primary constituent elements. Primary constituent elements include: (1) space for individual and population growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, rearing of offspring; and (5) habitats that are representative of the historic geographical and ecological distributions of a species (50 CFR 424). Hence, any effect to the stream channel or the quantity or quality of water in the lower 8 miles of the LCR is considered “destruction or adverse modification” of critical habitat (ESA, Section 7(a)(2)).

## 1.4 Adaptive Management

Adaptive management is the process by which ongoing management decisions are made based on information gathered from evaluation of those decisions. The FEIS on the Operation of Glen Canyon Dam was completed in March 1995, and a Record of Decision (ROD) was issued on October 9, 1996. Contained in the ROD is a program of *“...’adaptive management’, whereby the effects of dam operations on downstream resources would be assessed and the results of those resource assessments would form the basis for future modifications of dam operations.”* The process is directed by the Glen Canyon Dam Adaptive Management Program (GCDAMP), under the Federal Advisory Committee Act, and is composed of federal and state agency representatives, Native Americans, environmental groups, and public interest groups. The GCDAMP consists of an Adaptive Management Work Group (AMWG) that makes recommendations on the dam operations with technical assistance from the Technical Work Group (TWG).

Prior to completion of the FEIS, the U.S. Congress enacted the Grand Canyon Protection Act of 1992 (Act; title XVIII of Public Law 102-575). The Act addresses protection of Grand Canyon National Park and Glen Canyon National Recreation Area, and states that dam criteria and operating plans will be based on findings of the FEIS. The Act also established the Grand Canyon Monitoring and Research Center (GCMRC), a research program under the U.S. Geological Survey. The GCMRC was established to work cooperatively with, and under the direction of the AMWG and the TWG within the

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program of adaptive management established by the 1996 ROD. The AMWG reports to the Secretary on dam operations and other actions to fulfill provisions of the Act. The 2008 Biological Opinion on experimental operations of Glen Canyon Dam continues to promote adaptive management as an integral part of the AMP.

Because the GCDAMP deals primarily with impacts of dam management on resources in and along the Colorado River through Grand Canyon, this Little Colorado River Management Plan is tangential to the GCDAMP. The area encompassed by this Plan is the LCR Basin and spans beyond the area of responsibility of the GCDAMP. Nevertheless, the GCDAMP can help to foster relationships among LCR Basin stakeholders as part of this Plan, and the GCMRC can continue to be a source of technical expertise on the humpback chub in the lower LCR.

## **2.0 PHYSIOGRAPHY, CLIMATE, AND HYDROLOGY**

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### **2.1 Physiography**

The Little Colorado River is a 315-mile long tributary of the Colorado River in Grand Canyon, Arizona with its confluence 76 river miles downstream from Glen Canyon Dam (Figure 1). The LCR Basin encompasses 27,000 square miles of land, mostly within the State of Arizona. Headwaters for the LCR are at Baldy Peak in the White Mountains of east-central Arizona. Elevations in the basin range from 12,600 feet in the San Francisco Peaks near Flagstaff to 3,000 feet at the confluence. Topography varies dramatically within the LCR Basin, from alpine highlands on the San Francisco Peaks and White Mountains to the arid deserts of the Hopi Mesas, Painted Desert, and Defiance Plateau (Arizona Department of Water Resources [ADWR] 1989; Navajo Natural Heritage Program 1993).

There are a number of major tributaries to the LCR, which are referenced in this document. Moenkopi, Dennibito, Oraibi, Polucca, Jadito, Cottonwood, Pueblo, Colorado, and Leroux washes originate on Black Mesa in the northern region of the basin. The Puerco River originates on the Defiance Plateau-Chuska Mountains in the northeastern region, and the Zuni River, Largo Creek, and Carrizo Creek originate above the Zuni Reservation. Silver Creek and Show Low Creek originate in the White Mountains in the southeastern region of the basin. Chevelon Creek, Clear Creek, Salt Creek, and Jack's Canyon all originate on the Mogollon Rim in the southwestern region, and Deadman Wash and Cedar Wash drain the San Francisco Peaks at the western boundary of the basin (ADWR 1994a).

Surface geology of the LCR watershed includes volcanic and sedimentary rocks. The highest peaks are composed of volcanic rock atop sedimentary layers, with the remainder of the basin underlain by horizontally stratified sedimentary rock deposits of varying ages and characteristics. These sedimentary layers have been eroded into canyons, plateaus, mesas, and buttes. Despite the elevation range, most of the watershed has a low average local relief as a result of the flat sedimentary deposits. Alluvial deposits in the floodplains consist of loosely consolidated sedimentary materials that provide soil sources for the majority of agriculture within the basin (ADWR 1989).

### **2.2 Climate**

The LCR Basin is characterized by a wide variation in climate, from semi-arid below 4,500 feet elevation to relatively humid above 7,500 feet (Cooley et al. 1969). Annual precipitation ranges from more than 30 inches along the Mogollon Rim and in the White Mountains to less than 6 inches toward the interior of the basin. Most of the basin annually receives less than 12 inches of precipitation (Cooley et al. 1969; ADWR 1989). Generally, winter storms are of low intensity, but may last for several days and distribute moisture over a large area. Conversely, summer storms are convective in origin, and are of higher intensity, shorter duration, and affect a smaller area than winter storms. High intensity monsoon storms occur occasionally in late summer as a result of large moist air masses originating in the Gulf of Mexico (McGavock et al. 1986). These summer monsoonal rain storms can deliver large amounts of water down dry washes very quickly and cause very sudden and short-term flow peaks in the LCR.

Temperature varies with elevation in the LCR Basin. Average high temperatures in July at lower elevations are above 90EF, while those at higher elevations are between 80 and 90EF. High temperatures regularly exceed 100EF in the interior basin. During January, average low temperatures at all elevations are in the teens (ADWR 1989).

### **2.3 Hydrology**

The hydrology of the LCR is complex and a detailed description is beyond the scope of this document. The information contained in this section was taken from numerous sources which contain more comprehensive hydrologic descriptions. A good understanding of surface water flow and ground water aquifers, as well as the inter-relationship between these hydrologic systems, is vital to this document. Most notable are reports of the hydrogeology of the Coconino Plateau and adjacent areas (Bills et al. 2007), the Hopi Tribe on the characteristics of the LCR Basin (Hopi Tribe 1995), the hydrology of the LCR Basin (ADWR 1989), spring flow from Pre-Pennsylvanian Rocks in the Navajo Indian Reservation (Cooley 1976), and spring flow in the Colorado River, Lees Ferry to Lake Mead, Arizona (Johnson and Sanderson 1968).

### 2.3.1 Characteristics of Hydrologic Regime

The LCR was once a perennial stream throughout its course, except for years of drought (Hope Tribe 1995). Water depletions for domestic, industrial, and agricultural uses have transformed the LCR into an intermittent stream, with perennial flow only in the upper-most reaches. During much of the year, there is no surface flow in the lower LCR above a spring complex that maintains flow in the lower 13 miles. Annual surface runoff at Cameron, Arizona is 177,700 AF (1948-95), with 10% of flows exceeding 681 cfs and 50% exceeding 3.4 cfs (Rote et al. 1997). Mean annual discharge of surface water from the LCR Basin above the lower 13 miles is 219 cfs, as measured near Cameron (U.S. Geological Survey [USGS] Station 09402000, 1948-2007). This flow is intermittent and varies tremendously within a given year and between years (Figure 2). Snowmelt runoff from the San Francisco Plateau and Mogollon Slope in the southern portion of the LCR watershed provides the majority of surface water flow in spring at the Cameron gage. Instantaneous maximum flow of 119,913 cfs occurred in spring 1954 (U.S. Geological Survey 1954; Hereford 1984), and the highest mean daily discharge of 18,400 cfs occurred on October 19, 1972 (USGS Station 09402000, 1948-2007) as a result of an early winter storm.

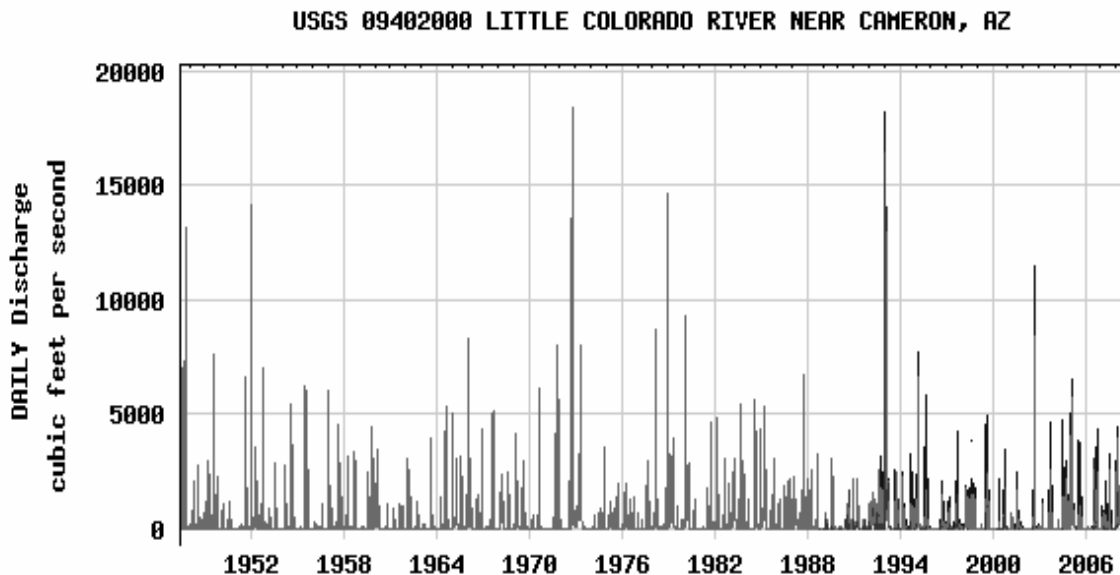


Figure 2. Mean daily discharge for the Little Colorado River near Cameron, Arizona for the period June 1, 1947 to September 24, 2008.

## 2.0 Physiography, Climate, and Hydrology

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Perennial flow in the lower 13 miles of the LCR comes entirely from a complex of springs, the largest of which is Blue Springs. Other springs discharge into this reach 3.1-14.7 miles upstream from the confluence with the Colorado River, but there is no apparent spring inflow in the last 3 miles above the confluence (Johnson and Sanderson 1968). Combined ground water discharge from these springs varies from 211 to 223 cfs, which constitutes base flow for the LCR at its confluence with the Colorado River (Figure 3). Blue Springs, the largest of these springs, contributes approximately 95 cfs (Cooley 1976), or 40-43% of the base LCR flow.

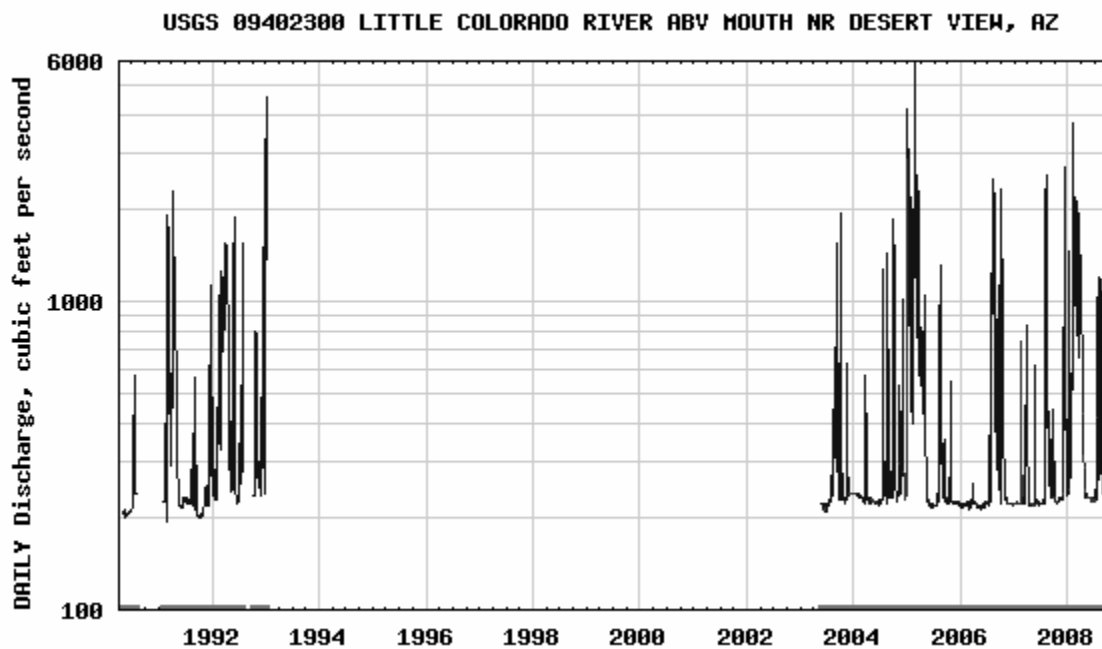


Figure 3. Mean daily discharge for the Little Colorado River above the confluence with the Colorado River and near Desert View, Arizona for the period April 5, 1990 to December 31, 1993, and June 1, 2003 to September 24, 2008.

The various springs of the Blue Springs complex differ considerably in concentration of dissolved solids. Water emitting from Blue Springs is highly mineralized with sodium, calcium, chloride, and bicarbonate salts. The spring has a total dissolved solids (TDS) content of 3,960 mg/L, with chloride composing 1,910 mg/L (Johnson and Sanderson 1968). The combination of these minerals imparts a milky blue or turquoise color to the water at base flow. Water from Blue Springs is 20EC (68EF) and has a high free carbon dioxide

## 2.0 Physiography, Climate, and Hydrology

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(CO<sub>2</sub>) level of 571 mg/L. As the water flows downstream, carbon dioxide gasses dissipate into the atmosphere and calcium carbonate (calcite) precipitates as tufa, forming small dams (Cole 1975). The calcite precipitate increases turbidity, imparting a milky color to the water and covers the stream bottom with a layer of unconsolidated whitish particles. Measurements of water quality parameters from various locations in the LCR are presented in Table 1 (Robinson et al. 1995a).

Table 1. Water quality parameters (means for 1991, 1992, and 1993) from four locations on the LCR, as measured upstream from the confluence with the Colorado River (Robinson et al. 1995a).

Parameter	7.8 miles	9.3 miles (Atomizer Falls)	10.9 miles	12.4 miles (Below Blue Springs)
Water Temperature (EC)	20.99	20.97	20.94	20.66
pH	7.17	7.45	7.24	6.53
Alkalinity (mg/L CaCO <sub>3</sub> )	596.65	672.30	671.53	740.48
Carbon dioxide (mg/L)	171.33	178.67	190.00	320.00
Dissolved oxygen (mg/L)	7.48	8.34	7.57	6.62
Conductivity (:S/cm)	4762.57	4545.74	4493.70	4468.71

Altogether, ground water and surface water contribute approximately equal portions of total annual streamflow through the lower 8 miles designated as critical habitat for humpback chub, although ground water is responsible for base flow in the absence of surface flow. A simplified compartmental diagram of the hydrologic regime of the LCR Basin is provided in Figure 4. This diagram shows the relationship of surface flow to ground water aquifers and estimated volume of water used from surface and ground water sources.

According to available literature, flow volume from the Blue Springs complex has remained relatively constant during the last five decades. Cooley (1976), using data from Johnson and Sanderson (1968), reported an average discharge of 223 cfs for the period 1950-67, while Loughlin (1983) measured flow of 211 cfs in the early 1980s. The Hopi Tribe (1995), in an analysis of USGS data, determined that the Blue Springs complex discharge during 1990-92 averaged 216 cfs. Approximately 90% of this discharge occurs between 10 and 13.3 miles upstream of the confluence with the Colorado River (Cooley 1976).



## 2.0 Physiography, Climate, and Hydrology

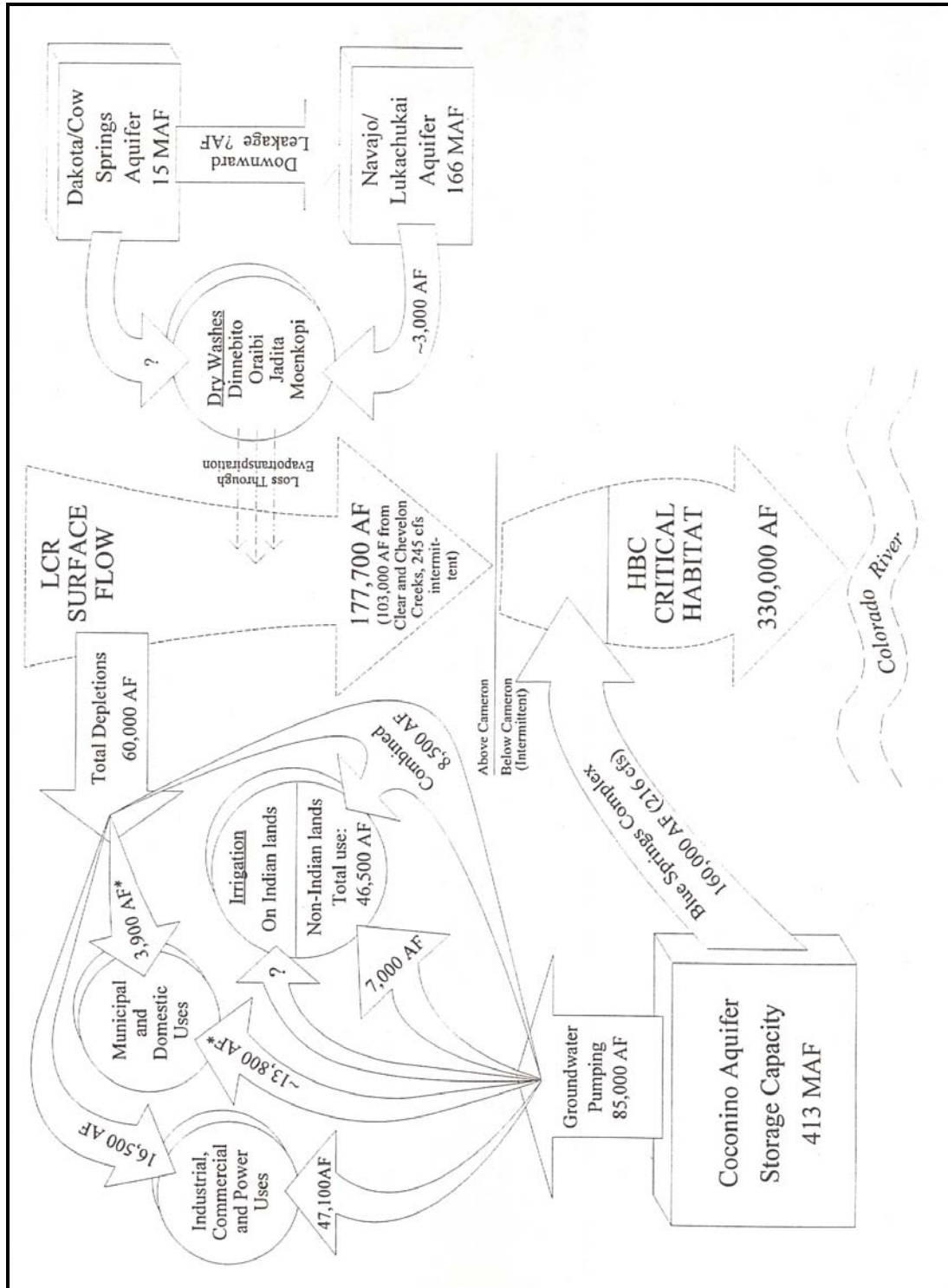


Figure 4. Compartmental model of the hydrologic regime for the Little Colorado River Basin. All volumes are annual volumes; AF=AF, MAF=million acre feet, HBC=humpback chub.

\*3,900 AF is only for Flagstaff; 13,800 AF is approximate, with 4,300 AF going to Flagstaff.

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Over 99% of the Blue Springs complex flow is discharged from a multiple aquifer system within the Redwall and Muav Limestones coming primarily from the Coconino aquifer (See Section 1.3.4.1; Cooley 1976). In the area of the LCR canyon, the Coconino aquifer drains downward into the Redwall-Muav aquifer via fractures through the Coconino, Hermit, and Supai formations. Once reaching the Redwall and Muav limestones, the water moves through solution channels and along fractures (Cooley 1976; Loughlin 1983; McGavock et al. 1986). Springs issuing from the Redwall Limestone in the lower LCR and in Havasu Creek have large discharges, but most other springs and seeps along the south rim of the Grand Canyon that issue from the Redwall and Muav Limestones have small discharges. The average flow of Blue Spring, one of dozens of outlets from the Redwall-Muav aquifer along the lower LCR, is about 95 cfs. Average discharge of Havasu Spring in Havasu Creek is about 64 cfs.

The Coconino aquifer underlies 14 million acres of the LCR Basin, and regional contributions from the aquifer to the Blue Springs complex discharge vary. To determine the geographical source(s) of this discharge, Loughlin (1983) collected and compiled water quality data for the Blue Springs complex, ground water wells near Cameron, and other sources leading up the Mogollon Slope to Flagstaff. Using these data in a mixing model, Loughlin (1983) determined that 75% of the Blue Springs complex was derived from the San Francisco volcanic field near Flagstaff, and 25% was derived from the eastern and southeastern portions of the LCR Basin. The San Francisco volcanic field is able to contribute more of the water discharged at the Blue Springs complex than the eastern portion of the basin because of: (1) much higher precipitation and recharge rates, and (2) secondary permeability imparted by the many faults and fractures in the area (Loughlin 1983). Also, ground-water flow paths originating on the Mogollon Rim in the Flagstaff area are much shorter than flow paths originating in the eastern part of the basin.

Based on the hydrologic relationships described above, concern exists that ground water utilization from the Coconino aquifer in the Flagstaff area has a greater and more immediate impact to discharge at the Blue Springs complex than equivalent water use from the Coconino aquifer in the eastern portion of the LCR Basin. The primary use of ground water in the Flagstaff area is for municipal purposes. During 1987-94, the City of Flagstaff

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pumped an average of 4,300 AF annually from the Coconino aquifer from its Lake Mary and Woody Mountain well fields (unpublished data provided by Ron Doba, Utilities Manager, City of Flagstaff); the Woody Mountain well field is included in this total because although it is south of the LCR Basin divide, it is north of the ground water divide. The total volume of water pumped from these two well fields is approximately 5% of the total combined municipal, industrial, and agricultural volume pumped annually from the Coconino aquifer. Since the secondary permeability of the geology in the Flagstaff region may allow ground water depletion in that region to manifest itself in decreased discharge at Blue Springs faster than ground water depletion in other parts of the basin, the seemingly low 5% figure may have an amplified significance. Hence, increased ground water pumping in the Flagstaff area could disproportionately decrease discharge at Blue Springs. By the year 2000, the volume of ground water pumped from the Coconino aquifer by Flagstaff had increased from 4,300 to about 4,960 AF annually (Montgomery et al. 2000).

### **2.3.2 Streamflow from Precipitation**

Surface flow in the LCR watershed from year to year is extremely variable. The USGS gage at Cameron (Figure 2) provides a streamflow record since 1948 and is located about 30 miles upstream of the Blue Springs complex. These discharge data are useful for portraying the contribution of LCR surface flow from above Blue Springs to the reach designated as critical habitat for humpback chub. The greatest mean monthly discharge of 610 cfs at the Cameron station for the period 1948-94 occurred in April (Figure 5a) as a result of snowmelt runoff from the Mogollon Slope and San Francisco Plateau. The largest contributions of snowmelt runoff are from the Chevelon Creek and Clear Creek watersheds (Figures 5b and 5c), with average peak discharges in April of 168 and 381 cfs, respectively. Annually, these two watersheds provide about 103,000 AF, or 50% of the surface water flow in the LCR reaching the Navajo Reservation (ADWR 1989; 1994g).

Summer storms cause peaks in streamflow at Cameron in August (Figure 5a), but these rainstorms provide a smaller volume of water to the LCR than snowmelt runoff peaks. Summer storms usually give rise to the largest flow events which occur each year in the northern tributaries of the LCR, as exemplified by the summer peak in mean monthly

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discharge for Moenkopi Wash and the LCR below the Zuni River confluence near Hunt (Figures 5d and 5e). The occurrence of summer flow events has a greater year-to-year variability than spring snowmelt (Hopi Tribe 1995), and after the spring runoff subsides, the northern washes and much of the mainstem and upper reaches of the LCR are dry or nearly dry between summer storm events.

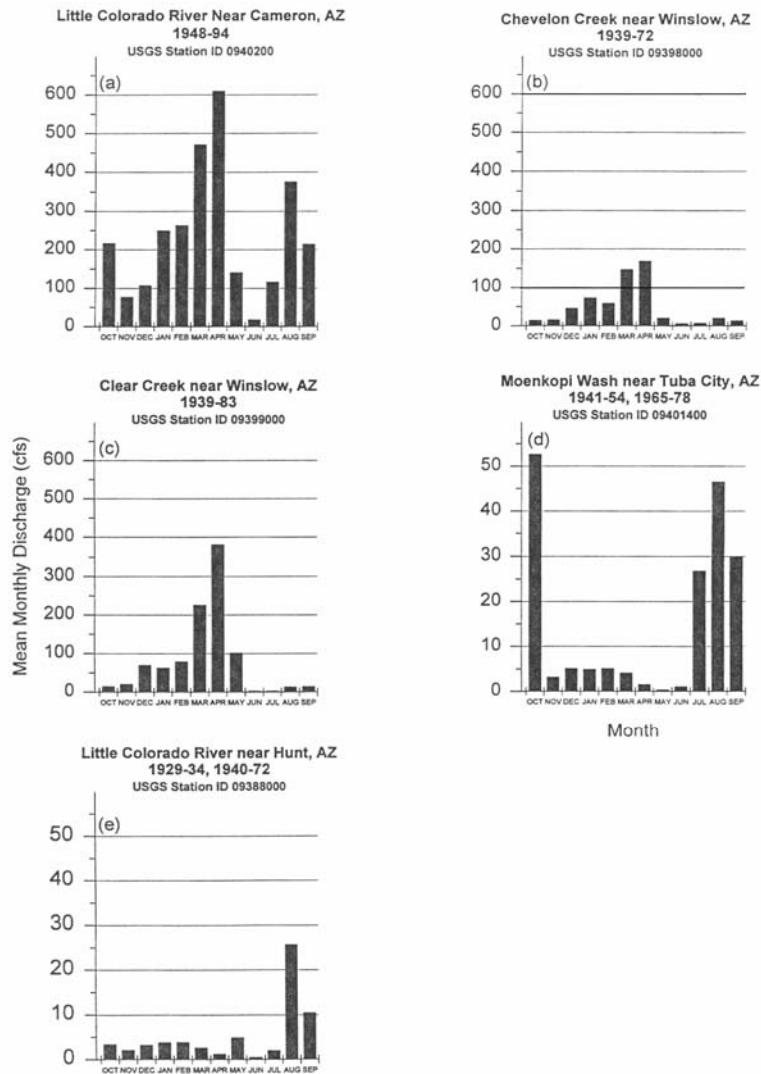


Figure 5. Mean monthly discharge at five gauging stations in the Little Colorado River (LCR) Basin: (a) LCR near Cameron, AZ, (b) Chevelon Creek near Winslow, AZ, (c) Clear Creek near Winslow, AZ, (d) Moenkopi Wash near Tuba City, AZ, and (e) LCR near Hunt, AZ. Note that scales of vertical axes differ (Adapted from The Hopi Tribe 1995).

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During the period 1948-2007, there was no flow in the LCR near Cameron for 23-230 days of the year, for an annual mean of 135 days (Figure 6). Despite intervening periods of drought over the 60 years of record, there was no distinct pattern for annual no-flow days using regression analysis ( $y = -0.312x + 144.78$ ;  $R^2 = 0.0129$ ). For the six decades of record since 1948, the average number of days with no flow ranged from 109 to 159, with no significant difference among means ( $\alpha = 0.095$ , ANOVA, Tukey HSD all-pairwise comparisons test), although the last three decades since 1978 have had fewer days with no flow in the LCR near Cameron.

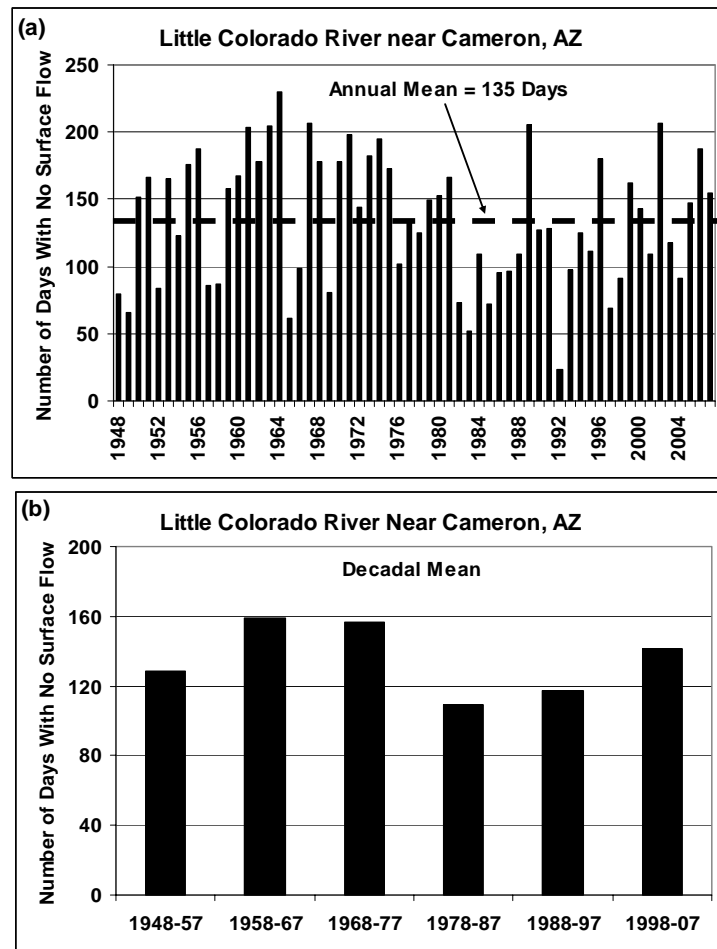


Figure 6. The Little Colorado River near Cameron, AZ, 1948-2007: (a) number of days per year with no surface flow, and (b) average number of days per decade with no surface flow (USGS Station 09402000).

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Peak flows of the LCR usually occur during late winter snow/rain storms mixed with spring snowmelt or during late summer monsoonal rainstorms. Peak flows for the period 1948-2007 ranged from 1,020 to 18,400 cfs for an overall annual average of 4,820 cfs (Figure 7). For the six decades of record since 1948, the average maximum daily flow ranged from 3,164 to 6,249 cfs, with no significant difference among means ( $\alpha = 0.425$ , ANOVA, Tukey HSD all-pairwise comparisons test). However, the last two decades since 1988 have had lower maximum daily flows than any of the prior four decades. This suggests that peak flows in the LCR have been lowered since about 1988, possibly as a result of an extended regional drought combined with increased capture of flows for human uses throughout the basin.

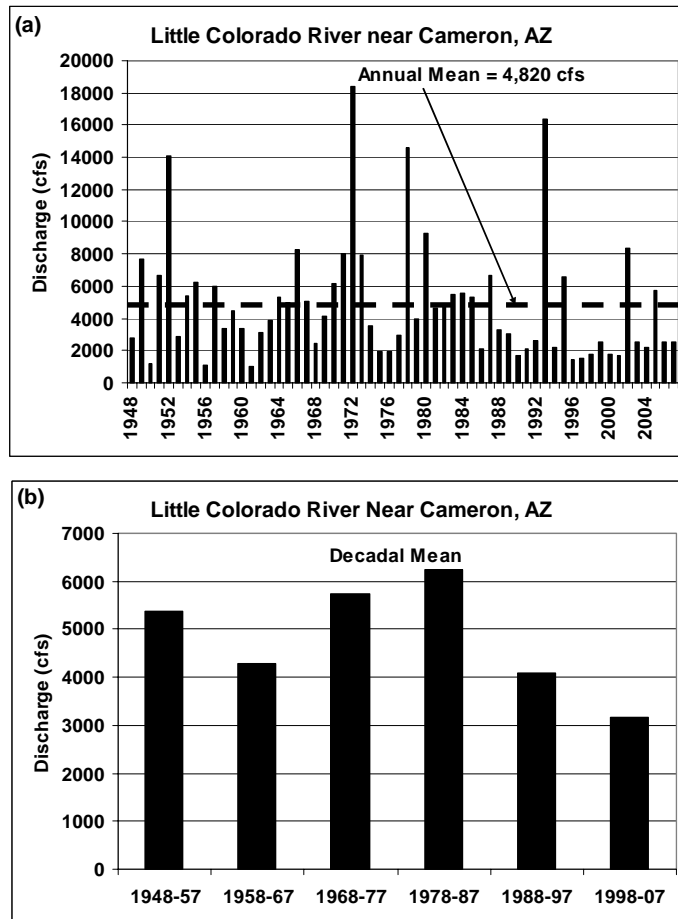


Figure 7. The Little Colorado River near Cameron, AZ, 1948-2007: (a) maximum daily discharge per year, and (b) average maximum daily discharge per decade (USGS Station 09402000).

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Peak daily flows of the LCR at Cameron that exceeded the overall mean peak flow of 4,820 cfs for the period 1948-2007 occurred most frequently in August, January, and February (Figure 8). The peak flows in August were caused by monsoonal rainstorms and occurred at a frequency of nearly twice as often as in September. The peak flows in January and February were caused by snowmelt runoff and late winter snow/rain storms. From the pattern of monthly peak flow frequencies shown in Figure 8, the effect of storms in late winter and late summer on peak flows is dramatic.

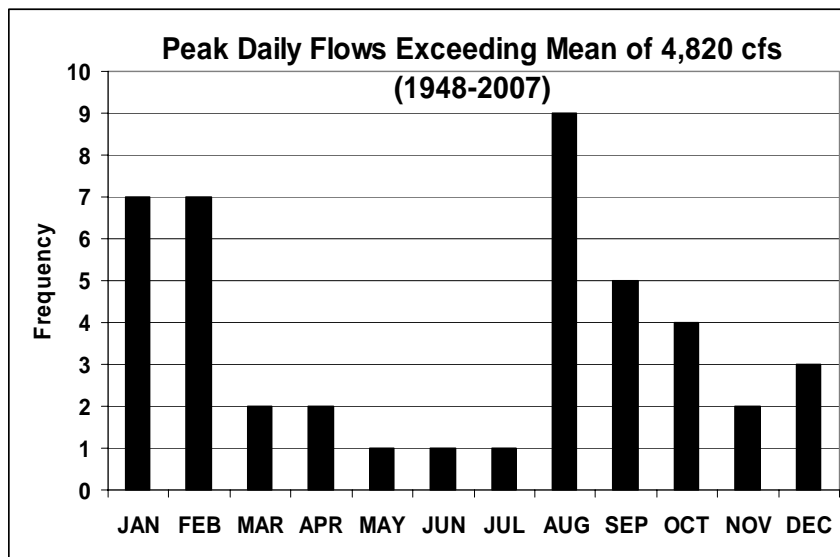


Figure 8. Frequency of peak daily flows by month for the Little Colorado River that exceeded overall mean peak flow of 4,820 cfs for the period 1948-2007.

Concurrent with the development of water resources in the LCR Basin and regional drought conditions (see Section 3.3.3), there has been a decrease in the extent of the perennial river and tributary reaches. The stretch of the LCR from Woodruff to Winslow was historically perennial, but now has intermittent flow with short ephemeral stretches associated with human development. ADWR (1989) estimates that these depletions reduce the total LCR discharge reaching the Navajo Nation border below Winslow by 25% or 60,000 AF annually.

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In addition, ground-water pumping has reduced surface flow in several areas as a result of two mechanisms. First, pumping from the Coconino aquifer can reduce ground water and ground water discharge to the alluvium which directly affects base flow. Second, surface flow is reduced as precipitation runoff replaces ground water pumped from the alluvium. Ground water pumping may also be contributing to reduction in surface flows in Show Low Creek, Silver Creek, and to a lesser extent, in the Puerco River (ADWR 1989).

### **2.3.3 Regional Climate Conditions**

Hydrology and water-supply of the Colorado River System are extremely sensitive to climate change that could occur over the next several decades (Nash and Gleick 1993). Recent and ongoing drought conditions in the southwestern United States during the end of the 20<sup>th</sup> century and the start of the 21<sup>st</sup> century have resulted in less than normal precipitation and reduced streamflows throughout the region. Climate change is of particular concern in the Colorado River System because of the sensitivity of the snow accumulation processes that dominate runoff generation, and because of a high water demand relative to supply (Loaiciga et al. 1996; National Research Council 2007). Global average temperature has risen by 0.74°C (range 0.56-0.92°C) for 1906-2005 (IPCC 2007), and General Circulation Models of the atmosphere predict increases in global mean annual air temperature between 1.4 and 5.8°C over the next century (IPCC 2001). Increases in temperature of 2°C alone with no change in precipitation are predicted to cause mean annual runoff of the Colorado River to decline by 4-12% (Nash and Gleick 1993).

The temperature-related effects on streamflow also include less winter snow storage, an earlier and faster spring snowmelt from an increased rain to snow ratio, and a decrease in summer runoff (Wolock and McCabe 1999). Natural streamflow of the Colorado River System by the mid 21st century is expected to decline as little as 6% (Christensen and Lettenmaier 2006) and as much as 45% (Hoerling and Eischeid 2007).

Studies of proxy records, in particular analyses of tree-rings throughout the Upper Colorado River Basin indicate that droughts lasting 15–20 years are not uncommon in the late Holocene (Webb et al. 2005). These findings, coupled with today's understanding of



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decadal cycles brought on by El Niño Southern Oscillations indicate that the current drought could continue.

The effect of climate change on the long-term conservation of the humpback chub is difficult to predict. Decreases in streamflow without intervening periods of high runoff are likely to be detrimental to the species, but these decreases are likely to occur as small changes and without dramatic annual shifts in flow volume, frequency, or timing. Hence, it is difficult to identify when and how climate change impacts can be addressed with specific actions, as specified for biological opinions in *Natural Resources Defense Council v. Kempthorne*, No. 05-1207 (E.D. Cal. May 25, 2007). Nevertheless, awareness by stakeholders across the LCR Basin is important in order to gain a better understanding of how to best manage water resources in the basin, given the likelihood of continued drought and continued strain on both surface and ground water supplies.

### **2.3.4 Ground Water Aquifers**

Four principal ground water aquifers are located within the LCR Basin. They are the Coconino, Dakota, Navajo, and Redwall/Muav aquifers, known as the C, D, N, and R aquifers, respectively. Except for the southeast portion of the D and N aquifers and the C and R aquifers west of Cameron, there is little interconnection among these major water bearing units. Table 2 summarizes some of their important attributes, such as location, capacity, water quality and use, and recharge and discharge areas. These four aquifers, as well as other local aquifers in the LCR Basin, are described below.

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Table 2. Attributes of principal ground water aquifers of the Little Colorado River Basin. Sources: Abruzzi (1985), ADWR (1989, 1994), Cooley et al. (1969).

Attribute	Coconino (C-aquifer)	Dakota (D-aquifer)	Navajo (N-aquifer)	Redwall-Muav (R-aquifer)
Capacity	<ul style="list-style-type: none"> <li>Area within LCR Basin: 14 million acres (940,000 acres considered dry)</li> <li>Storage: 413 MAF</li> <li>Well yields: 25-200 gpm, capable of 1,000-2,000 gpm</li> <li>Average saturated thickness: 400 ft (0-900 ft)</li> </ul>	<ul style="list-style-type: none"> <li>Area within LCR Basin: 2 million acres</li> <li>Storage: 15 MAF</li> <li>Well yields: &lt;5-25 gpm</li> <li>Average saturated thickness: 500 ft.</li> </ul>	<ul style="list-style-type: none"> <li>Area within LCR Basin: 4 million acres</li> <li>Storage: 166 MAF</li> <li>Well yields: 25-&gt;500 gpm</li> <li>Average saturated thickness: 400 ft.</li> </ul>	<ul style="list-style-type: none"> <li>Underlies C-aquifer and throughout the Coconino Plateau</li> <li>3,000-3,200 ft. below land surface</li> </ul>
Water quality and uses	<ul style="list-style-type: none"> <li>Domestic, irrigation, and industrial uses</li> <li>Withdrawals by industry and irrigation are 85,000 AF/yr</li> <li>Highest TDS of three aquifers, but variable</li> <li>TDS lower south of LCR (&lt;1,000 mg/L);</li> <li>Higher north of LCR (3,000-&gt;10,000 mg/L)</li> </ul>	<ul style="list-style-type: none"> <li>Quality suitable for all water uses</li> <li>Domestic, irrigation and livestock</li> <li>Because of low yields, aquifer use is limited (stock and domestic); ver little public supply</li> <li>TDS: 190-4,410 mg/L</li> </ul>	<ul style="list-style-type: none"> <li>Water quality is good to excellent, suitable for all uses</li> <li>Domestic, irrigation, municipal, livestock, and mining use, primarily in Tuba City and Peabody Coal Mine areas</li> <li>TDS generally &lt;500 mg/L</li> </ul>	<ul style="list-style-type: none"> <li>Great depth of aquifer limits access to pumping</li> </ul>
Location	<ul style="list-style-type: none"> <li>Underlies all but western extreme of LCR Basin</li> </ul>	<ul style="list-style-type: none"> <li>Underlies Hopi Reservation (except southwest portion and north-central portion</li> </ul>	<ul style="list-style-type: none"> <li>Underlies northwest portion of Navajo Reservation and the Hopi Reservation on Black</li> </ul>	<ul style="list-style-type: none"> <li>Underlies C-aquifer</li> </ul>

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Attribute	Coconino (C-aquifer)	Dakota (D-aquifer)	Navajo (N-aquifer)	Redwall-Muav (R-aquifer)
Geology	<ul style="list-style-type: none"> <li>Coconino Sandstone is the major water bearing unit, found throughout the basin, except in the Defiance Uplift area, where the DeChelly Sandstone is the major water bearing unit</li> <li>Also comprised of Kaibab Limestone</li> </ul>	<ul style="list-style-type: none"> <li>Dakota Sandstone, sandy units of the Morrison Formation, and Cow Springs Sandstone</li> </ul>	<ul style="list-style-type: none"> <li>Comprised of Navajo Sandstone, sandstones of Kayenta Formation, and Lukachukai member of Wingate Formation</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>
Recharge area(s)	<ul style="list-style-type: none"> <li>Defiance Plateau and Mogollon Rim, particularly where precipitation is highest</li> <li>No exchange of water between N and C aquifers due to 1000' of nearly impermeable Chinle shale between the two</li> </ul>	<ul style="list-style-type: none"> <li>Black Mesa</li> <li>Recharged from precipitation along eastern boundary</li> </ul>	<ul style="list-style-type: none"> <li>From Monument Upwarp to the north and from Echo Cliffs to the west, also Black Mesa, predominantly from precipitation on exposed aquifer units</li> <li>Limited recharge from overlying D-aquifer</li> </ul>	<ul style="list-style-type: none"> <li>Occurs almost entirely through faults, fractures, and other geologic structures, or by downward leakage from overlying units</li> <li>Receives inflow through cracks and fractures from the C-aquifer</li> </ul>
Discharge area(s)	<ul style="list-style-type: none"> <li>Most discharge is at Blue Springs from the Redwall and Muav Limestones (160,000 AF/yr)</li> </ul>	<ul style="list-style-type: none"> <li>Discharges to springs and alluvium and the Polacca, Jadito, Oraibi, and Dinnebito Washes, most of which is lost to evapotranspiration and results in little surface flow</li> <li>Discharge also occurs in northeast portion of the aquifer, out of LCR watershed</li> </ul>	<ul style="list-style-type: none"> <li>Moenkopi and Dinnebito Washes</li> <li>Northeast into Laguna Ck., northwest into Navajo Ck., and southwest into Moenkopi Wash, much of which is lost to evapotranspiration</li> </ul>	<ul style="list-style-type: none"> <li>Spring flow along the lower LCR and in tributaries of the Colorado River along the south rim of Grand Canyon, primarily Blue Springs and Havasu Creek</li> <li>Discharge from Redwall and Muav limestones</li> <li>Downward leakage into the Bright Angel Shale and Tapeats Sandstone</li> </ul>

## **2.0 Physiography, Climate, and Hydrology**

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### **2.3.4.1 Coconino Aquifer**

The C-aquifer is the largest aquifer in the LCR Basin with an areal extent of 21,655 square miles or over 14 million acres (Figure 9). The C-aquifer's main water-bearing units are the Kaibab Limestone, Coconino Sandstone, and upper sequences of the Supai Formation (Figure 10). The aquifer has an estimated storage capacity of 413 MAF and an average saturated thickness of 400 feet (ADWR 1989).

Recharge areas for the C-aquifer are the Mogollon Rim, the San Francisco Peaks, and the Defiance Plateau. Annual recharge of the C-aquifer is an estimated 319,000 AF/year, and most of the aquifer discharges at Blue Springs with a volume of about 164,000 AF/year. Ground water use in the LCR Basin from the C-aquifer is about 100,000 AF/year (Reclamation 2006). No leakage occurs into the C-aquifer from above because it is overlaid by the nearly impermeable shale of the Chinle Formation. Water-chemistry data from C-aquifer wells and springs in the Flagstaff area indicate that water in the aquifer is up to 7,000 years old with a mix of younger and older waters (Bills et al. 2007).

The C-aquifer is utilized primarily south of the LCR and along the eastern edge of the basin by communities such as Flagstaff, Heber, Overgaard, Show Low, Snowflake, and Concho (Bills et al. 2007). North of the LCR, the C-aquifer is either too deep to be economically useful or the water quality is unsuitable for most uses because of the high content of dissolved salts. Water yields of wells in the C-aquifer vary spatially, ranging from 25 to 2,000 gallons per minute (gpm). Water quality is also variable, depending on underlying and overlying formations, distance that water travels from the recharge area, and restricted ground water movement in the center of the basin (Cooley et al. 1969; ADWR 1989).

TDS concentrations are generally <1,000 mg/L for areas south of the LCR, 1,000-3,000 mg/L along the LCR, and 3,000-10,000 mg/L north of the LCR (ADWR 1989). Pumping for industrial, commercial, power generation, agricultural, domestic, and municipal purposes annually withdraws about 100,000 AF from the aquifer. These uses are described in more detail in Section 6.3 Industrial and Municipal Water Uses.

## 2.0 Physiography, Climate, and Hydrology

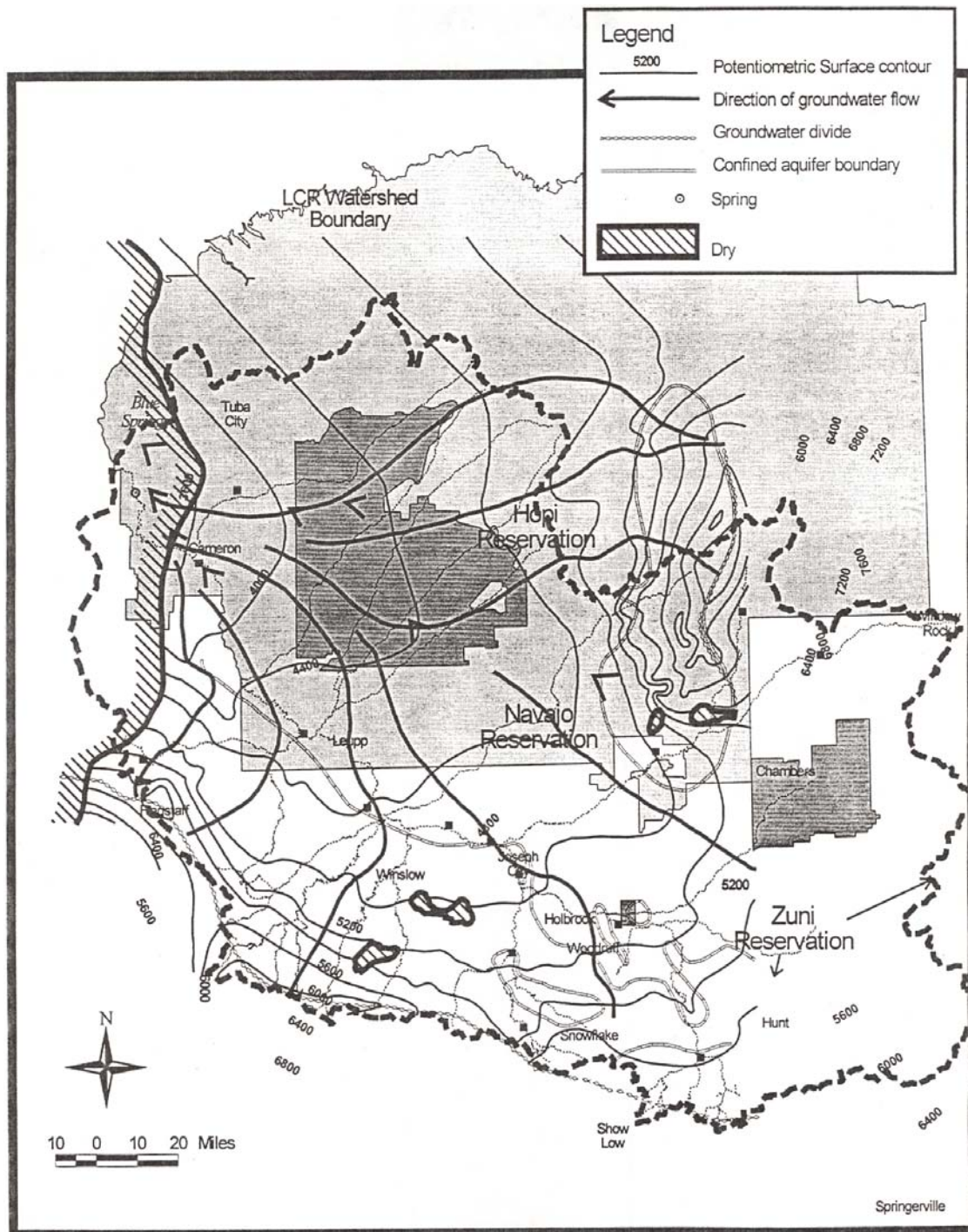


Figure 9. The Coconino aquifer. Source: ADWR, GCES.

## 2.0 Physiography, Climate, and Hydrology

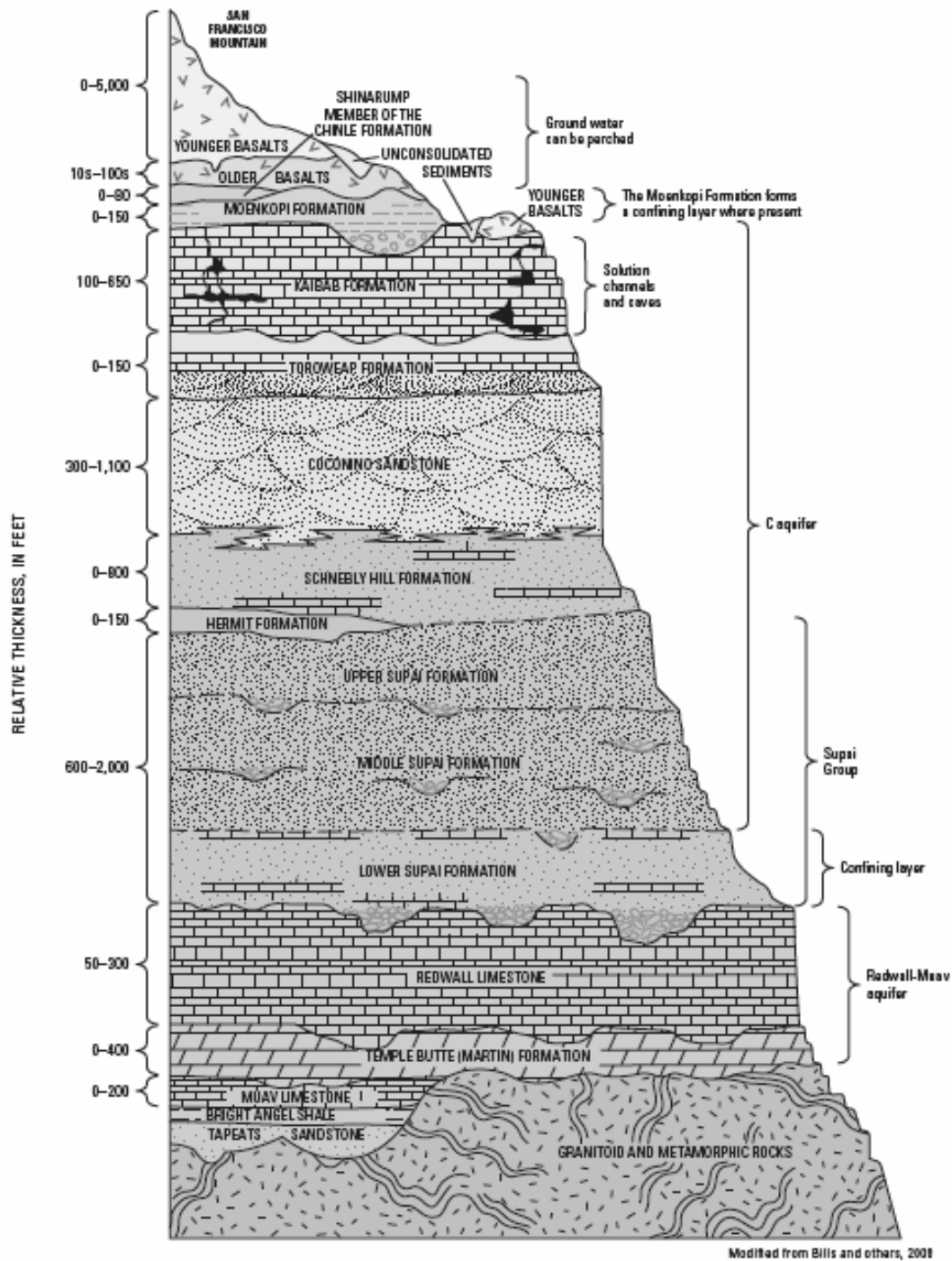


Figure 10. Generalized stratigraphic section of rock units in the Coconino Plateau, Coconino and Yavapai Counties, AZ. Source: Bills et al. (2007).

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As previously discussed, the C-aquifer discharges primarily at the Blue Springs complex via leakage into the Redwall and Muav Limestones on the south rim of the Grand Canyon (Figure 11). Leakage from the C-aquifer enters the underlying R-aquifer primarily in the LCR Gorge below Cameron and emerges at the Blue Springs complex. Due to low transmissivity and great areal extent, transport time through the C-aquifer may take hundreds or thousands of years (ADWR 1989). Thus, discharge quantities at the Blue Springs complex may reflect climatic conditions that occurred many years ago, and the impacts of contemporary activities on ground water from the C-aquifer may not be seen for many years. With the present understanding of ground water in this area, it is currently difficult to determine if a decline in discharge at the Blue Springs complex was a delayed result of climatic variation or the direct result of ground water pumping from the C-aquifer.

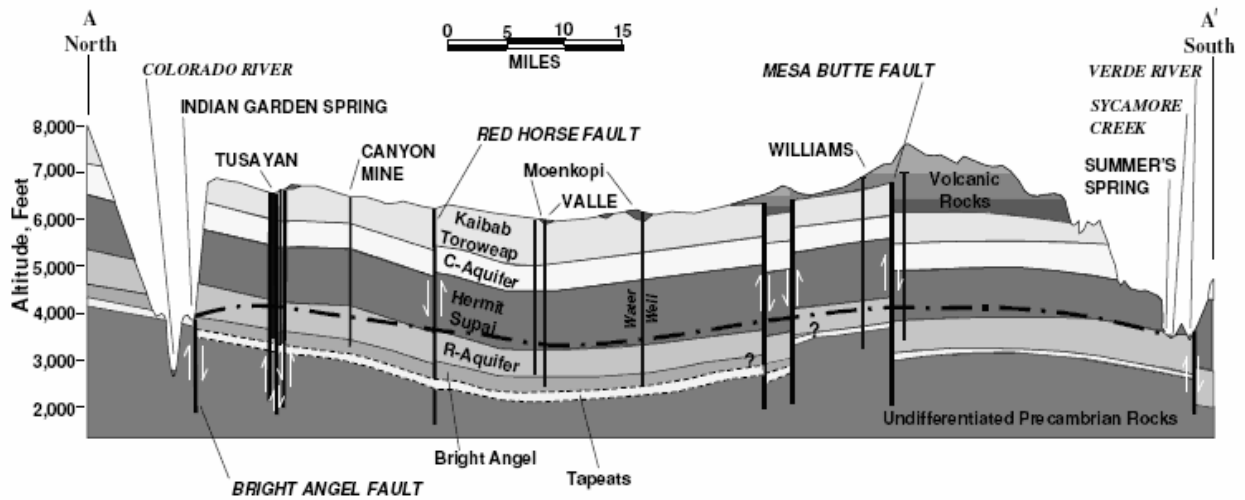


Figure 11. Hydrogeologic section of the Coconino and San Francisco Plateaus showing the location of the C-aquifer. Source: Montgomery et al. (2000).

The C-aquifer is still in hydrostatic equilibrium (steady-state); however, local ground water sinks or cones of depression are developing in areas of heavy pumping such as the paper mill near Snowflake and three of the power plants: Springerville Generating Station, Coronado Generating Station (St. Johns), and Cholla Generating Station (Joseph City/Holbrook). Nevertheless, base flow of the LCR continues to range from 211 to 223 cfs.

## ***2.0 Physiography, Climate, and Hydrology***

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Summer and winter base flows differ by about 10%; the difference is likely the result of differences in the amount of evapotranspiration in and near the channel during these seasons (Bills et al. 2007).

### ***2.3.4.2 Dakota Aquifer***

The D-aquifer (Figure 12) extends over 2 million acres of the northern LCR Basin, underlying most of the Hopi Reservation and the north-central portion of the Navajo Reservation. The D-aquifer is comprised of the Dakota Sandstone, sandy portions of the Morrison Formation, and the Cow Springs Sandstone. It has a storage capacity of 15 MAF and an average saturated thickness of 500 feet. Recharge is from precipitation on Black Mesa and along the eastern boundary of the aquifer. There is substantial leakage downward from the D-aquifer into the N-aquifer.

The D-aquifer discharges at springs along its eastern and northern boundaries and into the alluvium of the washes along its southwestern edges on the Hopi Reservation. Water discharged from the D-aquifer to washes, is consumed by evapotranspiration, and does not contribute to surface flow in the LCR. There is no hydrologic connection between the D-aquifer and the C-aquifer, and the D-aquifer does not contribute to ground water discharge at the Blue Springs complex. Hence, there is no potential for D-aquifer water use to affect water flows within the LCR critical habitat reach.

The D-aquifer is confined by the overlying Mancos Shale and is under pressure so that water from this aquifer rises above the level at which it is encountered by a well. Water yields of wells in the D-aquifer are low (<5-25 gpm). Water from the D-aquifer is marginal to unsuited for domestic use because total dissolved solids (TDS) concentrations are between 190 and 4,410 mg/L (ADWR 1989). The D-aquifer is used only sparingly for livestock and a small amount for domestic use because of low well yields and poor water quality. The D-aquifer is still in hydrostatic equilibrium (steady-state); however, local ground water sinks or cones of depression are developing in areas of heavy pumping.



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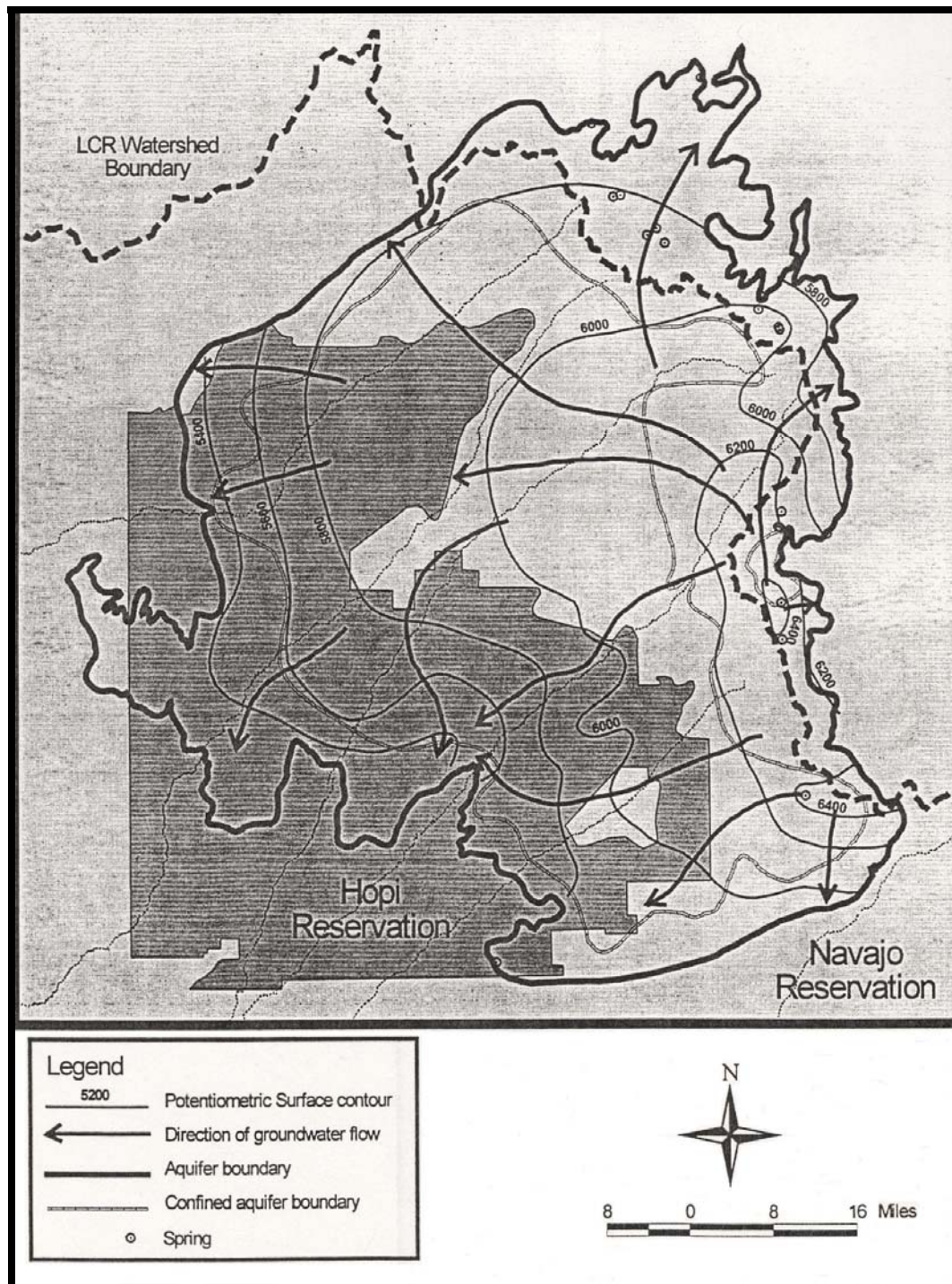


Figure 12. The Dakota aquifer.

### 2.3.4.3 *Navajo Aquifer*

The N-aquifer (Figure 13) extends over 4 million acres of the northern LCR Basin, underlying most of the Hopi Reservation and the northern part of the Navajo Reservation. The N-aquifer consists of the Navajo Sandstone, the Kayenta formation sandstones, and the Lukachukai member of the Wingate Sandstone. The N-aquifer is confined by the overlying Carmel Formation and has a storage capacity of 166 MAF and an average saturated thickness of 400 feet. It is over 1,200 feet thick in its northwestern extent, and gradually decreases until it disappears at its southeast boundary (Eychaner 1983).

Recharge for the N-aquifer is from precipitation on exposed aquifer units on Black Mesa, as well as from the Monument Upwarp to the north and the Echo Cliffs to the east. Some recharge also occurs from downward leakage from the D-aquifer. The N-aquifer discharges outside of the LCR Basin to the northeast and northwest. Within the basin, ground water from the N-aquifer discharges into Moenkopi Wash at springs along the aquifer boundary and into the alluvium of washes along the southern margin. There is little, if any, ground water interchange between the N-aquifer and the underlying C-aquifer because of 1,000 feet of essentially impermeable Chinle shale separating the two aquifers (ADWR 1989). The age of water in the N-aquifer was dated at 16,000-39,000 years old, and there is believed to be little annual recharge.

Water yields of wells in the N-aquifer are good, ranging from 25 to >500 gpm. The water quality is good to excellent, with TDS concentrations generally <500 mg/L and rarely >1,000 mg/L. Water from the N-aquifer is used for municipal, irrigation, domestic, and livestock purposes (ADWR 1989). Since 1965 Peabody Western Coal Company (PWCC) has been pumping water from the N-aquifer for its coal mining operation on Black Mesa. The Black Mesa mine supplies coal to the Mohave Generating Station (MGS) near Laughlin, Nevada. Electricity from this plant powers southern California, Las Vegas, and central Arizona. Most of the water is used to transport coal in a slurry line to the MGS. PWCC pumped an annual average of 3,543 AF between 1969 and 1993 (ADWR 1994e).



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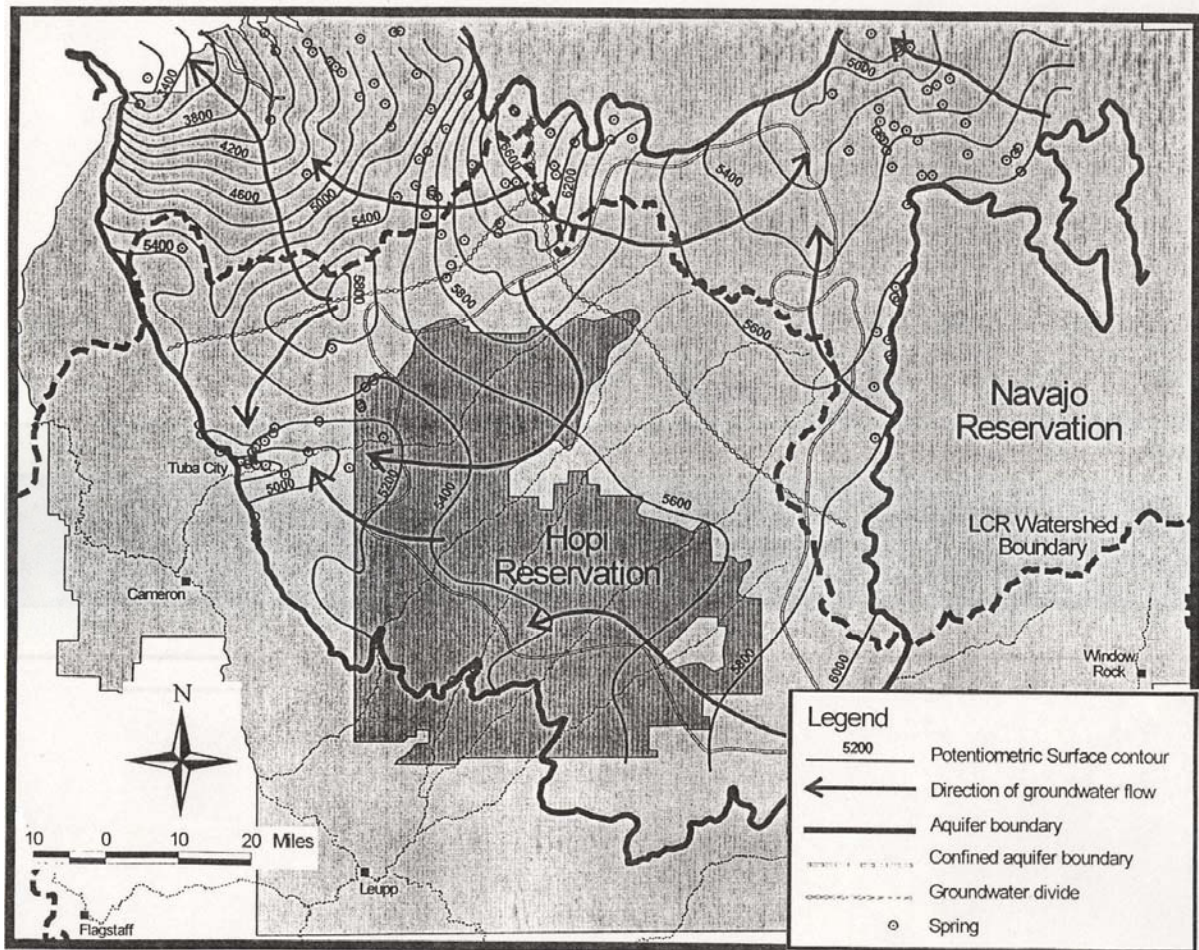


Figure 13. The Navajo aquifer.

The MGS began operation in 1970 and was suspended in December 2005 with the 35-year end of life for the slurry pipeline. In 2006, the Office of Surface Mining Reclamation and Enforcement (OSMRE) prepared an Environmental Impact Statement (EIS; U.S. Department of the Interior 2006) to analyze the effects of the Black Mesa Project. The Black Mesa Project consists of several proposed actions, including: (1) continue supplying coal from Black Mesa to the Navajo Generating Station near Page, Arizona, and (2) continue supplying coal from the Black Mesa mining operation to the Mohave Generating Station in Laughlin, Nevada. The project would consist of two pipelines, one is a 108-mile water-supply line from Leupp, Arizona to the Black Mesa to transfer water from the C-aquifer to the mining operation, and the second would be a 273-mile line to slurry coal from the mine to

## ***2.0 Physiography, Climate, and Hydrology***

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the MGS. C-aquifer water would be used to replace much of the water that has been used from the Navajo aquifer (N-aquifer) for those purposes. An estimated 3,700 AF/year of water from the C-aquifer would be needed for the Black Mesa Project. Also, the Hopi Tribe and Navajo Nation have proposed that the C-aquifer water-supply system could be expanded to provide an additional 5,600 AF/year of water for tribal domestic, municipal, industrial, and commercial uses. This proposal is not part of the Black Mesa Project EIS.

On May 18, 2007, OSMRE suspended work on the final EIS when Southern California Edison terminated funding of the EIS because it had not found new owners for the MGS. In 2007, PWCC, the sole supplier of coal to the MGS, notified OSMRE that the chances are remote for the MGS ever reopening. Therefore, the chances are unlikely that the Black Mesa Mine will resume coal production to feed the power plant. PWCC stated that it is also unlikely that the existing coal slurry preparation plant will be permitted, the coal-slurry pipeline will be rebuilt, and the new Coconino water-supply system will be built. At the time of the preparation of this document, the EIS was still under review (U.S. Department of the Interior 2008).

The N-aquifer was in equilibrium before 1965 when pumping by PWCC and increased municipal demand lowered the water table in the northeastern region of the LCR Basin (Eychaner 1983). Despite the projected N-aquifer potentiometric surface depressions and fluctuations, pumping from the aquifer has had little effect on streamflows in the critical habitat reach of the LCR. Since there is no substantial hydrologic connection between the C and N aquifers, water depletion from the N-aquifer is not likely to affect the C-aquifer and discharge from Blue Springs. Brown and Eychaner (1988) also showed that discharge to the Moenkopi Wash was not substantially affected by PWCC or municipal pumping. The estimated total annual ground water discharge to Moenkopi Wash of about 3,000 AF is small compared to the total annual discharge of 330,000 AF reaching the LCR mouth (Hopi Tribe 1995). Even if discharges to Moenkopi Wash were substantially affected by N-aquifer water use, the overall effect on surface flow in critical habitat would be small since much of the water in Moenkopi Wash is evapotranspired by phreatophytes and never reaches the LCR.

### 2.3.4.4 *Redwall-Muav Aquifer*

The R-aquifer underlies the C-aquifer in the LCR Basin (Figure 11). The Redwall and Muav Limestones are the principal water-bearing rock units of the R-aquifer. Because of the regional extent of these formations in northern Arizona, the Redwall and Muav Limestone has been defined as a multiple-aquifer system that is saturated to partly saturated and hydraulically connected Redwall, Temple Butte, and Muav Limestones (Cooley 1976). The static water level in wells developed in the R-aquifer is from one to several hundred feet above the top of the Redwall Limestone. It ranges from a few hundred feet to more than 2,900 feet below land surface. The Redwall Limestone is the upper rock unit of the R-aquifer and occurs throughout the LCR Basin. The formation crops out in steep canyons and escarpments in the northern, southern, and western parts of the basin at or near locations of ground-water discharge. The Redwall Limestone is variably saturated and in a few places along the south rim of Grand Canyon, it is partly saturated to unsaturated where ground water migrates into lower units of the aquifer (Bills et al. 2007).

The R-aquifer is confined throughout much of its occurrence by very fine-grained sediments in the overlying Lower Supai Formation and underlying Proterozoic granites and schists (Bills et al. 2007). All the ground water in the R-aquifer is the result of downward leakage from overlying units through faults, fractures, or other geologic structures, such as breccia pipes. Some leakage also occurs through the bottom of the R-aquifer to underlying basement rocks that are heavily eroded or fractured. Ground water in the R-aquifer flows northeastward toward discharge areas on the LCR at and below Blue Spring and westward and northwestward toward discharge areas along the south rim of Grand Canyon and in Havasu Creek. In the area west of Cameron, water from the C-aquifer is thought to move downward through faults and fractures in the Supai Formation into the R-aquifer before discharging at Blue Springs. Ground-water in the R-aquifer is estimated at 7,500-22,600 years old, and low tritium values indicate that this water is older than water discharging from the C-aquifer (Bills et al. 2007). Tritium and carbon-14 results indicate that ground water discharging at most springs and streams is a mixture of young and old ground waters, likely resulting from multiple flow paths and multiple recharge areas.

### **2.3.4.5 *Local Aquifers***

Local aquifers in the LCR Basin include the Alluvial, Bidahochi, Volcanic, and Cretaceous aquifers. These aquifers are used locally at various rates for domestic, stock, irrigation, and public supplies. The Alluvial aquifer is of relevance to flow in the LCR because it occurs along the LCR and its tributary streams and washes, except on the Mogollon Slope. It varies in extent, but may be up to 4 miles wide and up to 150 feet thick with wells that yield <5 to 1,500 gpm. The alluvium of this aquifer is a mixture of clays, gravels, and coarser materials. Streamflow infiltration, as well as discharge from the C-aquifer, contributes to recharge of this aquifer and determine water quality. Because it is partially recharged by surface water, the Alluvial aquifer is susceptible to pollution from human activity. In thicker sections the alluvium is a steady source of water, but small washes can go dry from overuse or drought.

## **3.0 LAND OWNERSHIP AND JURISDICTION**

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The LCR Basin is the second largest basin in Arizona with 27,000 square miles encompassing seven counties; several Native American Indian Reservations; and many local, state, and federal agency jurisdictions. Land ownership in the basin is 48% Indian Reservations, 23% private land ownership, 19% federal lands, and 10% State trust lands. Population of the watershed is about 300,000 people and growing rapidly. The following sections discuss the various entities within the LCR Basin with authority and jurisdiction over land and natural resource management. This includes five sovereign Native American groups, seven federal land management and regulatory agencies, and numerous state and municipal entities.

### **3.1 Native American Tribes**

#### **3.1.1 Navajo Nation**

The Navajo Reservation was established by treaty on June 1, 1868. The lands within the reservation were only a fraction of occupied and significant areas for the Navajo people. The original reservation of 3.5 million acres was modified 15 times between 1868 and 1955 to accommodate population and grazing expansion, including establishment of the western border of the reservation, which encompasses the LCR Gorge, by the Arizona Boundary Act of 1934. At present, the Navajo Reservation occupies an area of approximately 17.6 million acres within Coconino, Navajo, and Apache counties in Arizona; San Juan County in Utah; and San Juan and McKinley counties in New Mexico. Within the LCR Basin, the population centers are in Tuba City, Leupp, Cameron, Ganado, and Window Rock (ADWR 1994a). The Navajo Nation Reservation encompasses approximately 40% of the LCR watershed. Portions of Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Jadito Wash, Cottonwood Wash, Pueblo Colorado Wash, Leroux Wash, and the Puerco River drainages lie within the Navajo Reservation.

The boundary of the Navajo Reservation lies 0.25 miles north of the north bank of the LCR near the confluence of the LCR and Colorado River (Figure 9). It continues upstream

### ***3.0 Land Ownership and Jurisdiction***

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and parallel to the bank to a point approximately 2.5 miles from the confluence. At this point the western boundary of the Navajo Reservation lies on a line generally running north-south. The reservation shares a boundary with Grand Canyon National Park throughout this area. Hence, the upper 5.5 miles of humpback chub critical habitat is within the Navajo Reservation, and the lower 2.5 miles is within Grand Canyon National Park.

Navajo Nation agencies with land and wildlife management responsibilities are all under the Division of Natural Resources. These departments include Fish and Wildlife, Historic Preservation, Parks and Recreation, Water Resources Management, and Abandoned Mine Lands Reclamation (Navajo Nation 1993, 1994). The Fish and Wildlife Department is responsible for developing and recommending policies, rules and regulations, and management plans related to fish, wildlife, and native plant resources of the Navajo Nation. This includes hunting and fishing regulations and licensing, non-game wildlife, and research permitting. Any research being conducted on the reservation must be reviewed, approved, and permitted by the Department. Prospective researchers must submit an application to the Director of the Fish and Wildlife Department, outlining study plans, methods, locations, target species, and applicant qualifications and affiliations.

The Historic Preservation Department has authority over the protection of properties containing elements of Navajo traditional culture. This includes managing facilities and sites that contain cultural resources, as well as protection and interpretation of sacred sites and traditional cultural properties. The Historic Preservation Department is involved in planning processes which involve cultural resource compliance. The Parks and Recreation Department is responsible for recreational access and permitting on the reservation. This department oversees management of all Navajo Nation parks and monuments. This involves permitting of camping and recreational uses within any of these designated areas and enforcement of Fish and Wildlife Department regulations.

The Navajo Nation Department of Water Resources Management (NNWRM) is the lead agency for water management. The NNWRM has been established to protect water quantity and to some extent water quality, and manage the resource over a large area and for all beneficial uses, including drinking water. Wellhead protection can be an important component of the “Water Resource Development Strategy for the Navajo Nation”; serving as



### **3.0 Land Ownership and Jurisdiction**

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an initial starting point for implementation efforts. The NNWRM is also responsible for ground water rights, permitting well drillers, performing hydrologic studies on each ground water basin, recognizes the licensing of ground water/observation and monitoring well drillers and other programs relating to ground water management and protection. The NNWRM maintains an inventory of wells on the Navajo Nation including public and private water supplies along with livestock wells.

The Abandoned Mine Lands Reclamation Department identifies abandoned mines on the reservation and, together with the Environmental Protection Agency (EPA), evaluates potential health hazards and means of removing these hazards. This department also monitors water quality associated with abandoned mine and mill sites, and evaluates sources of potential contaminant spills or releases.

#### **3.1.2 Hopi Tribe**

The Hopi Reservation is located in the north-central portion of the LCR Basin (Figure 9). The original 2.5 million-acre reservation was established by President Chester Arthur through Executive Order on December 16, 1882. That order designated the Hopi Reservation for the Hopis and “...other such Indians as the Secretary of the Interior may see fit to settle thereon.” At present, the Hopi Reservation occupies 1,561,200 acres and encompasses a large portion of the drainages of Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Polacca Wash, and Jadito Wash. None of the mainstem LCR lies within the Hopi Reservation, yet the reservation lies entirely within the LCR Basin, and all of the streams and washes that cross the reservation originate on Black Mesa and are tributaries to the LCR (ADWR 1994a). As previously noted, the LCR Gorge is of major cultural significance to the Hopi people.

The Hopi Tribal government was organized under a constitution established in 1934. While the Tribal Council represents Hopi people in matters external to the tribe, Hopi villages maintain quasi-independence. Of the 12 villages, only 3 have adopted constitutions and established a western form of government. The remaining 9 villages vary in the degree to which they adhere to the traditional Hopi form of governance. Oraibi remains strictly traditional in its governing structure and does not accept funds or any other form of

### ***3.0 Land Ownership and Jurisdiction***

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assistance from the Tribal government. Other villages merge traditional with western governing policies by maintaining a village Kikmongwi (chief or leader) and by having representatives on the Tribal Council.

Today, the Hopi Tribal government is organized into several branches and departments to reflect the diversity of issues facing the Hopi People. The tribal government is organized as an Executive Branch, Legislative Branch, and Judicial Branch. The Executive Branch is made up of the departments of Administrative and Technical Services, Health and Human Services, and Natural Resources. The Department of Natural Resources includes the offices of Range Management, Cultural Preservation, Mining and Mineral Resources, Water Resources, and Hopi Lands. The Office of Range Management provides construction and maintenance activities for livestock producers and farmers across the Hopi Reservation. It is responsible for the equitable allocation of animal units for grazing purposes on Hopi rangeland. It is also responsible for monitoring and enforcement of the Grazing Ordinance. Other responsibilities include overseeing wildlife management programs such as golden eagle studies, woodlands management, wetlands rehabilitation and protection, pesticides research and management.

The Cultural Preservation Office represents the Hopi people's cultural interests both within and outside the Hopi Reservation. This responsibility requires the involvement and input of Hopi villages, clans, and religious societies as well as the Hopi tribal government. The Cultural Preservation Office is the central tribal clearinghouse for culturally related issues coming to the attention of the Hopi Tribe. The Office of Mining and Mineral Resources regulates and/or monitors energy and minerals development on Tribal lands and those lands where the Tribe has recognized ownership and management interests of subsurface resources. The Office of Water Resources functions as a policy recommending body and technical support program for the Hopi Tribe. The primary mission is to ensure that a safe, dependable, long-term water supply is available to the Hopi Tribe. The Office of Hopi Lands protects the rights and interests of the Hopi Tribe and the Hopi people on the Hopi Partitioned Lands, 1934 Hopi Partitioned Lands, and the newly acquired lands.

The Hopi Water Team was recently formed with the mission to “protect and advance the water rights of the Hopi Tribe.” The Water Team represents the Tribal Council in the

### ***3.0 Land Ownership and Jurisdiction***

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Little Colorado River Adjudication/Negotiations, and develops recommended strategy and settlement positions for the negotiations. The Water Team also recommends policy and ordinances designed to protect Hopi water rights and water quality. The major concern of the team is the adverse effects that the Peabody Western Coal Company is having on the N-aquifer. The slurry stage of processing the raw coal ore is a water intensive process. The only source of potable water for the Hopi Villages is the N-aquifer. The N-aquifer is the Navajo sandstone geological formation containing water that underlies the Hopi and Navajo Reservations. Of the five aquifers underlying the Hopi Reservation, only the N-aquifer has sufficient quality and accessibility to reliably supply drinking water. The Hopi Tribe has viewed pumping of water by Peabody Western Coal Company (PWCC) from the N-aquifer as detrimental to the aquifer and the Hopi water supply.

A proposal to construct a pipeline to supply water from Lake Powell is considered as an alternative water supply and critical to the Hopi people to: (1) ensure the future survival and prosperity of the homeland by securing an alternative source of water to replace the rapidly diminishing supply of ground water; (2) conserve the limited supply of ground water on the reservation through a management plan that will limit future Navajo and Hopi withdrawals from the N-aquifer; and (3) protect culturally significant springs, seeps and washes.

The N-aquifer is not fully recharged each year and it is in the heart of an arid area. Water use from the N-aquifer has increased because the Navajo/Hopi/Paiute populations are growing. According to the 1990 census, the combined Native American population living in the LCR Basin—Hopi, Navajo, and San Juan Paiute—was 68,750. This population has continued to increase, making the LCR Basin home to the largest concentrated Native American population in the country. There are also greater water demands because tribal standards of living have risen. All three tribes depend extensively on the N-aquifer to supply water for domestic use, irrigation, wetland habitats, and for wildlife and domestic animals.

Ground water use by the tribes and PWCC has increased steadily since 1985. It is increasingly clear that as tribal populations continue to grow, the N-aquifer will not be able to sustain water demands. As new housing is constructed and a higher standard of living is achieved, Indian water use will approximate average water consumption of non-Indian users

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in the area. Withdrawal of water from the N-aquifer is not likely to lessen in the future and the needs of growing populations make it inevitable that new sources of water must be found and existing supplies are wisely managed.

#### **3.1.3 Zuni Tribe**

The original Zuni Reservation was established by Executive Order in March of 1877. Between 1883 and 1900, the reservation was modified several times. The present Zuni Reservation is located in the eastern portion of the LCR Basin in western New Mexico (Figure 9). There is also a small in-holding of the Zuni Reservation on the LCR and Zuni River near Hunt, Arizona. The Zuni are thought to be direct descendants of the Anasazi, a large society that encompassed large amounts of land, riches, and many distinct cultures and civilizations over 1,000 years prior to the coming of the Europeans. The village of Zuni is the major population center within the reservation, and water withdrawals are minimal (ADWR 1994a). Zuni tribal agencies with wildlife and land management responsibilities include the Fish and Wildlife Service and the Conservation Project, both of which are under the Zuni Department of Natural Resources. The Zuni Tribe has no direct jurisdiction over the lower 8 miles of the LCR, which is the designated critical habitat for humpback chub.

#### **3.1.4 White Mountain Apache Tribe**

The White Mountain Apache Tribe is located in the east central region of Arizona, 194 miles northeast of Phoenix. Located in Apache, Gila, and Navajo counties, the nearly 12,000 members of the White Mountain Apache Indian Tribe reside on 1.6 million acres of ancestral homeland on the White Mountain Apache Reservation. Approximately 1,910 acres of the reservation along the northern boundary extends into the LCR Basin near Pinetop (ADWR 1994a). The Fort Apache Indian Reservation was established by Executive Order on November 9, 1891, but is now known as the White Mountain Apache Reservation.

The reservation originally included the San Carlos Apache Reservation but these were separated by an act of Congress in 1897. The original White Mountain Apache Reservation extended roughly from the Gila River to the Mogollon Rim, from Cherry Creek to the New Mexico border. The reservation is in the White Mountains, and is 75 miles long,

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45 miles wide. The Tonto National Forest, Sitgreaves National Forest, and Apache National Forest form the reservation's western, northern, and eastern boundaries. The reservation ranges from an elevation of 2,700 feet at the Salt River Canyon to 11,000 feet at Mount Baldy. The capital city of Whiteriver is the largest community with over 2,500 residents. Major industry consists of a timber mill and a re-manufacturing plant. The Wildlife and Outdoor Recreation Division of the White Mountain Apache agency has the primary recreation and wildlife management responsibilities. The White Mountain Apache Indian Tribe has no direct jurisdiction over the lower 8 miles of the LCR, which is the designated critical habitat for humpback chub.

#### **3.1.5 San Juan Southern Paiute Indian Tribe**

The San Juan Southern Paiute Indian Tribe is a newly recognized band of Southern Paiute Indians residing within the LCR Basin at Moenave on the western edge of the Kaibito Plateau west of Tuba City. At present, this band does not have a designated reservation, but resides within the Paiute/Navajo Joint Use Area. The process to establish a reservation for this band has been initiated (ADWR 1994a), and discussions between the San Juan Southern Paiute Indian Tribe and the Navajo Nation are on-going.

This is a small tribe of approximately 250 members. The San Juan Southern Paiutes have lived for several hundred years in territory east of the Grand Canyon, bounded by the San Juan and Colorado Rivers, with the Navajo and Hopi Tribes as their neighbors. They share a common heritage with the Southern Paiutes of northern Arizona, Utah, Nevada, and California, but retain their distinct language. Many San Juan Paiute tribal members live in communities on the Navajo Reservation, primarily in northern Arizona and southeastern Utah. The largest of these communities are at Willow Springs, near Tuba City, Arizona, and at Paiute Canyon/Navajo Mountain on the Arizona/Utah border. The Tribe is governed by a tribal assembly (*Shuupara'api*) which meets regularly and is drafting a constitution. Livestock grazing and subsistence farming are the tribe's economic mainstays. The tribe is also known for its hand-woven baskets which use designs that have been passed down for generations. The San Juan Southern Paiute Indian Tribe has no direct jurisdiction over the lower 8 miles of the LCR, which is the designated critical habitat for humpback chub.

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#### **3.1.6 Navajo - Hopi Land Dispute**

On-going negotiations and legal actions between the Navajo Nation and the Hopi Tribe concerning reservation boundaries could potentially affect jurisdiction and land ownership in the LCR Basin. The original Navajo and Hopi reservations were established in 1868 and 1882, respectively. The dispute between the Navajos and the Hopis is centered on conflicting claims to lands on Black Mesa, lands west of the current Hopi Reservation, and the LCR Gorge. In 1934, the Navajo Reservation was expanded to its current western boundary by an act of the U.S. Congress. The Hopi Tribe registered opposition to this action as they considered lands in this area to be appropriately within the Hopi Reservation, based on cultural and land use claims. The dispute continued, and in 1966 the Commissioner of Indian Affairs, Robert L. Bennett, implemented a policy suspending all housing construction, road and water development, and community medical clinics on lands west of the 1882 Hopi Reservation, which was occupied by Navajos and within Navajo Reservation boundaries at that time. The policy is referred to as the “Bennett Freeze.” The Bennett Freeze area included the Navajo Reservation within the LCR Basin west of Cameron (ADWR 1994a, 1994b).

In 1992, a Federal District Court awarded the Hopi Tribe exclusive ownership of 22,675 acres within the 1934 Navajo Reservation, and found 152,843 additional acres subject to partition. The District Court also lifted the Bennett Freeze (*Masayesva v. Zah*, 816 F. Supp. 1387 [S. Ariz. 1992]). The Ninth Circuit Court, in 1995, held that the District Court had no jurisdiction to lift the freeze and remanded the case to reassess the acreage determinations based on Hopi religious practices (*Masayesva v. Zah*, 65 F.3d 1445 [9th Cir. 1995]).

On Nov. 3, 2006, Interior Secretary Dirk Kempthorne, Navajo Nation President Joe Shirley Jr., and Hopi Vice Chairman Todd Honyaoma signed the Navajo-Hopi Intergovernmental Compact, lifting the 40-year-old Bennett Freeze. In September 2008, S. 531: A bill to repeal section 10(f) of Public Law 93-531, commonly known as the “Bennett Freeze” was passed by the U.S. Senate and a companion bill was expected before the House of Representatives at the time that this document was written.

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#### **3.1.7 Navajo - Peabody Western Coal Company Dispute**

In the 20<sup>th</sup> century, one of the richest deposits of high grade coal was discovered on the Black Mesa, a remote region of northern Arizona within the claimed traditional lands of the Navajo Nation. The Navajo people on the Black Mesa continue their traditional way of life on lands their families have lived on for thousands of years. On harsh lands deemed worthless to the rest of America, they were allowed to live unmolested carrying on their ancient societies based on dry-crop farming and sheep herding. But late in the twentieth century, these lands were discovered to hold the continent's richest supplies of mineral wealth. There is an estimated 20 billion tons of high grade, low-sulfur coal underlying the Black Mesa. Rich veins of the coal rest so near the surface that erosion has exposed them in many places.

The Navajo Nation has filed action against Peabody Western Coal Company and various Federal agencies claiming that the behavior of PWCC on Black Mesa, Arizona constitutes a violation of the human, civil and political rights of the Dineh (Navajo) people. The action questions: (1) whether the government of the United States is fulfilling its trust responsibility and duty to uphold and protect the human, civil and political rights, health, environment, safety and welfare of the Navajo people; (2) whether the government of the United States has the right to intervene on Indian lands to legislate relocation policies that negate property rights for Navajo people who have been living there before Europeans first came to this continent; and (3) whether the solarization of the Four Corners power plants and conversion of PWCC to large-scale solar operations can be implemented for the U.S. government to fulfill its obligation to the Navajo people.

The Department of the Interior, in partnership with utility companies and private parties, built the largest power plants in the U.S. in the four corners region (Four Corners Power Plant). Coal for the power plants is shipped through a slurry line that uses over 1.4 billion gallons of water each year pumped from the N-aquifer—the only source of potable water for the Hopi and much of the Navajo Reservations. Over 26 billion gallons of water had been pumped for this slurry line by the year 2000. Many springs and ground water sources have dried up and all but the deepest wells in the region have gone dry. It is estimated that several Hopi villages will soon run out of potable water at the present rate of

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usage. Coal mined from Black Mesa is used to generate and supply electricity for Las Vegas, southern California, and much of the southwest. Of the water wells that remain on Black Mesa, most have been fenced and capped due to either contamination or salt intrusion. People must haul water for themselves and their livestock from up to 40 miles each way on unmaintained and poorly graded dirt roads that are often impassable for weeks at a time.

On February 11, 1997, President Bill Clinton signed Executive Order 12898 on Environmental Justice. This Executive Order mandates all federal regulatory agencies to make environmental justice a priority and a part of their mission by identifying and addressing the effects of their respective programs, policies, and activities on minority and low-income communities. Executive Order 12898 further gives residents access to public information and the chance to take part in decisions about their environment and health. Executive Order 12898 encourages the application of existing civil rights and environmental statutes to promote environmental justice. Protection of the environment is a fundamental human right and civil right. The Black Mesa issue is the first case of environmental justice brought by Native people to the Executive Branch of the U.S. Government since President Clinton signed Executive Order 12898. Litigation and talks continue over this issue, and a resolution is likely to have significant impacts on water allocation and management in the LCR Basin.

On November 22, 2006, the Office of Surface Mining Reclamation and Enforcement (OSMRE) prepared an Environmental Impact Statement (EIS; U.S. Department of the Interior 2006) to analyze the effects of the Black Mesa Project. The Black Mesa Project consists of several proposed actions, including:

- Peabody Western Coal Company's proposed operation and reclamation plans for the Black Mesa and Kayenta coal mines.
- Black Mesa Pipeline's proposed operation and reclamation plan for the Coal Slurry Preparation Plant at the Black Mesa mine.
- The reconstruction of Black Mesa Pipelines 273-mile long Coal Slurry Pipeline across northern Arizona from the Coal Slurry Preparation Plant to the Mohave Generating Station in Laughlin, Nevada.
- The construction and operation of water wells in the Coconino aquifer northwest of



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Winslow, Arizona.

- The construction and operation of a water supply pipeline running about 108 miles across the Navajo and Hopi Reservations from the wells to the Coal Slurry Preparation Plant.

C-aquifer water would be used to replace much of the water that has been used from the Navajo aquifer (N-aquifer) for those purposes. An estimated 3,700 AF/year of water from the C-aquifer would be needed for the Black Mesa Project. Also, the Hopi Tribe and Navajo Nation have proposed that the C-aquifer water-supply system could be expanded to provide an additional 5,600 AF/year of water for tribal domestic, municipal, industrial, and commercial uses. This proposal is not part of the Black Mesa Project EIS.

On May 18, 2007, OSMRE suspended work on the final EIS when Southern California Edison terminated funding of the EIS because it had not found new owners for the MGS. In 2007, PWCC, the sole supplier of coal to the MGS, notified OSMRE that the chances are remote for the MGS ever reopening. Therefore, the chances are unlikely that the Black Mesa Mine will resume coal production to feed the power plant. PWCC stated that it is also unlikely that the existing coal slurry preparation plant will be permitted, the coal-slurry pipeline will be rebuilt, and the new Coconino water-supply system will be built. At the time of the preparation of this document, the EIS was still under review (U.S. Department of the Interior 2008).

### **3.2 Federal Agencies**

Only 19% of the LCR Basin is under federal jurisdiction. The majority of federal land in the basin is under the jurisdiction of the U.S. Forest Service and the Bureau of Land Management. A small area of the basin is under the authority of the National Park Service. Although the National Park Service, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, Bureau of Reclamation, and Natural Resources Conservation Service have little or no direct oversight of specific federal lands, these agencies have varying degrees of jurisdiction over resources within the LCR Basin.

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#### **3.2.1 Bureau of Reclamation**

The Bureau of Reclamation (Reclamation) was created by the Reclamation Act of 1902 to foster growth and development in the West. The agency is responsible for the reclamation of arid western lands through systems of irrigation works for the storage, diversion, and development of water. On the Colorado Plateau, Reclamation plays a large role in damming and diverting water from the Colorado River system to areas throughout the Southwest to provide for hydropower generation, irrigation, flood control, recreation, and municipal and industrial water resources. Reclamation is the agency that operates Glen Canyon Dam, which regulates the Colorado River through Grand Canyon.

Two of Reclamation's regions have responsibility in the LCR, including the Lower Colorado Region (Region 3) in Boulder City, Nevada and the Upper Colorado Region (Region 4) in Salt Lake City, Utah. Although the majority of the LCR Basin lies within the Lower Colorado Region, the Upper Colorado Region has the responsibility of managing Glen Canyon Dam, the largest reservoir in the Upper Colorado River Basin and the principle facility for water regulation between the upper and lower basins. The Lower Colorado Region serves as the "water master" for the last 688 miles of the Colorado River within the United States on behalf of the Secretary of the Interior. Reclamation manages the river and its reservoirs to meet water and power delivery obligations, protect endangered species and native habitat, enhance outdoor recreation opportunities, and provide flood control. The Lower Colorado Region covers an area of nearly 202,000 square miles, and encompasses parts of five states that contribute water to or draw water from the Colorado River: southern California; southern Nevada; the southwest corner of Utah; most of Arizona; and part of west-central New Mexico (<http://www.usbr.gov/lc/>).

The Upper Colorado Region includes the states of Utah, New Mexico, and Colorado west of the Continental Divide, southwest Wyoming, a small portion of Arizona, and a portion of Texas west of the Pecos River. The Upper Colorado Region manages water in the Colorado River upstream of Lees Ferry (legal dividing point between upper and lower basin). Reclamation manages the river and its reservoirs to meet water and power delivery obligations, protect endangered species and native habitat, enhance outdoor recreation opportunities, and provide flood control. The Upper Colorado Region also maintains,

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measures, and accounts for water use through the Aspinall Units (Blue Mesa and Crystal reservoirs), Flaming Gorge Reservoir, Fontenelle Reservoir, and Navajo Reservoir, as well as Elephant Butte Reservoir on the Rio Grande (<http://www.usbr.gov/uc/index.html>).

Although the LCR Basin is entirely within the Lower Colorado Region of Reclamation, the Upper Colorado Region's involvement is through the 1995 Biological Opinion on the operation of Glen Canyon Dam that requires Reclamation to be instrumental in developing a management plan for the LCR. The Upper Colorado Region has the lead on the operation of Glen Canyon Dam since the dam is upstream of Lees Ferry and therefore in that region's authority.

Reclamation has no current plans for projects within the LCR Basin and has not constructed or operated any facilities within the basin. Reclamation's role throughout its areas of authority has changed from involvement principally in dam and canal construction to assistance with water management at federal, state, and local levels. The Rural Water Supply Act of 2005 (S 895) establishes a rural water supply program within the Department of the Interior and authorizes Reclamation to develop programmatic criteria and guidelines giving Reclamation and rural communities a consistent and fair process for evaluating water supply needs and prospects in rural communities. Reclamation continues to support proper management of water supplies in the LCR Basin through this and other activities, including the development of watershed management plans for various parts of the basin. Reclamation provides financial assistance through grants to entities in the LCR Basin to insure proper management of water supplies.

#### **3.2.2 U.S. Fish and Wildlife Service**

The U.S. Fish and Wildlife Service is the principal Federal agency for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats for the continuing benefit of the American people. The Service manages the 93-million-acre National Wildlife Refuge System with more than 530 individual refuges, wetlands, and special management areas. The Service also operates 66 national fish hatcheries, 64 fishery resource offices, and 78 ecological services field stations. The Service enforces Federal wildlife protection laws, such as the Endangered Species Act, coordinates conservation efforts with State and local

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governments, and helps foreign governments with conservation efforts.

The LCR Basin lies within the authority of the Service's Southwest Region 2. Within this region, the Service owns, maintains, and operates three national fish hatcheries (Williams Creek, Alchesay, Willow Beach, all in Arizona) and one national fish hatchery and fisheries technical center (Dexter, New Mexico). The Williams Creek, Alchesay, and Willow Beach hatcheries are cold-water facilities that raise primarily salmonids for local distribution, including some tributaries of the LCR. Dexter National Fish Hatchery is designated primarily as a holding, culture, and rearing facility for threatened and endangered fishes, including many species from the Colorado River Basin.

The Service is one of two agencies (the other is the National Marine Fisheries Service) responsible for implementing and enforcing the Endangered Species Act of 1973, as amended (ESA; Public Law 97-304; 16 U.S.C. 1531 *et. seq.*). The Service has jurisdiction over non-anadromous and non-marine species. Under the ESA, the Service is authorized to list or delist species (Section 4); acquire property for protection of listed species (Section 5); develop cooperative agreements with other federal and state agencies for conservation of listed species (Section 6); initiate and conduct consultation with other federal agencies (Section 7); and grant take permits for listed species (Section 10). The Service is the agency that designated critical habitat for the humpback chub, and was ultimately responsible for developing and implementing the Humpback Chub Recovery Plan (U.S. Fish and Wildlife Service 1990) and the Humpback Chub Recovery Goals (U.S. Fish and Wildlife Service 2002). The Service is also the agency that enforces prohibitions against harassment, harm, pursuit, wounding, trapping, capturing, collection, or take of endangered species (Section 9). The scientific collection of any listed species must be reviewed, approved and permitted by the Service under the authority of 50 CFR § 17.22 and § 17.62.

Under Section 7 of the ESA, formal consultation with the Secretary of the Interior (through the Service) is required for any action authorized, funded, or carried out by any Federal agency. Following a biological assessment by the Federal agency, which addresses the likelihood of project effects on listed species, the Service issues a biological opinion that determines if the project is likely to jeopardize the continued existence of any threatened or endangered species, or result in destruction or adverse modification of critical habitat.

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Reasonable and prudent alternatives and/or conservation measures may be included in the opinion to reduce the likelihood of jeopardy.

Responsibility for conservation of the four endangered fishes of the Colorado River (i.e., Colorado pikeminnow, humpback chub, razorback sucker, and bonytail) is shared by two of the Service's regions. In Grand Canyon and the LCR, the Southwest Region 2 in Albuquerque, New Mexico has the lead on Section 7 consultations, while the Mountain-Prairie Region 6 in Denver, Colorado has the lead on recovery of the four species under Section 4. Region 2 issued the 1995 Final Biological Opinion on the Operation of Glen Canyon Dam and continues to monitor sufficient progress on the reasonable and prudent alternatives of that opinion through ongoing Section 7 consultation.

Region 6 issued recovery goals, as supplements to the recovery plans, through a Notice of Availability in the Federal Register on August 1, 2002 (U.S. Fish and Wildlife Service 2002). These goals identify site-specific management actions and objective, measurable criteria for recovering the four fish species throughout the Colorado River Basin. Site-specific management actions for the humpback chub in the mainstem Colorado River and LCR in Grand Canyon include: (1) investigate the role of the mainstem in maintaining the population, (2) provide flows necessary for all life stages, (3) investigate options and effects of warming mainstem temperatures, (4) protect the population from overutilization, (5) control Asian tapeworm, (6) regulate release and escapement of nonnative fishes, (7) control problematic nonnative fishes, (8) legally protect habitat, (9) provide for long-term management and protection of the population and its habitat, and (10) minimize risk of hazardous-materials spills in critical habitat. These actions must be implemented and achieved before the humpback chub can be delisted.

The Humpback Chub Recovery Goals (U.S. Fish and Wildlife Service 2002) contain all of the elements of the reasonable and prudent alternative (RPA) of the 1995 Final Biological Opinion. Site-specific management actions for the lower basin recovery unit of humpback chub include: (A-1) *“Investigate the role of mainstem Colorado River in maintaining the Grand Canyon humpback chub population and provide appropriate habitats in the mainstem, as necessary for recovery”*, and (A-2) *“Provide flows necessary for all life stages of humpback chub to support a recovered Grand Canyon population, based on*

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*demographic criteria.*” These management actions are consistent with element 1 of the RPA, which states that “*Attainment of riverine conditions that support all life stages of endangered and native fish species is essential to the Colorado River ecosystem.*” and element 1A, which identifies “*A program of experimental flows to benefit the endangered and native fishes through Grand Canyon.*” The Recovery Goals recognize that a number of actions may be implemented through adaptive management to achieve the flows necessary for all life stages, and do not specifically identify actions such as the low steady summer flow identified in the RPA.

Management Action A-3 of the Recovery Goals for the lower basin recovery unit of humpback chub also identifies the need to: “*Investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon that would allow for range expansion of the Grand Canyon humpback chub population and provide appropriate water temperatures, if determined feasible and necessary for recovery*”. This management action is consistent with elements 1B, 1C, and 4 of the RPA. Element 1B states that: “*Reclamation shall implement a selective withdrawal program for Lake Powell waters and determine feasibility...*” Element 1C requires Reclamation to: “*Determine responses of native fishes in Grand Canyon to various temperature regimes and river flows of the experimental flows and other operations of Glen Canyon Dam.*” These actions of the Recovery Goals and the RPA call for investigation of warmed releases into the Colorado River through Grand Canyon as a way to benefit endangered and native fishes. Element 4 of the RPA requires that Reclamation “*Establish a second spawning aggregation of humpback chub downstream of Glen Canyon Dam*”. The last part of Management Action A-3 of the Recovery Goals allows for range expansion of the Grand Canyon humpback chub population from appropriate water temperatures, if determined feasible and necessary for recovery of the species. This approach for establishing a second population is consistent with the metapopulation concept of mainstem expansion, as identified by Valdez et al. (2000).

Management Action A-2 of the Recovery Goals for the lower basin recovery unit of humpback chub provides flows and protection of habitat necessary for all life stages of humpback chub in Grand Canyon, and Task A-2.2 of that action identifies the need to: “*Identify, implement, evaluate, and revise (as necessary through adaptive management) a*

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*flow regime in the Little Colorado River to benefit humpback chub*". This action is consistent with element 2 of the RPA, which requires that Reclamation: "*Protect humpback chub spawning population and habitat in the LCR by being instrumental in developing a management plan for this river*". The Recovery Goals recognize that other options may be available to protect habitat and flows in the LCR, and do not specifically identify the need for an LCR management plan.

#### **3.2.3 National Park Service**

The general authority and jurisdiction of the National Park Service (NPS) was established under the Organic Act of 1916. This act mandates the NPS to "*...promote and regulate the use of the Federal areas known as national parks, monuments, and reservations ... for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*" (National Park Service Organic Act, 16 USC 1). There are several units of the NPS within the LCR Basin: Grand Canyon National Park (GCNP); Petrified Forest National Park, which straddles the eastern Navajo County border and the Puerco River; Waputki National Monument, which lies between the San Francisco Peaks and the LCR; Walnut Canyon National Monument southeast of Flagstaff; Sunset Crater National Monument northeast of Flagstaff; and Hubbell Trading Post National Historic Site southwest of Ganado. The boundary of GCNP encompasses the lower 2.5 miles of the LCR critical habitat reach. Petrified Forest National Park, Waputki National Monument, and Walnut Canyon National Monument are all located above this reach.

GCNP shares a common boundary with the Navajo Nation. The location of the boundary between the park and the reservation has been described previously under the Navajo Nation discussion. The eastern boundary of the GCNP, south of the confluence of the LCR and the Colorado River mainstem, is a line generally running north and south. North of the confluence, the boundary lies 0.25 miles east of the east bank of the Colorado River (National Park Service 1969).

A General Management Plan (GMP) for GCNP guides the management of resources, visitor use, and general development at the park over a 10-to 15-year period. The NPS formally revised the 1977 GMP and adopted a new GMP for GCNP in August 1995 (U.S.

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Department of the Interior 1995). This revised GMP identifies objectives which affect humpback chub conservation and activities in the critical habitat reach of the LCR, and include the following (National Park Service 1995a):

- Preserve, protect, and interpret the park's natural and scenic resources and values, and its ecological processes.
- Manage visitor use, development, and support services to protect the park's resources and values.
- Preserve and protect the genetic integrity and species composition within the park, consistent with natural ecosystem processes.
- To the maximum extent possible, restore altered ecosystems to their natural conditions. In managing naturalized ecosystems, ensure the preservation of native components through the active management of nonnative components and processes.
- Manage ecosystems to preserve critical processes and linkages that ensure the preservation of rare, endemic, and specially protected (threatened/endangered) plant and animal species.
- Preserve natural spring and stream flows and water quality. Withdraw only the minimum water necessary to meet park purposes. To the maximum extent feasible, strive to meet increases in water demand by conserving and reusing water.
- Provide opportunities for scientific study and research focused on Grand Canyon, consistent with resource protection and park purposes.
- Inventory, monitor, and maintain data on park natural and cultural resources and values, and utilize this information in the most effective ways possible to facilitate park management decisions to better preserve the park.
- Manage the Colorado River and its tributaries that meet the criteria for wild designation under the federal Wild and Scenic Rivers Act as a wild river. Actively pursue designation of these waters as part of the national wild and scenic rivers system.

The Colorado River Management Plan (CRMP) addresses management of recreational activities within the Colorado River corridor of GCNP and strategies for minimizing environmental impacts associated with these activities. The purpose of the plan



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is to supplement existing management guidelines and directives, such as those established in the GMP. The following river access and use regulations established in Commercial Operating Requirements of the CRMP are directly relevant to the protection, conservation, and management of the humpback chub and its critical habitat:

#### IV. Environmental Protection and Sanitation

- *“Cans, rubbish, and other refuse may not be discarded in the water or along the shore of the river, in canyons, trails, escape routes, or any other portions of the canyon ... Liquid garbage will be strained through a fine mesh screen into the river ...”*
- *“The use of soap is restricted to the mainstream of the Colorado River only. Use of soap in side streams or within 100 yards of the confluence of any side stream and the main river is prohibited.”*

#### V. Restricted Areas

- *“Little Colorado River confluence - no camping from Mile 60.5 to Mile 65.0 on the southeast (left) side of the Colorado River.”*

#### XV. Backcountry or Off-River Camping

- *“Permits and/or reservations are necessary for off-river camping in all areas of Grand Canyon National Park.”*

These regulations are repeated in Noncommercial Operating Requirements of the CRMP, where it is additionally stated that noncommercial kayaking trips must obtain a permit from the Navajo Tribe to traverse tribal lands (National Park Service 1989).

Research, monitoring and other studies conducted within the GCNP are managed through a permitting process, established in 36 CFR 2.5b, that assures that study projects meet the highest standards of scientific method and avoid unnecessary impact to the resource base and visitor enjoyment of the park (National Park Service 1995b). Applications for

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research activities within GCNP are peer-reviewed before being authorized or permitted. Research, monitoring, and collecting activities require one or more permits listed below and associated information unique to that permit (National Park Service 1995b):

- Research/Study Permit - Required for all natural, cultural, and social science monitoring and research projects within the GCNP. A formal proposal must be prepared and submitted as part of the permit application process.
- Collection Authorization - Required for all monitoring and research activities that necessitate collection of natural resource specimens. Collection includes the temporary capture, trapping or netting of fauna for the purpose of measuring, tagging, etc. The collection authorization is part of the research permit.
- Antiquities Permit - Required for research involving cultural resources.

Besides the identified existing management guidelines, directives, and regulations, a number of NPS proposals could directly affect the critical habitat reach, including efforts toward achieving a Wild and Scenic designation for the Colorado River. As an initial step in this process, the NPS is conducting a Wild and Scenic Rivers Suitability Study. If the Colorado River through the Grand Canyon were designated as a Wild and Scenic River, this would imply “...an adequate quantity of water, of acceptable quality, necessary to accomplish the purpose of preserving the free-flowing conditions of a designated river.” In general, the designation would mean long-term protection for the Colorado River in the Grand Canyon and its tributaries. The 2.5 miles of the LCR within GCNP is included for consideration (National Park Service 1994).

In addition, particular proposals addressing interagency resource management planning would have an affect on management of the critical habitat reach. The following are a number of such proposals (Navajo Nation 1995):

- GCNP is presently working on a new back country management plan.
- GCNP is involved in on-going discussions and negotiations with the Navajo Nation concerning boundary issues of concern for both entities.
- GCNP recognizes the fact that park visitors are impacting Navajo lands when

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accessing the park and plans to specifically assess the impacts of such access points.

#### **3.2.4 Bureau of Indian Affairs**

The Bureau of Indian Affairs (BIA) has administrative responsibility for coordinating governmental activities of Indian tribes. The agency serves as a liaison between tribal governments and the federal government, and Federal funding for tribal agencies is often administered by the BIA.

#### **3.2.5 Bureau of Land Management**

The Bureau of Land Management (BLM) is responsible for management of many Federal lands, especially in the western United States. BLM has several dispersed allotments within the LCR Basin. Like the U.S. Forest Service, the BLM manages its Resource Management Areas for multiple uses, including recreation, mining, grazing, and logging. Within the LCR Basin, the primary use on BLM lands is grazing, which has minimal direct impact on water quantity within the critical habitat reach.

#### **3.2.6 U.S. Department of Agriculture**

The Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture is an active participant in watershed planning and conservation in the LCR Basin. Under the Watershed and Flood Prevention Act, P.L. 83-566, of August 4, 1954 (16 U.S.C. 1001-1008), the Secretary of Agriculture is authorized to cooperate with States and local agencies in the planning and carrying out of programs for soil conservation, and for other purposes, and assist Federal, State, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, and sediment, and to conserve and develop water and land resources.

Resource concerns addressed by the NRCS include water quality, opportunities for water conservation, wetlands and water storage capacity, agricultural drought problems, rural development, municipal and industrial water needs, upstream flood damages, and water needs for fish, wildlife, and forest-based industries. This legislation enables stakeholders to

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focus on a watershed scale with surveys and plans that include watershed plans, river basin surveys and studies, flood hazard analyses, and floodplain management assistance. The focus of these plans is to identify solutions that use land treatment and nonstructural measures to solve resource problems.

Several programs of the NRCS support a variety of resources on a watershed scale, including the Small Watershed Program of Watersheds Operations. The Watershed Program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres. Both technical and financial assistance are available.

Under Section 3 of the Watershed and Flood Prevention Act, the Secretary of Agriculture is authorized to assist local organizations in preparing and carrying out plans for works of watershed improvement to:

- conduct such investigations and surveys as may be necessary to prepare plans for works of improvement;
- prepare plans and estimates required for adequate engineering evaluation;
- make allocations of costs to the various purposes to show the basis of such allocations; and to determine whether benefits exceed costs;
- cooperate and enter into agreements with and to furnish financial and other assistance to local organizations;
- obtain the cooperation and assistance of other Federal agencies in carrying out the purposes of this section; and
- enter into agreements with landowners, operators, and occupiers.

Section 3 of Public Law 83-566 provides for assisting sponsoring local organizations to develop a plan on watersheds not exceeding 250,000 acres. During planning, problems such as water quality, flooding, water and land management, and sedimentation are evaluated and works of improvement are proposed to alleviate problems. The resulting watershed plans

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estimate benefits, costs, cost-sharing rates, and arrange for operation and maintenance necessary to justify Federal assistance to install works of improvement. The Secretary shall require that project sponsors of watershed projects provide up to 50% of the cost of acquiring easements under subsection (1) of the legislation.

Section 6 of Public Law 83-566 provides for cooperation with other Federal and with States and local agencies to make investigations and surveys of the watersheds of rivers and other waterways as a basis for the development of coordinated programs. In areas where the programs of the Secretary of Agriculture may affect public or other lands under the jurisdiction of the Secretary of the Interior, the Secretary of the Interior is authorized to cooperate with the Secretary of Agriculture in the planning and development of works or programs for such lands. Reports of the investigations and surveys serve as guides for the development of water, land, and related resources in agricultural, rural, and urban areas within upstream watershed settings. They also serve as a basis for coordination with major river systems and other phases of water resource management and development.

#### **3.2.7 U.S. Forest Service**

The U.S. Forest Service is responsible for managing designated National Forest lands and multiple resource uses undertaken within these lands, including recreation, timber harvest, mining, and grazing. The three National Forests within the LCR Basin include the Kaibab National Forest, north of Flagstaff, Arizona; the Coconino National Forest, southeast of Flagstaff; and the Apache-Sitgreaves National Forest, which lies along the Mogollon Rim on the southern fringe of the basin. None of these National Forests have authority within the critical habitat reach of the LCR. Although there are activities or projects operating within the National Forests, such as mining, logging, or grazing that could potentially impact the quantity or quality of water of the LCR, none of these projects are extensive enough to represent substantial threats.

## **3.3 State Agencies**

### **3.3.1 Arizona Game and Fish Department**

Arizona Game and Fish Department (AGFD) has authority over hunting and fishing regulations and management, as well as over the scientific collection of any wildlife species in the state of Arizona, excluding animals on Native American tribal lands. AGFD also has authority over regulation of the sale, transport, and use of baitfish to minimize introductions of nonnative fish species. AGFD is also the lead state agency for stocking of nonnative sports fish in the State of Arizona. Any scientific collection to be conducted in the state for any species, including threatened and endangered species, requires a permit from AGFD. All applicants must submit a scientific collection permit form with a detailed description of the purpose, methods, completion schedule, and publication intentions.

AGFD is currently trying to reduce numbers of competing and predaceous nonnative fishes in the Colorado River through Grand Canyon by removing harvest limits on all nonnative game fishes. Several nonnative fishes, including rainbow trout, brown trout, channel catfish, and striped bass have been found to prey on humpback chub. In October 1997, AGFD implemented an unlimited harvest regulation of trout, striped bass, and channel catfish on 270 miles of the Colorado River, from the Paria River to the Lake Mead inflow. The majority of this reach of river is designated critical habitat for humpback chub (Nautiloid Canyon to Granite Park) and razorback sucker (Paria River to Hoover Dam). All fish caught by angling in this area must be kept. *“The overall result of these proposals is for the waters designated as critical habitat for threatened and endangered species to be principally managed for the native fish...”* (AGFD, Unpublished News Release, September 9, 1997).

### **3.3.2 New Mexico Department of Game and Fish**

New Mexico Department of Game and Fish (NMDGF) has authority over hunting and fishing regulations and management, as well as over the scientific collection of any wildlife species, in the state of New Mexico, except on lands within Indian reservations. Although LCR tributaries exist in New Mexico, there is no portion of the humpback chub range that extends east of Arizona. For this reason, NMDGF has little authority over any actions that could significantly impact the humpback chub in Grand Canyon.

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#### **3.3.3 Local Jurisdictions**

The states of Arizona and New Mexico each have a number of agencies that have some degree of jurisdiction within the LCR Basin. Beyond the game and fish departments, each state has a parks and recreation department, a water resources department, a state historic preservation office, and a natural heritage program. Arizona is the only state that encompasses areas of the critical habitat reach, and AGFD, as previously discussed, is the primary state agency involved with fisheries resources.

The following counties have various authorities which indirectly affect the humpback chub by defining and regulating land use within the LCR Basin:

- Coconino County, Arizona, encompasses the western portion of the LCR Basin, including the critical habitat reach, to a point within 5 miles of Winslow. Major population centers within Coconino County include Flagstaff, Cameron, Tuba City, and Leupp. One of the Phelps Dodge Trans-Basin Diversion projects, to be addressed in the following discussion of land uses, is located within this county.
- Navajo County, Arizona, is a narrow county encompassing the LCR Basin between Winslow and Petrified Forest National Park. The major Navajo County population centers within the basin include Oraibi, Kykotsmobi, Second Mesa, Polacca Keams Canyon, Winslow, Joseph City, Holbrook, Woodruff, Snowflake, Show Low, and Pinetop-Lakeside. The Peabody Western Coal Mine, Cholla Generating Station, Stone Container Field, and one of the Phelps Dodge Trans-Basin Diversion projects, to be addressed in the following discussion of land uses, are located within this county.
- Apache County, Arizona, is another narrow county and encompasses the LCR Basin from the common border with Navajo County to the eastern Arizona state line. The major Apache County population centers within the basin include Adamana, Ganado, Fort Defiance, Window Rock, Chambers, Sanders, Louck, Lupton, St. Johns, Concho, Springerville, and Greer. The Springerville Generating Station and Coronado

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Generating Station, to be addressed in the following discussion of land uses, are both located within this county.

- McKinley County, New Mexico, encompasses the northern portion of the LCR Basin within New Mexico. The major McKinley County population centers within the basin include Gamerco, Rehoboth, Gallup, Fort Wingate, Page, Zuni, and Ramah.
- Cibola County, New Mexico, encompasses the central portion of the LCR Basin within New Mexico to a point approximately 10 miles south of Fence Lake. The major Cibola County population centers within the basin include Fence Lake and Quemado.
- Catron County, New Mexico, extends south of Cibola County to encompass the southern portion of the LCR Basin within New Mexico. There are no Catron County population centers of note within the basin.

## **3.4 Non-Governmental Organizations**

### **3.4.1 Little Colorado RC&D**

The Little Colorado River Plateau Resource Conservation and Development Area, Inc. (Little Colorado RC&D) is organized as a non-profit 501(c)(3) corporation in Arizona. The Little Colorado RC&D is headed by a Board of Directors and serves as a forum to address local issues, coordinate technical and financial assistance programs, and bring together diverse stakeholders for the planning and development of natural resources. The Little Colorado River Watershed Coordinating Council is the coordinating body of the Little Colorado RC&D and works with the assistance of local, state, and federal agencies, and other organizations. The Little Colorado RC&D service area includes Southern Navajo and Apache counties.

The Little Colorado RC&D was organized in 1971 to address the conservation and development of natural resources in the LCR Basin. During the early years emphasis was



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placed on water resources and soil erosion projects. More recently, the Council has placed a higher priority on community and rural economic development with sustainable natural resource based industry. The mission of the Little Colorado RC&D is to support partnerships providing leadership in natural resource conservation and development within east-central Arizona communities. One of the most important services is to provide assistance to grassroots organizations, fully evaluate a problem or situation, and advise the local people where they can go for help with their specific problems and key issues.

Funding for the Little Colorado RC&D comes from three sources: (1) fifteen sponsors and other organizations contribute annual dues; (2) projects are funded through grants from state, federal and private foundations; and (3) individual and business contributions are accepted. Sponsors include Apache County, Navajo County, Eagar Town Council, Holbrook City Council, Pinetop/Lakeside Town Council, St. Johns Town Council, Show Low City Council, Snowflake Town Council, Springerville Town Council, Taylor Town Council, Winslow City Council, Apache & Navajo Natural Resource Conservation District, Hopi Tribal Council, Northern Arizona Council of Governments, Northland Pioneer College, The Stockmen's Bank, Western Moulding, Navopache Electric, and Salt River Project.

The Little Colorado RC&D and the Little Colorado River Watershed Coordinating Council have helped to organize a number of plans and partnerships that more specifically address issues at local levels. Among these are the Little Colorado River Watershed Project, the Little Colorado River Multi-Objective Management Plan, the Upper Little Colorado River Watershed Partnership, the Show Low Creek Watershed Enhancement Partnership, and the Northern Arizona Sustainable Forest Partnership. The Little Colorado RC&D and the Little Colorado River Watershed Coordinating Council also assist in the development of watershed plans, including the Upper Little Colorado River Watershed Plan, the NEMO Watershed-Based Plan, the Natural Resources and Conservation Service (NRCS) Rapid Watershed Assessment, and Reclamation's Watershed Management Plan.

The Little Colorado River Watershed Project is a community based watershed organization under the umbrella of the Little Colorado RC&D that serves the Little Colorado River communities in Arizona and New Mexico. The mission of the Little Colorado River Watershed Project is to maintain and enhance the resources of the Little Colorado River

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Watershed by fostering partnerships, education and communication among stakeholders and by facilitating local strategies and projects in support of the vision statement.

The Little Colorado River Multi-Objective Management (LCR-MOM) Program is under the umbrella of the Little Colorado RC&D and provides interaction, coordination, and liaison among all stakeholders in the Little Colorado River Watershed. It is made up of individuals, businesses, organizations, and government agencies. The LCR-MOM meets bi-monthly in different areas of the watershed to enable all citizens to take part. Altogether, the LCR-MOM consists of 10 local counties, municipalities, and water and development districts; one Native American Group (Navajo Nation); five Arizona State agencies; nine federal agencies (including Army Corps of Engineers, NPS, BLM, the Service, U.S. Forest Service); and the Northern Arizona Council of Governments.

The LCR-MOM came into existence because of erosion, silt deposit and increased risk of flooding in the LCR. The LCR-MOM covers over 26,000 square miles in northeast Arizona and northwest New Mexico, and is bounded by the basins of the Rio Grande, the Gila, the Salt, the San Juan, and the Colorado rivers. Nearly half the land in the LCR Basin is Native American Tribal Lands. The remainder is divided into public and private portions; about 23% of the total area is private. Most of the basin is rural, with major cities including Flagstaff, Arizona in the west and Gallup, New Mexico in the east. Economic activities include ranching, timber harvest, agriculture, mining, power generation, service industries, cultural preservation, tourism, and recreation.

The LCR-MOM began in 1996 with a concern over sediment deposition in the LCR in the Holbrook, Arizona area and the potential for increased risks of flooding. It was quickly realized that other issues were involved at a much larger scale and that there was a need to pursue a watershed approach. In response, Navajo County initiated an effort by responding to the Army Corps of Engineers' Task Force Based Floodplain Management Planning Assistance Program. Assisted by State and Federal agencies, Navajo County also sponsored a two-day workshop focusing on current watershed management practices and the potential benefits of a multi-objective management watershed process. This process simultaneously addressed social, economic and environmental concerns affecting the people and resources of the watershed and was initiated through a series of workshops.

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The Little Colorado RC&D administers this program (LCR-MOM) and is assisted by the Navajo (AZ) and San Francisco (NM) Soil and Water Conservation Districts. It receives financial support from the federal government, State of Arizona, Counties of Navajo and Apache and Hopi Tribe. Partner organizations in state government include the Department of Game and Fish, Department of Environmental Quality, Department of Water Resources, Navajo Nation Water Resources Department and Zuni Pueblo. Federal support comes from the U.S. Army Corps of Engineers, EPA, USDA Forest Service, USDA Natural Resources Conservation Service, National Park Service and Bureau of Reclamation.

Cooperation between the watershed partnership and the U.S. Army Corps of Engineers resulted in broadening the scope of a Reconnaissance Study, and the Bureau of Reclamation has begun a Data Inventory and Needs Assessment study. The National Park Service Rivers and Trails Program provided leadership in developing strategies to meet with watershed stakeholders in focus group workshops to define problems, opportunities and concerns in the watershed. Over 25 issues were identified by stakeholders that address all eight partnership watershed goals. The focus group workshops also identified potential strategies, partners and priority actions.

The LCR-MOM organizational structure is made up of four parts. Program Coordinating Team, Coordinating Committee, Action Committees, and Little Colorado RC&D. Participation and membership in the Program Coordinating Team (PCT) are voluntary and open to all interested parties. The role of the PCT is to facilitate interaction among government, tribal, private business, and special interest groups. The program has a Watershed Coordinator that organizes meetings, coordinates activities, and acts as a liaison among the various programs of the Little Colorado RC&D.

There are five Action Committees of the PCT, including:

- § Data Inventory – collection of information and identification of data needs.
- § Education & Stakeholder Outreach – creation and distribution of information on watershed projects process and topics to increase stakeholder participation.
- § Process/Funding – identifies and incorporates watershed process and potential

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resource support.

- § Projects – facilitates implementation of new and existing projects.
- § Coordinating Committee – meets to set up agendas and problem solving between PCT meetings.

The Little Colorado River Watershed Project Action Plan outlines the vision, mission, and goals of the LCR-MOM). Through a planning effort of stakeholders, the LCR-MOM has identified 12 major interrelated goals intended to help achieve the overall vision for the LCR Watershed.

The vision of the Little Colorado River Watershed Project is:

*“To maintain and enhance the quality of life in the Little Colorado River Watershed through management of natural resources that ensures equity among shared interests, respects diverse cultural values and preserves environmental health of our land, while promoting appropriate economic growth of financial security of present and future generations.”*

The mission of the Little Colorado River Watershed Project is:

*“To maintain and enhance the resources of the Little Colorado River Watershed by fostering partnerships, education and communication among stakeholders and by facilitating local strategies and projects in support of the vision statement.”*

The 12 major goals of the LCR-MOM are:

Goal 1: Broaden people's knowledge of and involvement in the LCR-MOM planning process. Multi-objective management and watershed planning are new concepts to some. Critical to the success of a community driven planning process is stakeholder understanding and support of the effort. Stakeholders can be defined as anyone who can affect or be affected by planning decisions. Through a consensus based philosophy, everyone is provided opportunities to participate in decision making. This goal reflects the desire to inform, receive input from, and include all people who have an interest or stake in the health and

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future of the Little Colorado River Watershed.

Goal 2: Improve information and technology transfer on the resources of the Little Colorado River Watershed. Studies are useless if unknown to those who could use the information. Dozens of federal, state, tribal, and local agencies manage elaborate databases on natural resources, recreational opportunities, socio-economics and others. Ideally, this information would be shared and made available through a central clearinghouse. One proposed action is to develop a comprehensive Internet web page. This goal addresses the need to get meaningful information out to people making resource management decisions that affect the health of the watershed.

Goal 3: Sustain economic growth of the natural resources industry within the Little Colorado River Watershed. Success breeds success. Sharing information about economic successes and available assistance helps everyone. The LCR-MOM will work with industry to explore innovative ways of providing employment, while at the same time conserving the watershed's natural resources. This goal emphasizes the benefits of fostering economic development activities which are consistent with protecting and improving the health of the Little Colorado River Watershed.

Goal 4: Enhance the quality of life within the Little Colorado River Watershed. The Little Colorado River Watershed offers a mixture of ecosystem types, from mountains to desert, as well as diverse cultures, and recreational and tourism opportunities. Communities are encouraged to recognize the "values and assets" that make them unique and work to preserve them. Community values may include access to national forests for recreation and fuel wood, small town character, inexpensive cost of living, history and culture, trails and greenways, open space, scenic vistas, and clean industry. This goal provides the opportunity to include proposed actions that are expected to enhance the quality of life, but do not naturally fall under one of the other goal categories.

Goal 5: Reduce risk and economic impacts from floods and other natural disasters within the Little Colorado River Watershed. Flood disasters, though infrequent, can be devastating to small communities. County floodplain managers realize structural controls, such as levees, are only part of the flood mitigation strategy. Improved land use practices

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help to reduce stream sediment loading and flash flooding. Communities are encouraged to continue identifying flood-prone areas and restricting new developments in floodplains. Wildfires are another natural event that can be managed to restore forest health. This goal stresses the importance of taking actions to minimize the potential for loss of life and damage to property from natural disaster.

Goal 6: Increase the proper functioning characteristics of the Little Colorado River system. Man has caused immense change to the LCR and its tributaries. Channelization, diversions, introduction of invasive plant species, and loss of streamside habitat have altered stream function and the capability to effectively transport sediment to the Colorado River. The LCR-MOM will facilitate local strategies and projects that restore stream form and function. This goal addresses the need to work toward restoration of the river system.

Goal 7: Enhance recreational opportunities within the Little Colorado River Watershed. Recreational opportunities are as varied as the topography. Marketing outdoor recreational opportunities would generate increased economic activity as tourists visit more often and stay for longer periods of time. Providing local trail networks with linkages to public lands and river corridors would offer residents and visitors increased opportunities to enjoy the watershed. This goal encourages the consideration of recreation enhancements in the Little Colorado River Watershed.

Goal 8: Preserve the cultural heritage of the Little Colorado River Watershed. Only through a greater understanding and appreciation for the varied cultural heritage within the watershed can we hope to enjoy and preserve this heritage. One of the most important roles the LCR-MOM plan is to educate the watershed community on the unique cultural heritage of the Little Colorado River Watershed and the importance of assuring that cultural and historical landscapes are preserved. This goal emphasizes the need to recognize and preserve cultural resources throughout the Little Colorado River Watershed.

Goal 9: Maintain and improve water quality for all uses within the Little Colorado River Watershed. Due to the scarcity of water in the region, conservation and multiple use of water are necessary for survival. Water conservation and multiple use projects help to stretch available water supplies. The LCR-MOM will facilitate local water conservation strategies

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and projects that involve and benefit stakeholders across jurisdictional boundaries. This goal encourages innovative water resource efforts.

Goal 10: Increase opportunities for conservation and multiple use of the water resources of the Little Colorado River Watershed. Scarcity of water in the region requires conservation and multiple use of water as necessary for survival. Water conservation and multiple use projects help to stretch available water supplies. The LCR-MOM will facilitate local water conservation strategies and projects that involve and benefit stakeholders across jurisdictional boundaries. This goal encourages innovative water conservation efforts.

Goal 11: Improve watershed and stream function to promote diverse, stable and productive wildlife and fish habitat within the Little Colorado River Watershed. Land use activities upstream and throughout the watershed have an effect on downstream habitats. It is important to consider conditions throughout the watershed when developing habitat improvement projects. The LCR-MOM facilitates local strategies and protects and educates the watershed community on the interconnections between water quality and quantity, land use, and healthy fish and wildlife habitat. This goal emphasizes the linkage between watershed function and healthy habitat.

Goal 12: Enhance networking among individuals, agencies and organizations with an interest in the Little Colorado River Watershed. Only by pooling information, resources, and talents can a successful watershed management program be established. Working together can enhance all varied interests and agendas. One proposed action is development of an e-mail list server to provide interested parties information on the latest watershed based efforts, projects, and activities. This goal recognizes the role that the LCR-MOM can play in fostering good communication by providing networking opportunities among existing and new partners.

#### **3.4.2 National Heritage Area**

The LCR Basin is being proposed as the Little Colorado River Valley National Heritage Area. A National Heritage Area is designated by Congress to bring together local stakeholders seeking to preserve and promote the unique natural and cultural landscapes of

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this region. The Little Colorado River Valley is a unique and diverse watershed in the southwestern United States, encompassing a mosaic of cultures and history. National Heritage Areas seek to preserve and celebrate America's defining landscapes and diverse cultural traditions. The project is being headed by the Center of Desert Archaeology, a private nonprofit organization.

National Heritage Areas are designated by Congress and promote three main goals:

- increased economic growth through heritage tourism;
- care and promotion of natural and cultural resources; and
- enhanced educational opportunities about the region's heritage

Designation as a National Heritage Area does not add any federal regulation to private or public property use or development, and the growth of heritage tourism and resource conservation brings long term economic and community benefits. The 37 existing National Heritage Areas contain many natural, cultural, and recreational resources. These resources form a cohesive, nationally distinctive landscape that arose from patterns of past and present human activity.

National Heritage Areas are usually managed by a 501(c)(3) nonprofit corporation made up of local residents, such as the Little Colorado RC&D. Technical assistance and funding, up to \$10 million during the first 15 years, is available from the National Park Service.



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Various land uses have the potential to result in direct or indirect impacts to humpback chub and designated critical habitat. Land uses of concern include agriculture, mining, and industrial projects that affect water quantity or quality within the critical habitat reach. Each of these land uses is discussed in terms of the largest component projects, the extent and source of water withdrawal, and the potential for negatively impacting the LCR and particularly the humpback chub and its critical habitat.

### 4.1 Agriculture

The primary land use within the LCR Basin is agriculture, including grazing and dry-land and irrigated farming. Within the upper LCR Basin, hydrologic impacts of surface water use by stock ponds less than 2 acres in surface area have been determined by the Arizona Department of Water Resources (1993) to be *de minimis*, a term used to describe “...small water rights which are believed to be inconsequential to the large, and typically senior, rights within a river system.” Stock ponds and domestic wells have been determined to constitute a small use of water in the basin and are considered below the level of regulatory concern in the LCR water rights adjudication (discussed in detail in the next section). Although disperse and small, water uses from stock ponds and small reservoirs constitute a major use of water in the LCR Basin.

Irrigation in the LCR Basin is a notable water use activity. There are several major irrigation companies and many private individuals utilizing surface flow for agricultural purposes. On non-Indian lands within the LCR Basin, 23,390 acres are irrigated (ADWR 1994c, 1994d). Over 46,500 AF of water are applied to these lands annually. Lands irrigated solely with surface water use 31,000 AF. Lands irrigated solely with ground water use 7,000 AF. Lands irrigated by a combination of surface and ground water use 8,500 AF (see Figure 4).

Of the Navajo Nation lands within the LCR Basin, currently 1,630 acres are irrigated, although historically, as many as 11,719 acres have been irrigated. Irrigation projects have

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historically been relatively small to medium in size (i.e., 60-2,210 acres), and obtain water by diverting flood flows from washes. Irrigated projects are generally on the alluvial floodplains scattered through the reservation. Dry farming methods are also implemented. Besides pasture land, the primary crops supported by these irrigation systems are hay/alfalfa, corn, squash, melons, oats, and grapes. The primary irrigation centers include Tolani Lakes, north of Leupp; Moenkopi Wash near Tuba City; the Ganado area; and Black Creek and Red Creek near Window Rock. Irrigation projects on the Hopi Reservation support the same crops, are generally smaller in size, and often utilize dry farming techniques (ADWR 1994a).

There are 2,716 reservoirs in the non-Indian lands of the LCR Basin, including 2,227 reservoirs of less than 2 surface acres. These reservoirs hold 252,711 AF/year, and the largest reservoir, Mormon Lake, has an area of 2,560 surface acres (ADWR 1994c; 1994d). Total estimated surface runoff in the LCR Basin is 177,700 AF/year; hence reservoirs in basin hold about 1.4 years of annual surface runoff. Except for Lyman Lake near Saint Johns, there are no reservoirs on the mainstem LCR in the mid and lower elevations. Virtually all of these reservoirs are high in the drainage near the headwaters and in tributaries. Hence, water from large rainstorms in the central and lower reaches of the basin is largely uncaptured and manifest in the lower LCR as peak flows laden with sediment.

The aridity of the region and population growth have placed increasing demands on surface and shallow ground waters, rendering these supplies increasingly less reliable. This has necessitated finding new water supplies, and water projects are becoming increasingly dependent on ground water. Although ground water was initially exploited to supplement surface water supplies, it has become the primary source of irrigation for many communities and has allowed agriculture to spread to locations formerly removed from irrigation systems (Abruzzi 1985). Community irrigation projects pumping from the Puerco River alluvium are significant enough to cause a localized lowering of the potentiometric water surface where the alluvium is underlain by the impervious Chinle and Moenkopi formations (ADWR 1989).

#### **4.2 Mining**

The major mineral resources within the LCR Basin are coal, copper, and uranium. Economic quantities of these minerals are mined within the basin and are important to the

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economic well-being of small, local communities. These mining activities, which all need water for various processing and related activities, draw from both surface and ground water sources.

##### **4.2.1 Coal**

Economic quantities of coal are mined at two locations within the LCR Basin; PWCC at Black Mesa (south of Kayenta) mines 5.5 million tons annually, and Pittsburgh and Midway Corporation, (between Gallup and Window Rock) mines 4 million tons annually. The Black Mesa mine is located on leased Navajo and Hopi lands, for which PWCC holds mineral interests and surface rights (ADWR 1994a). The Black Mesa mine, operated by PWCC, the largest mining operator in the basin, relies heavily on ground water from the N-aquifer. To support this mine, PWCC pumped an average of 3,543 AF of water annually from the N-aquifer during 1969-93. Uses of this water include a slurry pipeline, coal washing, dust control, construction, reclamation, drinking, sanitation, and evaporation from sediment ponds. PWCC also uses an average of about 287 AF/year of surface water through sediment pond pumping for reclamation activities (ADWR 1994e).

##### **4.2.2 Copper**

Water that originates in the LCR Basin is important to copper mining in surrounding areas. Phelps Dodge Corporation (PDC) utilizes water resources within the LCR Basin to provide for mining operations in the adjoining Gila River Basin. Surface water is diverted from the LCR Basin through two reservoirs as part of the Phelps Dodge-Salt River Project. Annually, transbasin exports to the Salt River drainage from Blue Ridge Reservoir and Show Low Lake are 9,600 and 3,600 AF, respectively. These diversions compensate for water diverted from the Salt River Basin into the Gila River Basin for the PDC copper mine in Morenci. Combined, these two projects account for 80% of the 16,500 AF of surface water diverted annually from the LCR Basin for mining and industrial purposes (ADWR 1994e).

##### **4.2.3 Uranium**

Uranium was mined extensively throughout the Colorado Plateau from the late 1950s

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to the mid-1980s. Within the LCR Basin, uranium mining occurred at approximately 80 sites between Cameron and Grand Falls; some of this ore was processed at the Tuba City mill site. Uranium mining also occurred during 1960-61 and 1967-86 near Pipeline Arroyo, about 22 miles northeast of Gallup, New Mexico, in the Puerco River drainage (Van Metre and Gray 1992).

These uranium mines have had considerable environmental impact and associated health risk to the region. At the abandoned Tuba City mill site, surface remediation to contain materials that pose risks to human health and the environment was completed in 1990. The tailings, demolished mill building, windblown and waterborne deposits, and other contaminated materials were stabilized on site. Approximately 785,000 cubic yards of material from 327 acres were stabilized in a 50-acre disposal cell. Currently, the U.S. Department of Energy is addressing ground water contamination at the Tuba City mill site, along with 23 other inactive uranium processing sites, as part of the Uranium Mill Tailings Remediation Action Ground Water Project. Ground water beneath the mill site in the N-aquifer has been contaminated, resulting in nitrate, selenium, and uranium concentrations and net gross alpha activity exceeding levels of concern. The plume of contamination is just over 1 mile from Moenkopi Wash, but it is migrating toward the wash at an average rate of 10 to 200 feet per year.

Uranium mining near Pipeline Arroyo involved release of contaminated water into the Puerco River, as part of mine dewatering. From 1967 to 1986, average discharge from mine dewatering was 8.1 cfs. This discharge changed the Puerco River from an intermittent to a perennial river, but the mine drainage contained elevated gross alpha, gross beta, uranium, and radium activities, as well as selenium and molybdenum concentrations. Cumulatively, this drainage discharged an estimated 560 mg of uranium and 260 Ci (Curie) of gross alpha activity. In addition, on June 16, 1979, an earthen dam retaining a tailings pond failed near Pipeline Arroyo, sending 1.5 mg of uranium and 46 Ci of gross alpha activity into the Puerco River (Van Metre and Gray 1992). Wirt (1994), however, determined from a study conducted during 1988-92 that Puerco River streamflow was no longer contaminated as a result of uranium mining activities. Wirt (1994) also concluded the following:

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- Differences in radioactivity of sediment found throughout the LCR Basin were due to geographical differences in geology.
- High sediment concentrations in the LCR and Puerco River cause streamflows to exceed standards established under the Safe Drinking Water Act for uranium and radium, as well as for non-radioactive metals such as beryllium, copper, lead, manganese, and nickel. However, filtered water from these rivers generally meets drinking water standards.

##### **4.2.4 Miscellaneous Mining Activities**

In addition to coal and uranium, other mineral deposits of economic importance are scattered across the LCR Basin. A bentonite mine is operated in Sander, and a pumice mine and some volcanic cinder pits are operated on the Coconino National Forest in the San Francisco Peaks area. Small sand and gravel mines are operated on the Navajo reservation at miscellaneous sites. Many abandoned mine sites also exist throughout the LCR Basin.

#### **4.3 Industrial and Municipal Water Uses**

Because of the ephemeral nature of surface water flow in the LCR system, industrial and municipal projects rely mostly on the more reliable ground water resources. For example, municipal water use in the lower LCR Basin totaled 13,320 AF in 1992, only 29% of which was surface water (ADWR 1994d).

Water uses from the C-aquifer for industrial, commercial, and power generation purposes deplete 47,100 AF annually. Sixty percent of this volume is depleted by three power generating stations. The Arizona Public Service-Cholla Generating Station at Joseph City depletes approximately 13,385 AF of ground water from the C-aquifer annually. The Salt River Project-Coronado Generating Station (northeast of St. Johns) uses 10,143 AF/year (Apache County 1998), and the Tucson Electric Power Company-Springerville Generating Station (north of Springerville) uses another 7,072 AF/year. Another major user of ground water is the Stone Container Corporation's Snowflake Pulp Mill, with eight production wells that withdraw 16,950 AF/year. Combined, these four projects use 45,240 of the 47,100 AF

#### **4.0 Land and Water Use**

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of water annually from the C-aquifer for all industrial, commercial, and power purposes (ADWR 1994e). These projects cause a lowering of the potentiometric water surface in the area of pumping. When combined with municipal and irrigation depletions, total withdrawals cause a decrease in discharge from the C-aquifer to the alluvial system, potentially decreasing the base flow of the LCR and some of its tributaries (ADWR 1994e).

#### **4.4 LCR Adjudication**

The claim to water rights is important for economic salience in the Southwest, and water users of the LCR have been involved in an on-going process of asserting their claims. The adjudication process—the judicial determination of the extent and priority of water rights within the system—is expected to finalize the water rights for the different cities, towns, farms, ranches, mines, domestic users, instream flow components, state and federal entities, and Indian tribes. This process was initiated in 1978 and is authorized under Arizona Revised Statutes § § 45-251 to 450-260 (ADWR 1994a). No water rights have been determined under the adjudication process, but settlement agreements are being prepared for review by the courts. There are over 3,000 parties in the Little Colorado River Adjudication. Because of the complexity of the legal and hydrologic issues involved, final resolution of the water rights in these basins is elusive. The adjudication proceedings have been ongoing for several decades, and it is likely that there will be no significant resolution in the near future. This lack of certainty limits management options and makes enforcement of the surface water law more difficult.

The general stream adjudication statutes were significantly amended in 1995. All of the tribes in the LCR Basin joined in an action pending before the Arizona Supreme Court challenging the validity of the amended statute (San Carlos Apache Tribe, Tonto Apache Tribe, and Yavapai Apache Tribe v. Superior Court of Arizona, in and for the county of Maricopa, et al., Supreme Court No. CV-95-0161-SA). Challenges of these statutes are not anticipated to be resolved for several years.

In the LCR adjudication, as in other general stream adjudications in the Southwest, the potentially large, unquantified “reserved water rights” of the tribes create uncertainty as

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to the continued use of water by non-Indian parties. The concept of “reserved water rights” has its genesis in the United State Supreme Court decision of Winters v. U.S., 201 U.S. 564 (1908). The court held that Indian water rights are based on the amount of water necessary to fulfill the purposes of the Indian reservations. Their priority date is based on the date the lands were set aside for Indian tribes. The Winters rights are not based on the amount of water actually appropriated, as under state law.

Although the Winters Doctrine did not articulate how such rights are to be quantified, the Court later held in Arizona v. California, 373 U.S. 546 (1963), that for the reservations in Arizona on the Colorado River, the tribes were entitled to the quantity of water required to irrigate all of the “practicable irrigable acreage” (PIA) within the reservations. The standard of PIA has been applied to other Indian reservations in Wyoming and New Mexico (In re Rights to Use Water in Big Horn River, 753 P.2d 76 [Wyo. 1988]; New Mexico v. Lewis, 861 P.2d 235 [N.M. App. 1993]). The PIA in the LCR Basin was calculated based on the technology available at the time. Currently, with the expansion of irrigation capabilities and ground water utilization, the tribes are beginning to not only exercise their existing water rights, but to also claim additional rights based on updated PIA calculations.

The Navajo Nation is the largest claimant of water in the LCR Basin, claiming in excess of 500,000 AF of surface and ground water annually. The Hopi Tribe also claims significant quantities of water in the basin. Because of the size of these claims and the potential risk that non-Indian water users may have to forego further water development in the basin, the parties are engaged in active settlement negotiations. The NPS is one of these non-Indian claimants in the process, requesting sufficient flow to maintain the elemental resources of GCNP, including the aquatic species and the humpback chub. Although the focus of the adjudication process is on current water uses, decisions on water rights apportionment will undeniably direct the patterns of future water use within the LCR Basin, specifically with regard to Indian uses.

The settlement negotiations mentioned above have resulted in some agreements concerning water rights and uses in the LCR Basin. The NPS and the Salt River Project (SRP) Agricultural Improvement and Power District have published draft stipulations, as have NPS and the Navajo Nation. However, it is important to note that these and all other

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draft stipulations in this matter must be approved by an act of Congress before they are legally binding. This process is not expected to be complete for several years.

In the draft stipulations between NPS and SRP, SRP agreed to not object to various claims filed by the NPS for water rights, both surface and ground water, serving Walnut Canyon National Monument, Sunset Crater National Monument, Petrified Forest National Park, Wupatki National Monument, Hubbell Trading Post National Historic Site, and Grand Canyon National Park. In turn, NPS agreed to not object to SRP's present use of 10,143 AF per annum of underground water from N-aquifer servicing the Coronado Generating Station. In addition, NPS agreed to not object to, for the next 50 years, withdrawal of up to an additional 11,257 AF per annum of ground water for use associated with the Coronado Generating Station. At the end of the 50 years, NPS can challenge SRP's right to the additional 11,257 AF per annum of water based on proof that such use is causing "specific and significant adverse impacts" to NPS wells or surface flows within the aforementioned NPS lands. With respect to the LCR Basin, the draft stipulation states that "*specific and significant adverse impacts occur when existing flows in the Little Colorado River...are reduced by more than five percent by pumping of SRP's wells*" (Apache County 1998).

In the draft stipulations between NPS and the Navajo Nation, the Navajo Nation agreed to not object to the same NPS claims as SRP above. However, NPS recognized that its reserved water rights in these areas were "*...junior in priority to the reserved water rights of the Navajo Nation that are diverted and used on lands reserved prior to the establishment of the affected park unit.*" The NPS agreed to not contest the rights of the Navajo Nation to "*...make use of all surface water, which is unappropriated...*" from LCR tributaries that lie within the reservation both to the north and south of the LCR. Furthermore, NPS agreed to the Navajo Nation's "*...right to use, including the right to store, all surface water flow, which is unappropriated ... in the 3-Canyon drainage area, including Chevelon Creek, Clear Creek, and Jack's Canyon*" (Apache County 1998).

Arizona's water supplies are physically constrained by climate conditions, but they also are legally constrained through interstate and international compacts, federal decrees and state law. Although surface water rights in Arizona are based on the relatively common "prior appropriation" or "first in time, first in right" system, the ground water rights within



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the Active Management Areas (AMAs) are unique. Arizona's courts since statehood have handled surface water and ground water separately, despite the hydrologic connection between the two sources. This results in a number of legal and institutional issues. Surface water allocations are based on the "first in time, first in right" priority system. Ground water generally is governed by the reasonable use doctrine that the landowner, without waste, can use water beneath the land for any beneficial purpose. There is no priority system for ground water, other than the grandfathered ground water rights system within the AMAs that protects water users that were in place prior to the 1980 adoption of the GMA. Rights to ground water were relegated to the courts for some time before any action was taken by the state legislature to regulate or control its use.

Because the water rights system does not acknowledge the hydrologic connection between surface water and ground water, it generally is not possible to limit ground water pumping in order to protect surface water rights or riparian habitat. However, the courts have found that if pumping subsurface water appreciably diminishes the flow of the surface stream, then the water is deemed to be subflow and subject to the general adjudication. An Arizona Supreme Court case determined in 2000 that a well is subject to adjudication if it is located either in the saturated floodplain alluvium or outside of the younger alluvium and has a cone of depression that extends into the subflow zone. Factors likely to be considered in individual cases include the elevation, gradient, flow direction and chemical makeup of the water.

An important aspect of water law and its application to the LCR Basin is the manner in which the many small and dispersed water rights are treated. The ADWR has proposed that two categories of ground water use, characterized for the Silver Creek watershed, be considered *de minimis*, and therefore exempt from the adjudication process. These two categories are (1) all domestic uses and other irrigation uses of less than 10 AF/year, and (2) domestic, other irrigation, and municipal uses of less than 56 AF/year (ADWR 1994f, 1994g). The exemption of these uses is dependent, in part, on whether the revised adjudication statutes are upheld by the Arizona Supreme Court. These exemptions could have a significant impact on the total amount of water withdrawn from aquifers with the many small volume uses.

### **4.5 Hazardous-Materials and Emergency Response**

Hazardous materials are generated as products, byproducts, or wastes in a wide variety of activities. These materials pose a risk to the environment when there is a probability of a release, and that release can result in harm to a component of the environment. Risk is heightened when the consequences of a release increase in severity and/or the potential for a release increases.

The critical habitat reach and the humpback chub population in the LCR are at risk from hazardous materials released into the LCR watershed. This risk is potentially significant because it is conceivable that either a catastrophic or chronic release of hazardous materials could harm or eliminate the humpback chub population and/or adversely modify or destroy its critical habitat. The most likely source of hazardous materials to the lower LCR is an overturned truck from the two U.S. Highway 89 bridges at Cameron or from State Highway 64 as it parallels part of the LCR Gorge northwest of Cameron. U.S. Highway 89 is used as a route for transporting a variety of hazardous materials.

A series of regulatory programs for hazardous materials and environmental quality have been implemented under state and federal laws. Germane federal statutes include the Toxic Substances Control Act, Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act, and Comprehensive Environmental Response, Compensation and Recovery Act. These laws and their associated regulations specify handling, storage, transport, and disposal of hazardous materials. Risks to the environment are substantially reduced by adherence to these regulations. Nevertheless, even close adherence to these regulations cannot prevent unforeseen accidents. Assessment and management of risks associated with hazardous materials include identifying where and how potential discharges could occur, and developing programs to minimize the risk of discharge and to improve responses to control resulting environmental damage.

Previous efforts have been made by state and federal agencies and Native American groups to identify potential hazardous-materials risks in the LCR Basin and to develop plans for appropriate responses in case of a release. This section presents pertinent findings from agency documents regarding hazardous materials and emergency response in the LCR Basin.

##### **4.5.1 Potential Hazardous-Materials Release Sites**

Residual radionuclide and trace element contamination from past uranium mine dewatering has been a water quality concern in the Puerco River Basin. However, data indicate that contamination levels now found in the Puerco River are comparable to values found at multiple control sites within the basin, and therefore, are probably natural in origin (Wirt 1994). Radio-chemicals and heavy metals attached to suspended sediments were reported at much higher concentrations than standards for total metals and radio-chemicals in water. However, when the suspended sediments were removed by filtration, the stream water typically met water quality (dissolved) standards.

Inadequate disposal and reclamation at uranium mining and milling operations exist at several locations on reservation lands in the basin. Near Cameron, the Navajo Nation has identified approximately 80 abandoned uranium pits. The Navajo Abandoned Mine Lands Reclamation Department is currently reclaiming many of these sites. Water sometimes found in these abandoned pits is primarily derived from surface water runoff. Nickel concentrations at two sites exceeded EPA's public drinking water standards, and radium-226 exceeded these standards at four sites. Although there are currently no public drinking water standards for total uranium or radon, standards have been proposed by the EPA. Uranium exceeded the proposed standards at nine of twelve shallow ground water and surface sites, and radon exceeded the proposed standard at all three sites monitored (Arizona Department of Environmental Quality (ADEQ) 1994).

The U.S. Environmental Protection Agency (1995) completed a chemical hazards analysis for the Navajo Nation that identified ten facilities within the LCR Basin which either store or transport hazardous materials (Table 3). Of these ten facilities, three are of concern because of their potential to adversely affect waterways and wildlife in the event of a hazardous-materials release from Interstate 40, Santa Fe Railway, or U.S. Highway 89. U.S. Highway 89 is the greatest concern, since it crosses the LCR at Cameron and hazardous materials are regularly transported along this route. Should an accident or other event result in a spill on this bridge, materials could be discharged directly into the LCR, about 30 miles upstream of the designated critical habitat.

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Table 3. Facilities in the LCR Basin that store or transport hazardous materials.

Facility	Hazardous Material(s)
AT&T - Sanders	Sulfuric acid (in batteries)
El Paso Natural Gas Company, Fixed Sites	Chlorine, sulfuric acid
Hopi High School - Keams Canyon	Chlorine
Interstate 40	Various transported hazardous materials
MCI Telecommunications, Preston Mesa	Sulfuric acid (batteries), propane, diesel fuel
Navajo Tribal Utility Authority (NTUA)	Chlorine
Santa Fe Railway	Various transported hazardous materials
Transwestern Pipeline	Natural Gas
U.S. Highway 89	Various transported hazardous materials
U.S. West - Winslow	Sulfuric acid

Because the bridges at Cameron are located within the Navajo Nation, primary responsibility for response to and containment of a spill lies with the Navajo Nation, the EPA, and the Arizona Department of Transportation. The EPA's chemical hazards analysis does not discuss the Cameron bridges, but considers U.S. Highway 89 in its entirety. Of the 16 sites evaluated in the document, Highway 89 tied for fourth as highest total risk value. In the evaluation of sites, each was assessed a "Likelihood of Hazardous Materials Release Ranking". The highway was given a ranking of 3 on a scale of 0 to 4 (0 = release not going to happen; 1 = probably won't happen; 2 = might happen; 3 = probably will happen; 4 = will happen). Little data currently exist to confirm the risks posed by highway hazards, but local reports indicate that large quantities of hazardous materials are routinely transported through the reservation via Highway 89 and across the bridges at Cameron. Gasoline is the hazardous material transported across the bridges with the greatest frequency. Large quantities of chlorine destined for wastewater treatment facilities are also transported regularly.

#### ***4.0 Land and Water Use***

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The U.S. Highway 89 bridges are not modified for containment and/or recovery of hazardous-materials spills. The LCR at Cameron is frequently dry, especially during the summer months. Recovery of a spill at the bridge when the river is dry is possible, especially with bridge modifications. However, in the event of a spill when the river is flowing, materials would flow freely from the bridge structure, down the embankment and directly into the river. Released materials could reach the critical habitat reach, about 30 miles downstream, within a period of 10 hours, depending on river flow volume and velocity.

#### **4.5.2 Existing Emergency Response Planning**

Hazardous-materials emergency response plans and protocols for Arizona are outlined by the Arizona Division of Emergency Management (ADEM 1993) in the “Hazardous Materials Response and Recovery Plan”. “The Colorado River Area Contingency Plan” (U.S. Environmental Protection Agency 1993) outlines a specific response plan for the Colorado River below Hoover Dam. These plans, as they exist or with some modification, may provide sufficient protection against hazardous-materials spills in the LCR. These documents and their application to the LCR Basin are reviewed below.

The State of Arizona “Hazardous Materials Response and Recovery Plan” (Arizona Division of Emergency Management 1993) delineates the direct responsibilities of the State. The document does not offer contingency plans for the LCR or any particular areas of the State, but rather outlines the protocol to be followed by specific state officials and agencies. This protocol and chain-of-command are described in the following sections.

##### ***4.5.2.1 Local Government (Town, City, County)***

Emergency response agencies of local governments respond to hazardous-materials incidents in accordance with their departmental standard operating procedures and town/city/county emergency operations plans for hazardous-materials incidents. Emergency response agencies make an immediate appraisal of the situation and its potential. On-scene command and control is the responsibility of the jurisdiction in which the incident occurs. The local incident commander is in charge of all personnel at the scene.

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### ***4.5.2.2 State Government***

Various state agencies (Arizona Department of Public Safety, ADEM, ADEQ, Radiation Regulatory Agency, etc.) have hazardous-materials emergency response units. In addition, the Arizona State Corporation Commission has designated personnel who will respond to pipeline incidents. The Department of Health Services has designated personnel who will respond to incidents involving public health issues, and the Department of Transportation will respond to incidents occurring on state highways. These units will respond individually, or as a team, to incidents when assistance is requested by local governments. The “Hazardous Materials Response and Recovery Plan” (Arizona Division of Emergency Management 1993) states how requests for response and assistance should be initiated, and the role of the State On-Scene Coordinator (SOSC).

### ***4.5.2.3 Federal Government***

Requests for federal agency assistance (i.e. Federal On-Scene Coordinator [FOSC]) will be initiated by the ADEQ SOSC or the Arizona Department of Environmental and Military Affairs Regional Response Team representative in coordination with the local incident commander.

### ***4.5.2.4 Private Sector***

The private sector may be able to provide the SOSC with technical advice and recommendations, or provide specialized personnel and resources. The SOSC shall initiate requests for private sector assistance, in coordination with the local government incident commander. Private clean-up contractors under state contract will initiate clean-up and disposal of hazardous materials at the direction of the SOSC.

### ***4.5.2.5 Response on Federal Lands***

Response on federal lands will normally be provided by the impacted federal agency and/or the EPA, Region IX. In the event of a hazardous-materials incident on federal land, including Indian reservations, the State may respond and initiate emergency actions for the

#### ***4.0 Land and Water Use***

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protection of life, property, and the environment. Requests for state response to federal land should be initiated by the federal agency having jurisdiction over the affected area.

Plans, assessments, and task forces exist that can help to consolidate information, clarify responsibilities, and coordinate efforts. “The Colorado River Area Contingency Plan” (U.S. Environmental Protection Agency 1993) outlines roles and responsibilities for responsible parties, local jurisdictions, state and federal and combined agencies; operational response phases; response resources; and mutual aid agreements for the lower Colorado River and the bordering areas of Arizona and California. It also provides a directory of all agencies and individuals who may be called upon in the event of a hazardous-materials discharge. This document can serve as a model for a contingency plan for the LCR Basin.

The “Arizona Water Quality Assessment” (Arizona Department of Environmental Quality 1994) provides information on the status of waters within the state, not including reservations. Included is information on surface monitoring programs and control programs for point and non-point source pollution. An extensive network of monitoring stations is currently in operation within the LCR Basin.

In 1989 and 1990, the U.S. Department of the Interior assembled a Colorado River Emergency Response Task Force, which discussed an emergency response plan for hazardous-materials spills within areas managed by Interior agencies. As part of that process, structural modifications to the Highway 89 bridge to contain spills were identified as a method to reduce risks to downstream resources (Cannon 1990). No emergency response planning document has been generated by the Task Force.

The principal hazardous-materials risks to critical habitat and humpback chub in the LCR appear to be spills and associated discharges at Cameron associated with hazardous materials transported on Highway 89. The other identified risks are either a long distances upstream from the critical habitat reach or they have a low level of release potential, or both. Cameron is a relatively remote location with limited capacity for immediate response to a spill event. Potential adverse effects of a discharge at Cameron could be reduced by more detailed response planning, deployment of appropriate equipment, and possibly, structural modification to the Highway 89 bridge.

## 5.0 SOCIAL AND CULTURAL SETTING

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Five Native American groups have close cultural ties to the LCR Basin, including the Navajo, Hopi, Zuni, White Mountain Apache, and San Juan Southern Paiute peoples. Various geographic locations and areas are important culturally and spiritually to these groups, but the Navajo, Hopi, and Zuni peoples have specific ties to the LCR Gorge downstream of Blue Springs and in critical habitat of humpback chub. Maintaining and preserving the integrity and spiritual well-being of resources in and around the LCR Gorge is vital to these Native American groups (Navajo Natural Heritage Program 1993). The following narratives describe the relationship of these tribes to the LCR Gorge (i.e. the canyon downstream of Cameron).

### 5.1 Navajo Culture and Religion

The Navajo Nation is currently the second largest federally recognized Native American tribe in the United States, with 298,197 people claiming to be full or partial Navajo, according to the 2000 U.S. census. Navajo, or Diné, means *The People*. The Navajo people originated from the Athabaskan region of the Great Slave Lake in Canada. Evidence suggests that ancestors of the modern Navajo entered the Southwest between 1,000 and 1,400 A.D. These groups intermarried and traded with neighboring Pueblo peoples and the traditional Navajo culture is a result of these interactions. Evidence clearly establishes Navajo settlement on the plateaus surrounding the Grand Canyon and LCR Gorge by the 1700s. By at least the mid-1800s, Navajos were fully using resources in the LCR Basin.

Throughout the LCR are places of historical, cultural, and religious importance to the Navajo people. Navajos believe they originated from three underworlds and emerged through a series of events into this, the fourth world. Water is the basis for the origins of many Navajo clans and is important in oral tradition and in many ceremonies. The Colorado River is a sacred female being to the Navajos. The LCR is a sacred male being. These rivers provide protection to the Navajo people, not only in the water that is ceremonially used, but in the refuge provided by the canyons to Navajos throughout history. Grand Canyon and the LCR Gorge are sources of vegetation and minerals that continue to be used for medicinal,



## **5.0 Social and Cultural Setting**

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ceremonial, and daily domestic purposes. The salt mines, located on the banks of the Colorado River about 2.5 miles downstream of the LCR, provide salt that is still used ceremonially and was used historically to season food. Resources within the LCR Basin are among the many sacred and secular to the Navajo people.

### **5.2 Hopi Culture and Religion**

The Hopi are Native American people who live primarily on three mesas on the Hopi Reservation in northeastern Arizona, an area that is entirely surrounded by the much larger Navajo Reservation. The reservation had a 2000 census population of 6,946 persons. The LCR Gorge is significant in defining the cultural and religious life of the Hopi people. The LCR Gorge extends from downstream of Cameron for about 40 miles to the confluence of the Colorado River, and includes critical habitat in the lower 8 miles. The LCR Gorge contains archaeological sites, shrines, and sources of minerals and other materials that are essential in the perpetuation of Hopi cultural and religious life. The Hopi people continue to use the LCR and Grand Canyon for important ceremonial and religious purposes. Hopi culture begins with the emergence of people into this present world from the *Sipapuni*, a tufa cone on the banks of the LCR about 5 miles upstream from the confluence with the Colorado River. After their emergence, Hopi people migrated around the Southwest and came together at the Hopi Mesas.

The salt mines on the Colorado River and trails and shrines within Salt Trail Canyon, a side canyon of the LCR, are the focus of an arduous pilgrimage associated with initiation rites. The Twin War Gods established the trail for this salt pilgrimage and identified many shrines where offerings and rituals are conducted. Hopis use these places for prayer, where they make offerings during winter ceremonies conducted on the Hopi Mesas. Circumstances relating to trail access and theft of ritual items have precluded the initiation rites which would allow Hopis to take part in the pilgrimages. Without initiation, Hopi visits to the mines are considered too dangerous. All Hopi ancestors have returned to Grand Canyon and now occupy it in spirit. The presence of their ancestors makes the Grand Canyon a holy and spiritually dangerous place, and all use of the area requires proper spiritual preparation and respectful attitude.

## 5.0 Social and Cultural Setting

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The Hopis believe that humans are stewards of the earth and should nurture all living things. All living things play an important role in creation and therefore have a right to exist. The Hopi people think the loss of any fish (including the humpback chub), animal, or plant species would impoverish the world and thus have a negative impact on Hopi life. Given the sanctity of the LCR Gorge and the responsibility for stewardship of natural resources, the Hopis are concerned about impacts to sacred sites and practices within the LCR, as well as the attitudes of people who use the canyon for recreation and research. This includes the use of sites such as the *Sipapuni* for alternative religious or other practices.

## 5.3 Zuni Culture and Religion

The Zuni are thought to be direct descendants of the Ancient Pueblo People (Anasazi), a large society that encompassed much of the southwestern United States. Most Zuni people (about 12,000) live in the Pueblo of Zuni on the Zuni River, a tributary of the LCR in western New Mexico. The LCR forms part of the far northern boundary of the traditional territory of the Zuni Tribe. Archaeological sites, traditional cultural places, and other sacred locations along the LCR are important to Zuni traditional and cultural values, providing important spiritual linkages to the place of emergence for the Zuni Tribe. The LCR was the corridor used by the Zuni people from the Colorado River onto the high plateau. This corridor is the "umbilical cord" for the Zuni people to the place of emergence in Grand Canyon. Areas where soil, water, plants, and rocks are collected for ceremonies, as well as a portion of the Zuni Grand Canyon Trail are within the LCR Gorge. Trails used by the Zunis for religious purposes have special significance and are protected by particular blessings and prayers. The Zuni people have concerns about the ancient Zuni trail from their village through the LCR corridor to the bottom of Grand Canyon. The Zuni Tribe is in the process of identifying cultural resources of importance to the tribe within Grand Canyon.

The Zuni Reservation includes Zuni Heaven, a 17-square mile area with no population centers, which is located northeast of St. Johns, Arizona. Zuni Heaven is an extremely important religious area for the Zuni. This significance was acknowledged by the United States in Public Law 98-408, which returned the lands comprising Zuni Heaven to the Zuni Tribe. Any resource management planning which would affect biotic or hydrologic resources in Zuni Heaven would have to involve discussions with the Zuni Tribe.

## 6.0 BIOLOGICAL RESOURCES

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### 6.1 Terrestrial Communities

Vegetation types within the LCR watershed vary in relation to elevation and precipitation patterns. Vegetative communities range from coniferous forests in the mountain highlands to woodlands, grasslands, and desert-scrub in the middle and lower elevations. Narrow strips of dense vegetation often denote riparian areas along stream corridors. Forests are utilized for their timber, recreational values, and as watersheds. Woodlands, grasslands and desert-scrub provide areas for grazing and agriculture (ADWR 1989; Navajo Natural Heritage Program 1993). There is little terrestrial vegetation on exposed slopes in the immediate vicinity of the reach designated as critical habitat for humpback chub, because of the steep and precipitous nature of the LCR Gorge and the narrow floodplain corridor.

### 6.2 Riparian Communities

The majority of vegetation in the LCR Gorge is associated with riparian communities. Like many riparian areas of the Southwest, the riparian zone within the LCR Basin has undergone many changes in extent and species composition. Presently, the species dominating this ecosystem are phreatophytes; i.e., plants with extensive taproot systems that can effectively draw water from saturated zones at great depths. Most native cottonwood stands have been replaced by thickets of nonnative tamarisk (*Tamarix chinensis*), a common phreatophyte. Tamarisk is easily able to out-compete and replace native cottonwoods and willows as a result of their rapid growth rates, effective taproot systems, and resistance to flooding and drought. This change in vegetative assemblages has generally reduced aerial coverage of vegetation, and increased water losses through surface runoff and evaporation. Native plants have been replaced by nonnative phreatophytes, effectively increasing evapotranspiration rates. The combined effects of water withdrawal for domestic, industrial, and agricultural uses, together with changes in vegetative cover, have resulted in a general reduction in streamflow, rendering surface flow in the middle region of the LCR ephemeral.

## 6.0 Biological Resources

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In the lower 13-mile perennial reach of the LCR, dominant riparian vegetation is a mixture of native plants including catclaw acacia (*Acacia greggii*), honey mesquite (*Prosopis glandulosa*), coyote willow (*Salix exigua*), arrowweed (*Tessaria sericea*), and nonnative plants including tamarisk, camelthorn (*Alhagi camelorum*), giant reed (*Phragmites australis*), and cattail (*Typha* spp.) (Carothers and Minckley 1981; Carothers and Brown 1991). Catclaw acacia, honey mesquite, and camelthorn tend to occur at and above the high water line, and often form thick, nearly impenetrable low-lying forests. Coyote willow, arrowweed, and tamarisk line much of the river corridor and occur at the low water line. Giant reeds and cattails grow in patches along the stream banks, the former often occurring in association with overhanging grassy banks and providing overhead cover for fish. Riparian vegetation also provides shelter for fish during high torrential floods in the LCR that often occur in late winter (January-February), spring (April-May), and late summer (late July-August). These high floods are important for maintaining the riparian zone by resupplying soil moisture and maintaining subsurface flows.

### 6.3 Aquatic Communities

#### 6.3.1 Algae and Macrophytes

Algae are uncommon in the LCR, except for small local growths of filamentous green algae in quiet, shallow, streamside areas. The reason for this absence of algae is poor water quality, low year-around light penetration from constant calcite turbidity and frequent sediment-charged floods, and enormous scouring from periodic high-magnitude, sediment-laden floods.

Instream macrophytes are also uncommon for the same reasons discussed for algae. However, in the early 1990s, a macrophyte was noted invading the lower end of the LCR, just upstream of the confluence. This unidentified plant was used by large schools of carp as substrate for attaching their adhesive eggs during incubation (Personal observation, Richard Valdez, SWCA, Inc.). The macrophyte was tentatively identified as a *Ranunculus* species.

### 6.3.2 Aquatic Macroinvertebrates

Robinson et al. (1995a) reported 9 taxa of aquatic macroinvertebrates in June and 12 taxa in August from fine substrates at five sites in the LCR (Table 4). Chironomidae (midges) were dominant in both periods with up to 11,051 individuals/m<sup>2</sup> in June. There were localized abundances of Baetidae (mayflies), Ostracoda (water fleas), Ceratopogonidae (biting midges), Oligochaeta, and Nemertina (i.e., Nemertea, proboscis worms). Chironomidae, Ostracoda, Ceratopogonidae, Oligochaeta, and Nemertina were prevalent in August, with increasing upstream abundance, except at Blue Springs, where high carbon dioxide and low oxygen levels limit aquatic fauna and flora.

Other taxa included Empididae (dance flies), Ephydriidae (shore flies), Hydropsychidae (caseless caddis flies), Corydalidae (dobsonflies), Hydrophilidae (beetles), Copepoda, and Nematoda. It is noted that Copepoda were not found in June, but were found in low numbers only at the Atomizer Falls site in August. Individuals of the genus *Cyclops* are believed to be in the LCR, since it is the intermediate host for the Asian tapeworm, a relatively new and dangerous parasite to fish of the LCR (Brouder and Hoffnagle 1996; Clarkson et al. 1997). Robinson et al. (1995a) also found 11 and 13 taxa of macroinvertebrates from cobble substrates in June and August, respectively. Abundance patterns were similar to those found in fine substrates, except that densities of most taxa were highest at Blue Springs, except for Chironomidae, Ostracoda, and Oligochaeta. Additional taxa not found in fine substrates included Saldidae (shore bugs), Hydroptilidae (caddis flies), and Veliidae (water striders).

Arizona Game and Fish Department (1993) identified 18 taxa of macroinvertebrates from drift samples in the LCR in 1991-92 (Table 4). Total drift density was highest in October, with 6,406 individuals/1,000 m<sup>3</sup>. The dominant taxa were Diptera (including midges, dance flies, shore flies, biting midges) and Homoptera (cicadas, aphids), with peak densities of 2,346 and 2,921 individuals/1,000 m<sup>3</sup> in October. Other taxa included Ephemeroptera, Hymenoptera (ants, wasps, bees), Hemiptera (true bugs), Trichoptera (caddis flies), Neuroptera, Thysanoptera (thrips), Coleoptera, Mollusca (snails), Nematoda, Arachnida (water mites), Annelida (earthworms), Ostracoda, Psocoptera (psocids), Collembola (springtails), Lepidoptera (moths and butterflies), and Strepsiptera.

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Table 4. Relative abundance of macroinvertebrate taxa found in benthic samples and in drift of the LCR in 1991-92 (Arizona Game and Fish Department 1993; Robinson et al. 1995a).

Taxa	Benthic Samples	Drift Samples
Diptera	Abundant	Abundant
Chironomidae	Abundant	--
Certaopogonidae	Common	--
Empididae	Rare	--
Ephydriidae	Rare	--
Homoptera	--	Abundant
Hemiptera	--	Common
Ephemeroptera	--	Abundant
Baetidae	Common	--
Trichoptera	--	Common
Hydropsychidae	Common	--
Neuroptera	--	Common
Thysanoptera	--	Rare
Coleoptera	--	Rare
Hydrophilidae	Rare	--
Dytiscidae	Rare	--
Megaloptera	--	--
Corydalidae	Rare	Rare
Mollusca	--	Rare
Ostracoda	Abundant	Rare
Oligochaeta	Common	--
Nematoda	Rare	Rare
Nemertina	Rare	--
Arachnida	--	Rare
Annelida	--	Rare
Psocoptera	--	Rare
Collembola	--	Rare
Lepidoptera	--	Rare
Streptaria	--	Rare

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It appears that the introduced freshwater shrimp, *Gammarus lacustris*, has not invaded the LCR, despite its prevalence in the mainstem Colorado River downstream of Lees Ferry. This amphipod prefers cool to cold water and requires stands of algae for cover and diatoms for food. It is unlikely that this organism will invade the LCR since these life history requirements are missing or limited in the LCR.

The federally endangered Kanab ambersnail (*Oxyloma haydeni kanabensis*) is not found in the LCR. The nearest known population is at Vasey's Paradise, about 29 miles upstream of the LCR confluence, on the Colorado River. The spring that discharges into Vasey's Paradise is associated with Fence Fault, and is unrelated to ground water from any of the aquifers underlying the LCR Basin.

Two potentially problematic nonnative mussels have been found in Arizona, but not in the LCR Basin. The zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*Dreissena rostriformis bugensis*) are freshwater, bivalve mollusks that came to North America in ballast waters of overseas ships from Eastern Europe. They are spreading rapidly across the U.S. through waterways into lakes and reservoirs. Quagga mussels caused millions of dollars in damage in the Great Lakes region, and have been spreading west in boat live wells and attached to boat hulls. The quagga mussel was first discovered in Lake Mead in January 2007 and in Pleasant Lake in December 2007. In fall of 2007, quagga mussels were also discovered in a segment of the Central Arizona Project (CAP) Canal in Scottsdale. The CAP canal originates at Lake Havasu. Water from the CAP is used to fill Lake Pleasant. Given their need for cool waters and lentic habitat with high nutrient levels, it is unlikely that these mussels will become established in the Colorado River through Grand Canyon (Kennedy 2007) or the LCR.

### 6.3.3 Fish

Native fish species of the LCR Basin include the primary eight big river fishes; humpback chub, roundtail chub (*Gila robusta*), bonytail, Colorado pikeminnow, razorback sucker, flannelmouth sucker, bluehead sucker, and speckled dace; as well as the Little Colorado spinedace. The humpback chub, razorback sucker, Colorado pikeminnow, and bonytail are listed as endangered species under the ESA. Critical habitat was designated for

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these four species on March 21, 1994 (59 FR 13374). The roundtail chub, flannelmouth sucker, and bluehead sucker are conservation species under the 2004 Range-Wide Conservation Agreement among the states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming (Colorado River Fish and Wildlife Council 2004). A statewide conservation agreement is being implemented by the State of Arizona to ensure the conservation of these and other imperiled species throughout Arizona (Arizona Department of Game and Fish 2006).

Original descriptions of the roundtail chub and the bonytail by S.F. Baird and Charles Girard in 1853 were of specimens taken from the Zuni River by Dr. S.W. Woodhouse, while attached as Surgeon and Naturalist to the expedition of Captain L. Sitgreaves (1853). The Zuni River is a tributary of the LCR about 200 miles upstream of the Colorado River. These historic collections show that roundtail chub and bonytail were historically in the LCR drainage, but their exact distribution was not reported.

In May of 1911, Ellsworth and Emory Kolb (Kolb and Kolb 1914) reported a large aggregation of spawning “bony tail” (i.e., humpback chub) in the lower LCR, providing evidence of humpback chub abundance in this tributary early in the century. Past collections of Colorado pikeminnow, roundtail chub, and bonytail in the pools below Grand Falls in the 1940s (Miller 1968; Smith et al. 1979; Minckley 1973) indicate that the big river fishes were also present approximately 90 miles upstream from the mainstem Colorado River just over 50 years ago.

Today, two of the eight native big river fishes have been extirpated from the LCR and Colorado River in Grand Canyon (Colorado pikeminnow, bonytail), and the roundtail chub is found only locally in Chevelon Creek and East Clear Creek (Bezzarides and Bestgen 2002; Clarkson and Marsh 2005). The razorback sucker is extremely rare in the Grand Canyon region (Miller 1968; Maddux et al. 1987; Valdez 1996; Valdez and Ryel 1995). The majority of the humpback chub population in Grand Canyon is located in and around the LCR, and flannelmouth sucker and bluehead sucker rely heavily on the LCR for spawning and rearing of young.

Water depletions in the LCR Basin have rendered the river upstream of Blue Springs

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ephemeral, with surface flow only during spring runoff and heavy local rainstorms. These water depletions have reduced available habitat for fish. Loss of perennial flow above Blue Springs has concentrated chemicals in the water, possibly increasing the rate of calcite deposition and rendering many tufa dams more precipitous and difficult for fish to traverse (Robinson et al. 1995a). Of the native big river fishes, only roundtail chub have been reported recently from the upper reaches of the LCR Basin; these fish are likely residents and not recent migrants from the Colorado River mainstem (Clarkson and Marsh 2005).

Species composition in the lower LCR has remained approximately the same over the last 20 years. Native fishes far outnumbered nonnatives in the 1980s (Kaeding and Zimmerman 1983) and into the early and mid-1990s (Robinson and Clarkson 1992; Robinson 1995; Table 5). Relative abundance of native fishes remained above 98% in 1987-89, decreased to 84% in 1990, and was 88% in 1994. This variation is likely attributed to sample variation, time of year, and relative strength of year classes of different species. Red shiners (*Cyrinella lutrensis*) were caught in the lower LCR in the early 1990s following heavy flooding that likely transported the fish from reaches upstream of Blue Springs (Arizona Game and Fish Department 1993, 1996).

Table 5. Approximate percentage composition of fish species found in the LCR in 1980-81 and 1991-92 (Kaeding and Zimmerman 1983; Robinson and Clarkson 1992; Robinson 1995).

Fish Species	1980-81 (%)	1991-94 (%)
humpback chub ( <i>Gila cypha</i> )	30	35
speckled dace ( <i>Rhinichthys osculus</i> )	45	45
fathead minnow ( <i>Pimephales promelas</i> )	10	3
common carp ( <i>Cyprinus carpio</i> )	not reported	<1
bluehead sucker ( <i>Catostomus discobolus</i> )	10	8
flannelmouth sucker ( <i>Catostomus latipinnis</i> )	5	5
rainbow trout ( <i>Oncorhynchus mykiss</i> )	<1	<1
channel catfish ( <i>Ictalurus punctatus</i> )	not reported	<1
plains killifish ( <i>Fundulus zebrinus</i> )	<1	<1
yellow bullhead ( <i>Ictalurus natalis</i> )	not reported	<1

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The LCR continues to be an important spawning area for both native and nonnative fishes, and could be a major source of nonnative fish to if mainstem temperature increased (Clarkson et al. 1994). Humpback chub, flannelmouth suckers, and bluehead suckers congregated in April-May in the LCR for spawning. Congregations of large adult channel catfish are also seen annually in May-June in the outflow of the LCR, and appear to be ascending the LCR to spawn. Stomach samples from these large predators have also revealed that these catfish are preying on native fishes, including humpback chub (Valdez and Ryel 1995, 1997; Marsh and Douglas 1997).

Large numbers of common carp are also seen in the lower LCR year-around. Higher numbers appear to occur in spring and early summer, presumably as spawning aggregations. Spawning females broadcast adhesive eggs that become attached to exposed roots of reeds and cattails, where the eggs incubate and young hatch as tiny larvae. Adults weigh 1-10 pounds and disturb much of the substrate as they vacuum the river bottom for aquatic invertebrates, detritus, and other food materials. The full impact of carp and other nonnative fishes to native species in the LCR is not well understood.

### **6.3.3.1 Humpback Chub**

The humpback chub remains as six self-sustaining populations, including five in the Upper Colorado River Basin and one in Grand Canyon, which is the largest population (Valdez and Ryel 1995, 1997). Humpback chub occupy the lower 9.3 miles of the LCR as a resident population and as adult spawners ascending from the Colorado River. The fish are prevented from moving further upstream by a series of precipitous tufa dams, Atomizer Falls (Kaeding and Zimmerman 1983; Douglas and Marsh 1996a), although a translocation plan was successful and humpback chub reside above Atomizer Falls to the Blue Springs complex. Spawning by humpback chub occurs primarily in the LCR, although some successful spawning is suspected in the mainstem or other tributary inflows in Grand Canyon. Protecting flows and water quality in the LCR watershed is vital to the survival of this population of humpback chub.

Seven reaches of the Colorado River Basin, totaling 379 miles, were designated as critical habitat for humpback chub, including portions of the Colorado, Green, and Yampa

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Rivers in the upper basin, and the Colorado River and LCR in Grand Canyon. Critical habitat in Grand Canyon includes the Colorado River from Nautiloid Canyon (River Mile [RM] 34), to Granite Park (RM 208), and the lower 8 miles of the LCR above the confluence with the Colorado River (Figure 14). Of the 8 miles of critical habitat in the LCR, the upper 5.5 miles are within the Navajo Nation and the lower 2.5 miles are within Grand Canyon National Park.

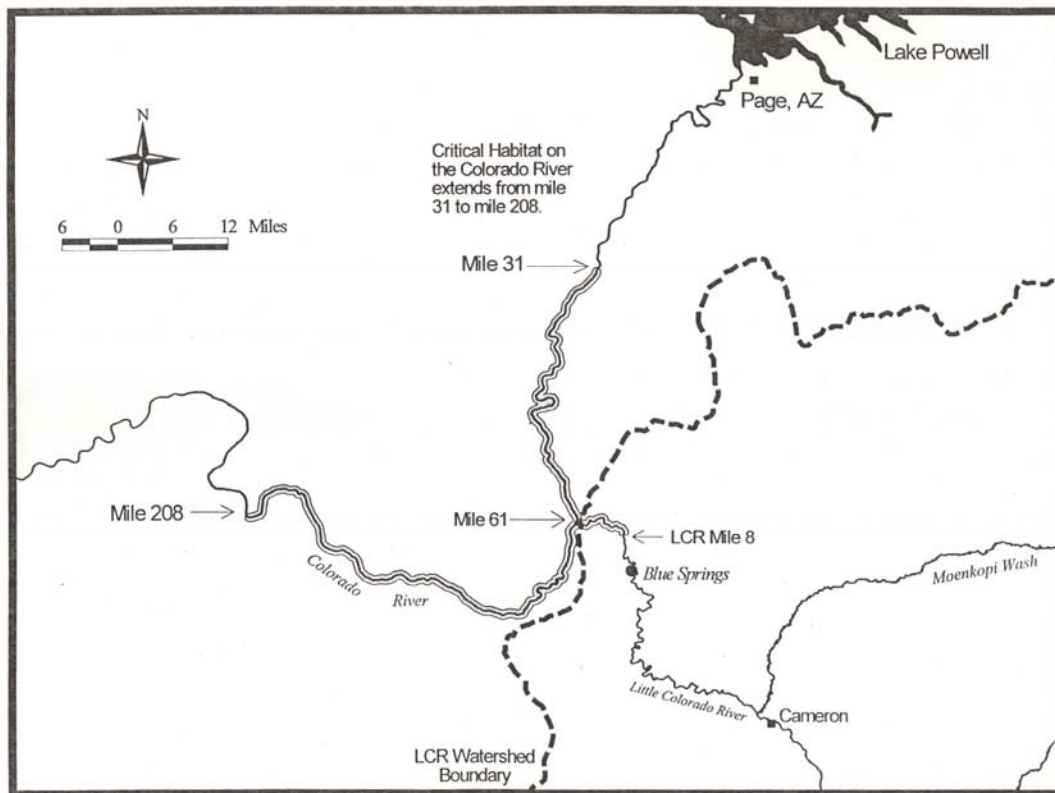


Figure 14. Designated critical habitat for the humpback chub in Grand Canyon.

### 6.3.3.2 Razorback Sucker

The razorback sucker was listed as endangered on October 23, 1991 (56 FR 54957), and is afforded protection under provisions of the ESA. A Recovery Plan was approved on December 23, 1998 (U.S. Fish and Wildlife Service 1998), and Recovery Goals were approved on August 1, 2002 (U.S. Fish and Wildlife Service 2002). The razorback sucker is

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rare in Grand Canyon with only 10 documented specimens reported between 1944 and 1990 (Valdez 1996). Largest numbers of fish found basin-wide are in Lake Mohave and in the Green River of the upper basin (Minckley et al. 1991). Only four documented razorback sucker have been captured in the LCR (all near the outflow) and the species is considered nearly extirpated from Grand Canyon (Valdez and Ryel 1995, Valdez 1996). Since the species is unlikely to occur in the LCR, other than on rare occasions, specific management actions for the razorback sucker are impractical. However, actions intended to benefit the humpback chub are likely to also benefit the razorback sucker.

Fifteen reaches of the Colorado River Basin, totaling 1,724 miles, were designated as critical habitat for the razorback sucker, including the 100-year floodplain of the Colorado River from the confluence with the Paria River (RM 1) through Grand Canyon and Lake Mead to Hoover Dam (approximately 380 miles). The LCR is not designated as critical habitat for the razorback sucker.

## **6.4 Threats to Humpback Chub**

### **6.4.1 Impacts Generated Outside of Critical Habitat**

#### ***6.4.1.1 Ground Water Depletion***

Base instream flow of the LCR through the critical habitat reach is dependent on outflow from the C-aquifer that is hydrologically isolated from the N and D aquifers, but drains into the underlying R-aquifer just downstream of Cameron. Depletions of the D and N aquifers do not appear to constitute a threat to Blue Springs discharge and base flow in the lower LCR. Therefore, activities that extract ground water from the D and N aquifers are not considered as a potential threat to the humpback chub and critical habitat in the LCR. These activities include the Peabody Western Coal Company (PWCC) mine on Black Mesa and municipal uses in the Tuba City and Kykotsmovi areas. Depletions to the R-aquifer could affect discharge at Blue Springs, but that aquifer is inaccessibly deep throughout.

Depletions from the C-aquifer merit consideration. Ground water depletions from the C-aquifer have been summarized in sections 3.3.4.1 and 6.0 of this document. Withdrawals

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by industry and irrigation projects deplete a total of 85,000 AF/year of the 100,000 AF/year total basin-wide depletion. The Tucson Electric Power Company-Springerville Generating Station, Salt River Project-Coronado Generating Station, Arizona Public Service-Cholla Generating Station, and Stone Container Corporation-Snowflake Pulp Mill projects account for 47,240 (56%) of the total. These uses are located in the upper portion of the basin, between Springerville and Winslow, Arizona.

Hydrochemical analyses indicate that 75% of the flow from the Blue Springs complex is derived from the San Francisco Peaks volcanic field near Flagstaff, while 25% is derived from the eastern and southeastern portion of the LCR Basin (Loughlin 1983). Ground-water flow paths originating in the San Francisco Peaks area are much shorter than those originating in the eastern part of the basin where the above projects are located. Hence, ground water depletion from the C-aquifer in the Flagstaff area could manifest itself in decreased discharge at Blue Springs faster than depletion in other parts of the basin. These relationships suggest that ground water use from the C-aquifer in the Flagstaff/San Francisco Peaks area could potentially have a greater and more immediate impact to discharge at the Blue Springs complex than equivalent water use from the C-aquifer in the eastern portion of the LCR Basin.

The primary use of ground water in the Flagstaff area is for municipal purposes. During 1987-94, the city of Flagstaff pumped an average of 4,300 AF annually from the C-aquifer from its Lake Mary and Woody Mountain well fields. This amount is only about 5% of the total combined annual municipal, industrial, and agricultural pumping from the C-aquifer (i.e., 85,000 AF). Current limited understanding of the C-aquifer does not help to resolve the question of whether the apparent dependence of the Blue Springs complex on recharge from the Flagstaff/San Francisco Peaks area means that depletions in that area will have a greater or more immediate effect, if any, on Blue Springs discharge.

An important consideration is that discharge volume from the Blue Springs complex appears to be stable. Estimates of discharge over the last five decades are relatively consistent. If ongoing depletions are not affecting Blue Springs discharge, it may be that recharge adequately offsets current withdrawals, or travel time through the aquifer and the moderating effect of an estimated 413 MAF in storage in the aquifer delay the appearance of

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an effect. In addition, although localized lowering of water tables may occur in the vicinity of irrigation projects, power generating stations, or municipalities, it is not possible at this time to definitively assess individual or cumulative impacts of these depletions.

Projecting impacts of future projects that would make use of C-aquifer ground water resources is also difficult. Expanding human populations in the basin, as well as increasing use of mineral resources mean additional ground water depletions, since surface water resources are limited. The lack of a coordinated water management plan in the basin precludes an understanding of potential cumulative effects from future projects, particularly in the eastern portion of the LCR Basin.

Ground water projects in the vicinity of Blue Springs would be expected to have a more immediate impact on Blue Springs discharge than projects at greater distances. Depletion from the Redwall and Muav limestones in areas that are transporting water derived from the C-aquifer could result in a more immediate effect on discharge from the Blue Springs complex. This area of concern lies within a 15 to 20-mile radius of the Blue Springs complex, particularly to the north, south, and east. This area is relatively inaccessible, with only a few isolated dwellings and small numbers of inhabitants. Permeability through these limestone formations is high due to structural deformities and solution channels. Thus, the lag time between the commencement of ground water pumping and the resulting decrease in Blue Springs flow is estimated to be short. However, since total annual discharge at Blue Springs is approximately 160,000 AF/year, relatively small-scale ground water usage in this area would be expected to have less than a significant impact. Furthermore, ground water quality in this area is low and may preclude many uses.

Except for some perched lenses of ground water, the C-aquifer is basically dry in the extreme western portion of the LCR Basin (McGavock et al. 1986; ADWR 1989). This is because the westerly-moving ground water in the C-aquifer is drained downward through numerous fractures in the vicinity into the deep, underlying Redwall and Muav limestones (R-aquifer). However, recent work by the USGS suggests that a ground water divide in the limestone aquifer underlying the C-aquifer may be located along a north-south line between Williams and the south rim entrance of GCNP (Personal communication between D.J. Bills, United States Geological Survey, Flagstaff, Arizona, and B. Leibfried, SWCA). This

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limestone aquifer includes the Redwall and Muav limestones, which have much higher permeabilities than the Coconino sandstone aquifer due to the presence of fractures and solution channels. Flow to the west of this divide feeds into the Havasu drainage, while flow to the east is towards the LCR. Thus, ground water use in the Grand Canyon-Williams area from the limestone aquifer east of this ground water divide has the potential to affect discharge at the Blue Springs complex. More work is needed to better define the location and nature of this ground water divide, especially in light of proposals for considerable development in the Tusayan area as a staging point for visitors to GCNP.

The C-aquifer is not considered to be water bearing in the Echo Cliffs area. In addition, the direction of ground water flow in the Echo Cliffs area is west towards the Colorado River. Therefore, any ground water development in this area would be marginal and would not affect discharge at the Blue Springs complex.

### **6.4.1.2 Surface Water Depletion**

While it is clear that perennial discharge from the Blue Springs complex is essential in maintaining critical habitat for the humpback chub, surface water flows originating in the LCR Basin appear to be equally important for delivering floods that scour and reshape the channel, prepare spawning beds, provide migration and spawning cues, and redistribute nutrients. The sources of these flows are spring snowmelt runoff from the Mogollon Rim, and summer convective and monsoonal storms. The importance of magnitude and seasonality of these flows to the humpback chub is not entirely clear. It is known that spawning by humpback chub commences when stream temperatures warm in spring and early summer, which coincides with rising seasonal air temperature and the descending limb of the snowmelt runoff hydrograph. These high flows also scour and cleanse spawning beds of accumulated sediments and calcite precipitates. Following exceptionally high winter floods in the LCR of 16,400 cfs in January 1993, pools and runs were significantly deepened and young humpback chub were observed in high numbers (Gorman 1994; Valdez and Ryel 1995), suggesting that floods are vital to reproductive success of the humpback chub.

When considering surface flow requirements necessary to maintain critical habitat, it should be recognized that current conditions of diversions and depletions within the LCR

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Basin continue to provide a suitable environment for successful spawning and recruitment of humpback chub. Without a clear understanding of the significance of surface flows upstream of the Blue Springs complex to the life history requirements of the humpback chub, it is difficult to determine the effect of changes in the surface hydrologic regime. It is clear that the Chevelon Creek and Clear Creek watersheds provide the majority of snowmelt flows reaching the Navajo Nation boundary, and hence provide the majority of spring surface flows above the Blue Springs complex.

If the surface water hydrologic regime necessary to maintain critical habitat could be quantified or better characterized through scientific research, acceptable changes to the hydrologic regime of the LCR Basin could be determined. If such a determination were possible, then impact analyses of potential reservoir projects would focus on whether changes to the hydrologic regime imposed by the project would satisfy these pre-established, acceptable conditions. Quantifying total acceptable change to the hydrologic system could provide a framework within which further development of water resources could be compatible with protection of resources necessary to conserve the humpback chub.

### ***6.4.1.3 Degraded Water Quality***

Potential threats to humpback chub populations from deterioration of water quality fall into three categories:

- chronic discharges of substances harmful to humpback chub into the watershed and transport into the critical habitat reach,
- spills of hazardous materials creating a direct acute threat to humpback chub, and
- potential changes in water chemistry of Blue Springs due to changes in discharge or contamination.

Chronic Discharges. Potential threats from chronic discharges are largely related to releases of hazardous materials at industrial or municipal facilities, and escape of radionuclides at active or abandoned uranium mines and/or uranium ore processing facilities. Hazardous materials have been identified as present at facilities in the basin, but the kinds of materials, location of facilities, and existing regulatory and monitoring programs appear to



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adequately limit risks to humpback chub.

Hazardous-Materials Spills. The humpback chub population and critical habitat reach in the LCR are directly threatened by the possibility of a hazardous-materials spill into the LCR. Such an incident could not only decimate the humpback chub population, but also have a significant impact on resources of the Grand Canyon. Of particular concern are the U.S. Highway 89 bridges across the LCR at Cameron. Hazardous materials, such as chlorine and gasoline, are routinely transported along this route. The bridges have no structural modifications for spill containment. Furthermore, current emergency response planning has not specifically addressed procedures for response to and/or containment of a hazardous-materials spill into the LCR at the Cameron Bridges, and the response capacities of responsible agencies are apparently limited by Cameron's remote location.

Changes in Water Quality of Blue Springs. Assessing the potential threat to humpback chub from changes in the quality of water discharged at Blue Springs requires an understanding of the relationship of water quality and water quantity of Blue Springs, as well as a better understanding of the water quality requirements for the species. Some water quality limitations are known for the species, but more information is needed on tolerance and acclimation to free carbon dioxide and pH. It is difficult to determine which actions or events would result in a change in water quantity and hence, water quality of Blue Springs. It can only be assumed that a reduction in discharge is likely to result in a change in the quality of the discharge. An additional consideration may be potential limitations of existing water quality in the LCR on nonnative fish species or parasites, as a benefit to the humpback chub.

### **6.4.2 Impacts Generated Within Critical Habitat**

#### ***6.4.2.1 Instream Flow Needs***

Our present understanding of instream flow needs of humpback chub in the LCR is based on observations and inferences made from a history of population work on the species in this tributary (Kaeding and Zimmerman 1983; Minckley et al. 1980; Kubly 1990; Minckley 1992; Mattes 1993; Gorman 1994; Douglas and Marsh 1996b, 1996c; Stone 1999;

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Gorman and Stone 1999). Unfortunately, none of these studies related physical habitat to flow in order to develop flow to habitat relationships. However, inferences on flow needs can be made from our understanding of the life history of the humpback chub in the LCR and from the present hydrology of the system.

The life history of the humpback chub is clearly matched to hydrology and water quality dynamics of the LCR (Figure 15). Spawning occurs in spring, and is preceded by pre-spawning aggregations of fish in February and March. These aggregations are most apparent for mainstem adults congregated at the mouth of the LCR (Valdez and Ryel 1995), but local congregations of fish are also evident in the LCR (Gorman and Stone 1999). Weight at length is greatest for both males and females at this time (Meretsky et al. 2000), and the fish are tubercled with pre-nuptial rosy colors along the belly and sides. It is believed that the combination of extended daylight (i.e., greater photoperiod) and warming seasonal water temperatures from the LCR elicit these physiological responses (Valdez and Ryel 1995). The majority of fish ascending the LCR from the mainstem move during descending spring flows, rising water temperatures, and increasing water clarity (Valdez and Ryel 1995).

It has also been noted that high spring flows are important for cleansing spawning areas and reshaping habitat (Gorman 1994). One of the strongest year classes of humpback chub in the LCR occurred in 1993, following exceptionally high flows of 16,400 cfs in mid-January, 1993. These high flows scoured tufa and gravels from pools, cleansed spawning areas, and stimulated primary and secondary production; these conditions were highly suitable for successful reproduction and survival by humpback chub. Clearly, the seasonal warming pattern and variable flow of the LCR, in contrast to the regulated mainstem Colorado River, are important elements of spawning by humpback chub in that tributary.

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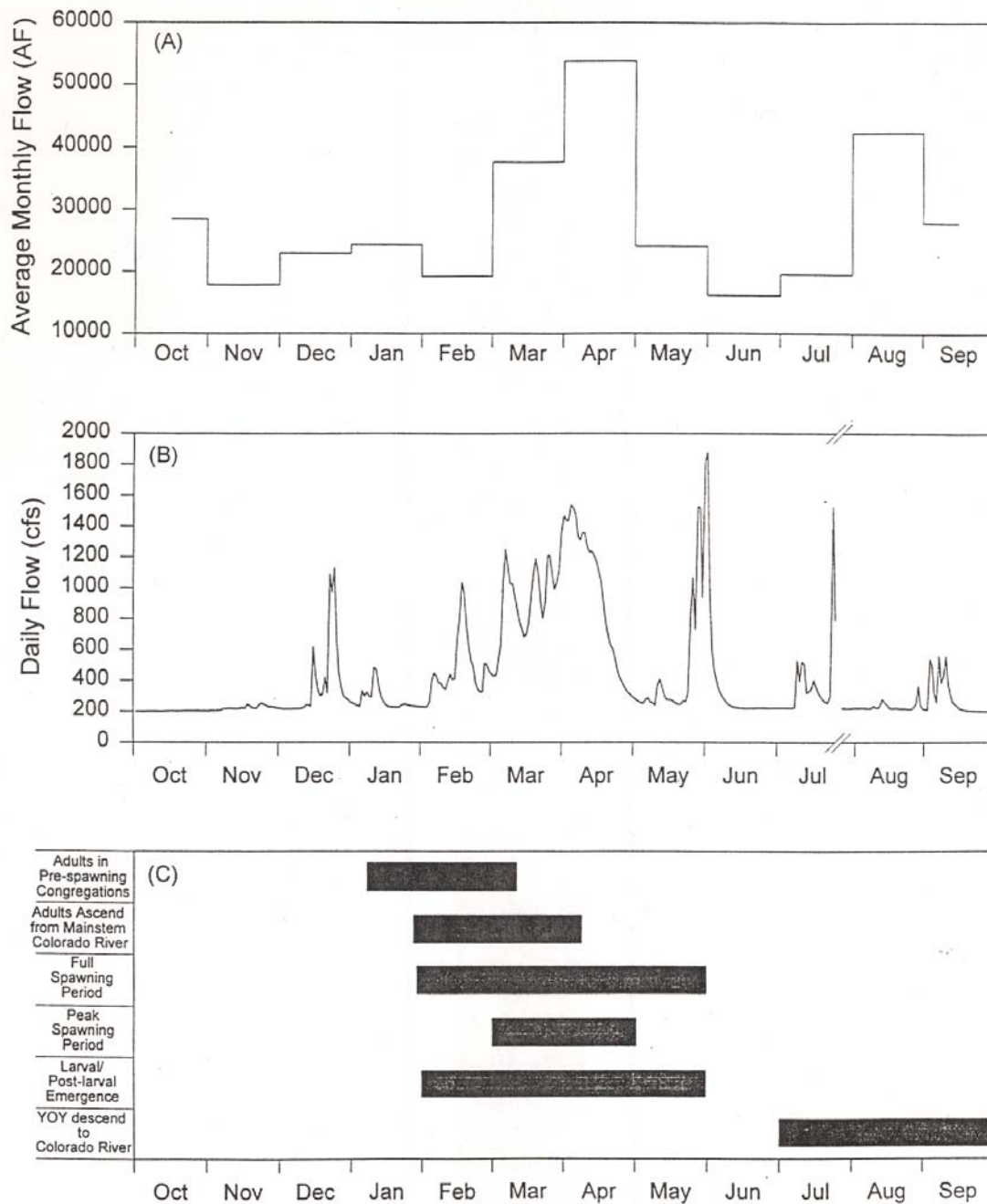


Figure 15. Monthly and daily hydrographs for the Little Colorado River near the outflow compared to life history schedule for humpback chub.

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Spawning by humpback chub in the LCR appears to extend over a period of several months, from February through June, depending on flows and warming patterns, but the peak usually occurs during the period March-May (Kaeding and Zimmerman 1983; Douglas and Marsh 1996c; Gorman and Stone 1999). Although spawning by humpback chub in the LCR has not been directly observed, it appears to occur at a range of flows, from base flows of 230 cfs to well over 1,000 cfs. Water temperature at spawning is believed to be 16-22EC, since this is the optimum temperature range for egg incubation and larval hatching under laboratory and hatchery conditions (Hamman 1982; Marsh 1985).

Spawning by humpback chub has not been observed and little is known of depth, velocity, or substrate requirements. Gorman and Stone (1999) inferred from behavior of adults in the LCR that *“Spawning occurs below large travertine dams and reefs in association with gravel substrate. These areas are strewn with large angular boulders and travertine structures that form a complex channel configuration with a matrix of plunge pool, chute, run, and eddy habitats and depths ranging from 0.5-2.0 m.”* The eggs hatch in 5-6 days at water temperatures of 16-22EC. The larvae remain in interstices among gravel and boulders for 5-10 days, sustaining themselves with the food reserves in their yolk sacs. Larval and post-larval humpback chub remain in shallow, sheltered shorelines, hidden in nearby cover during the day and emerging during crepuscular periods and at night (Kaeding and Zimmerman 1983; Robinson et al. 1995b, 1998; Childs et al. 1998). This life stage of the species usually coincides with receding or stable base flows in the LCR and with a period (May-June) usually marked by dry weather and the absence of monsoonal freshets.

During 1990-1992, young humpback chub were reported descending from the LCR to the mainstem Colorado River with monsoonal freshets during July, August, and September (Valdez and Ryel 1995; Converse et al. 1998). The 1993 year class of humpback chub in the LCR was substantially larger than year classes for 1990-1992, and large numbers of YOY descended in June and July in the absence of monsoonal freshets. During summer of 1993, Gorman (1994) observed adult humpback chub cannibalizing YOY humpback chub and speculated that this predation was caused by habitat saturation; the LCR was at or near base flow of 230 cfs. By August, many YOY appeared emaciated and dying, which was interpreted by Gorman (1994) as a consequence of changing food availability, diets, and habitat use. By late summer, densities of YOY humpback chub in the LCR had declined and habitat use patterns described above were emerging. These observations suggest that during

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summer, when the LCR is at base flow, physical habitat, food availability, or other factors limit densities of fish. It is not known if movement of young fish from the LCR to the mainstem Colorado River is prompted by these limitations or by the stimulus of monsoonal freshets. However, in at least one year (1993) descent of young fish occurred in the absence of these freshets, suggesting that habitat and food availability could not support the large numbers of fish in the system.

Based on these apparent habitat and food limitations, we hypothesize that the LCR supported a higher density of humpback chub before the extensive flow regulation in the upper LCR Basin prevented perennial surface flow downstream of Cameron. The current situation for humpback chub in the LCR clearly shows the importance of Blue Springs flow to sustaining that population and to providing the only area in Grand Canyon where spawning by this species is successful. At this time, disruption of Blue Springs flows and/or further capture of spring runoff and summer monsoonal freshets would in all likelihood have a detrimental effect on this endangered species.

Management of water in the LCR Basin should strive to protect flows from Blue Springs and to insure that spring runoff and monsoonal freshets are allowed to reach the lower reach of the LCR where humpback chub reside. Any diversion or dam structure on the LCR that would interfere with high spring and summer surface flows could detrimentally impact reproductive potential for humpback chub in the lower LCR. Furthermore, disruption of flows from Blue Springs would clearly limit population size in a system that appears to already be habitat limiting.

### **6.4.2.2 Nonnative Fish**

Channel catfish, common carp, brown trout, and rainbow trout alien species that are resident to the Colorado River and the LCR; these fish prey on and compete with humpback chub at all life stages. The extent of these interactions among these species is unclear and the impact to the humpback chub population is not entirely understood. Predation by brown trout, channel catfish, and rainbow trout in the Colorado River, near the LCR confluence, has been documented, and it is possible that these species consume large numbers of humpback chub annually (Valdez and Ryel 1995, 1997; Marsh and Douglas 1997). Removal of

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nonnative brown trout from Bright Angel Creek was shown to be effective and may be a tactic for reducing the overall population by removing fish from spawning areas (Leibfried et al. 2005). An invasive aquatic species management plan is being prepared for the mainstem Colorado River through Grand Canyon with provisions to extend into the LCR (Hilwig et al. 2007).

### 6.4.2.3 Incidental Angler Catch

In the mid-1980s, the National Park Service implemented a closure of fishing in the lower LCR and within 100 m of the mouth of the LCR in order to protect the native fish, particularly humpback chub, from incidental catch by anglers. This fishing closure has apparently been effective and it is rare that an angler catches a native fish in Grand Canyon.

In 1998, the Arizona Game and Fish Commission adopted Commission Order 40: *“Fish, to establish open seasons, open areas, and bag and possession limits for 1998”*. Commission Order 40 is a fishing regulation change that allows unlimited harvest of nonnative species (e.g., largemouth bass, smallmouth bass, channel catfish, trout) and restricts use and transport of live bait fish in specified waters within the State of Arizona that are inhabited by native listed species or are designated critical habitat under the ESA. The following recommendations affect the Colorado River in Grand Canyon and the LCR and were adopted by the Commission:

*“The unlimited harvest of trout, channel catfish and striped bass in the Colorado River, in the Grand Canyon from Separation Canyon to Mile 21 Rapids including all tributaries.”*

The Commission also adopted:

*“Unlimited harvest of trout from September 1 to May 1 from...East Clear Creek in Coconino and Navajo Counties and its tributaries from the confluence of the Little Colorado River including Blue Ridge and Knoll Reservoirs...[and]...Chevelon Creek, in Coconino and Navajo Counties downstream from Chevelon Crossing to the Little Colorado River.”*

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The latter regulation is intended to protect the listed Colorado River spinedace and does not affect the lower reach occupied by the humpback chub. Although not stated in Commission Order 40, this order is not expected to change the closure of fishing in the LCR and within 100 m of the confluence of the LCR and the Colorado River, as imposed by the National Park Service in the mid-1980s.

### **6.4.2.4 Parasites and Diseases**

The Asian tapeworm is currently found in juvenile and adult humpback chub in the LCR (Arizona Game and Fish Department 1993; Brouder and Hoffnagle 1996; Clarkson et al. 1997). The tapeworm was first observed in fish of the LCR in 1990, with over 80% of adults infested (Angradi et. al. 1992). Granath and Esch (1983) determined that temperatures above 20EC were optimal for maturation and growth of tapeworms. Temperatures in the LCR during summer are conducive to the growth and proliferation of the Asian tapeworm. Decreased flow in the LCR could increase water temperature at base flow, leading to increased stress by fish, enhance maturation and reproduction of tapeworms, as well as increase suitable low-velocity habitat for the intermediate tapeworm host, the *Cyclops* copepod. Infestations of the Asian tapeworm can cause blockage of the intestinal tract that can lead to emaciation and eventually death.

Parasitic copepods are found on humpback chub and other native fishes in the LCR and the mainstem Colorado River (Arizona Game and Fish Department 1994; Valdez and Ryel 1995). As with Asian tapeworms, temperatures in the LCR during summer are conducive to the growth and proliferation of anchor worms. Although anchor worms do not appear to pose a significant threat to humpback chub under current conditions, reduced flows in the LCR could result in stress to the fish and increased susceptibility to secondary infection from anchor worm wounds.

### **6.4.2.5 Research Activities**

Scientific research can directly impact humpback chub and chub habitat. GCES Phase II included several research programs with large numbers of research personnel and extensive logistical support. Research scientists handled over 10,000 humpback chub

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between 1990 and 1995, with many individual fish repeatedly recaptured and handled. The recapture rate for adult humpback chub in the LCR based on Arizona State University data for 1994 was approximately 77%, an increase in recapture rate of 40% from 1991. Concerns regarding potential cumulative effects of research on the LCR humpback chub population were stated in a memo from GCES to GCNP dated July 7, 1992 (Glen Canyon Environmental Studies 1992). Research activities including sampling, habitat measurements, and camp activities have been observed to impact both the aquatic and riparian habitats of the LCR. The long-term effect of these research activities on this population of humpback chub remains unknown.

The current research program in the LCR includes a mark-recapture population estimator for adult humpback chub that requires capturing fish in hoop nets, anesthetizing them for weighing and measuring, and injecting a Passive Integrated Transponder (PIT) tag into the abdominal cavity. Most of the fish older than about 5 years of age have been previously marked and their recapture rate is as high as 80%. Sampling takes place in March and April when the adults congregate in the LCR to spawn. Sampling during spawning events induces stress of adults that may cause females to absorb eggs and fail to spawn. Recent studies indicate that excessive handling may also affect growth and condition of fish. Paukert et al. (2005) showed that bonytail (closely related to humpback chub) captured multiple times grew significantly less in length ( $p < 0.001$ ) and weight ( $p < 0.001$ ) than fish not recaptured. Fish recaptured up to five times grew only 12.8% of their initial weight compared to fish not recaptured which grew 29.7% of their initial weight.

Research activities must be recognized as a potential threat to humpback chub in the LCR. Researchers need to be cognizant of this threat and need to be constantly vigilant of handling schedules and protocols to insure that their activities induce the minimum of stress of the fish possible and necessary to achieve the study objectives.

### **6.4.2.6 Recreational Activities**

Recreational use by river runners and hikers can generate impacts to the humpback chub and its habitat. Current regulations limit the level of use and specific activities within GCNP. These regulations restrict fishing and camping in and around the LCR, use of soaps,



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trash disposal, and other potentially detrimental activities. However, extensive day-use occurs along the LCR, and during spring and summer months, numerous rafting trips stop at the mouth of the LCR and allow passengers to hike and swim the lower 2 miles. On any given day as many as 100-150 people can be found wading and swimming in the warm LCR water. It is unknown whether these activities pose a significant threat to humpback chub by disrupting spawning behavior, disturbing habitat, or inducing other impacts. Restricting visitation in the lower 9.3 miles of the LCR during the peak of spawning season, in March-May, would reduce disturbances to the fish and possibly enhance reproductive success and survival of young.

Recreationists are required to obtain permits to visit the portion the LCR within the Navajo Reservation, starting 2.5 miles above the confluence. There are fewer restrictions on activities in the reservation, compared to those in GCNP. Establishing consistency, where appropriate, could reduce the potential for impacts.

## 7.0 STRATEGIES AND ACTIONS

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This section identifies threats to the humpback chub, strategies and actions that protect the spawning population and critical habitat in the lower LCR, and the stakeholders that could contribute to this plan.

### 7.1 Principal Threats to Humpback Chub

Principal threats to the humpback chub have been identified and described in recovery plans (U.S. Fish and Wildlife Service 1990) and recovery goals (U.S. Fish and Wildlife Service 2002) as streamflow regulation, habitat modification, competition with and predation by nonnative fish species, and pesticides and pollutants. Threats to the humpback chub are further described in Section 7.4 of this document.

In Grand Canyon, specific threats are related to:

- Streamflow depletion from upstream diversions and ground water pumping;
- Predation and competition by a suite of nonnative fish species, principally channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), black bullhead (*Ictalurus melas*), red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*), green sunfish (*Lepomis cyanellus*), striped bass (*Morone saxatilis*), and smallmouth bass (*Micropterus dolomieu*); and
- Infestation by parasites, principally the Asian tapeworm (*Bothriocephalus acheilognathi*) and the parasitic copepod (*Lernaea cyprinacea*).

### 7.2 Strategies

The following are the three strategies of this Plan to protect the spawning population of humpback chub and its critical habitat in the lower LCR:

## 7.0 Strategies and Actions

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### ***I. Utilize Reclamation's authorities where appropriate and applicable.***

The Bureau of Reclamation has legislative mandates and discretionary authorities related to federal laws, executive orders, federal and state statutes, interstate compacts, court decisions, and decrees. Legislative mandates take effect with a federal action that requires Reclamation to comply with one or more laws and related policies or implementing regulations. Examples of these are the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq.*) and the Endangered Species Act of 1973, as amended (16 U.S.C. 1532 *et seq.*). An overview of the authorities and institutional constraints for Reclamation in the Grand Canyon region is provided in the Glen Canyon Dam FEIS (U.S. Department of the Interior 1995). Reclamation does not currently own or operate any major facility in the LCR Basin and is not legally mandated to comply with legislation as a result of any federal action at this time. Reclamation's authorities and responsibilities with regard to the operation of Glen Canyon Dam do not extend into the LCR because that operation does not affect the LCR.

Reclamation has discretionary authority that allows it to implement activities consistent with its mission and with certain legislative mandates. However, this discretionary authority does not allow Reclamation to mandate federal or state agencies or private interests to comply with those activities. Reclamation lacks the legislative authority to mandate other parties to develop a management plan for the LCR, and its discretionary authority restricts Reclamation to take actions only under its control and to work with and support the complementary actions of others.

In the LCR Basin, Reclamation has the discretionary authority under the Reclamation Act of 1902 (32 Stat. 388; 43 U.S.C. 391 *et seq.*) and subsequent related legislation, consistent with its mission to provide guidance and support for development and execution of projects that provide municipal and industrial water supplies, hydroelectric power generation and transmission, water quality improvement, flood control, navigation, and river regulation and control. Under Section 7(a)(1) of the ESA, Reclamation is encouraged to use its authorities in consultation with the Service to further the conservation of threatened or endangered species. This provision of the ESA gives Reclamation the authority to take actions to conserve threatened and endangered species while consulting on a federal action.

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Reclamation is mandated under the 1995 Opinion to be instrumental in the development of a management plan for the LCR. Reclamation can help to develop such a plan, but does not have the legal authority to implement, enforce, or fund such a plan. Even under Section 7(a)(1), where Reclamation is given some discretion on using its authorities to conserve threatened and endangered species, Reclamation “...*must comply with applicable permit requirements (50 CFR parts 17, 220, 222, and 227) for listed species and should be coordinated with the appropriate Secretary.*” (50 CFR 402.01). In other words, unless a federal action is taking place, Reclamation does not have authority under the ESA to require other parties to develop a management plan for the LCR.

Reclamation is currently involved in a number of major programs in the Lower Colorado River Basin, including the Glen Canyon Dam Long-Term Experimental Program and the GCDAMP. These programs and others provide Reclamation with an opportunity to exercise discretionary authority of providing guidance and assistance in the implementation of the actions identified and described in this plan. Some of these actions are ongoing and Reclamation has some involvement that is affirmed by this Plan. Other actions should be implemented to help the Service move toward recovery of the endangered humpback chub.

### ***II. Encourage and assist other federal and state agencies in the use of their authorities, where appropriate and applicable.***

Land ownership in the LCR Basin includes 48% Indian Reservations, 23% private lands, 19% federal lands, and 10% state trust lands. Over 70% of the land in the LCR Basin is reservation or private land and largely inaccessible to either federal or state jurisdiction. Less than 30% of the land in the basin is under federal or state jurisdiction and most of these lands are not strategically located to have a significant impact on water delivery to the lower LCR. Hence, federal and state authorities in the LCR Basin are limited. Descriptions of the authorities and responsibilities of the federal and state agencies in the LCR Basin are presented in Section 5.0.

The U.S. Forest Service has jurisdiction over the largest areas of federal land in the basin, primarily as national forests in the upper watershed. The Bureau of Land Management

## ***7.0 Strategies and Actions***

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has jurisdiction over mostly arid lands and some streams and riparian areas in a checker-board pattern adjacent to mostly state and private lands. Finally, the National Park Service has jurisdiction over monuments in the LCR Basin and over the lower 2.5 miles of the LCR in Grand Canyon National Park. Generally, lands that are under federal jurisdiction are not strategically located along stream channels or with water delivery infrastructures to enable the federal agencies to affect water management. Only 10% of the land in the LCR Basin is state trust land and the state has little legal authority or jurisdiction over water management that could significantly affect a greater part of the basin. Despite the lack of ownership, authority, or jurisdiction, federal and state agencies are encouraged under this Plan to work closely with stakeholders in the LCR Basin and help to coordinate wise water management.

### ***III. Communicate with, assist, and help to coordinate stakeholders and interested parties in the LCR Basin.***

Several organizations are currently in place in the LCR Basin that serve to bring together stakeholders and interested parties on a regular basis. The Little Colorado River Plateau Resource Conservation and Development Area, Inc. (Little Colorado RC&D) is a non-profit 501(c)(3) corporation that is the largest entity in the LCR Basin that can affect water management. The Little Colorado RC&D addresses local issues, coordinates technical and financial assistance programs, and brings together diverse stakeholders for the planning and development of natural resources in the LCR Basin. The coordinating body for the Little Colorado River RC&D is the Little Colorado River Watershed Coordinating Council (Council). The Council works with the assistance of local, state, and federal agencies, and other organizations to help coordinate water management activities within the LCR. The Council has a Water Quality Improvement Grants program that provides interested parties with federal grants to improve water quality in the LCR watershed. Many of the federal grants are funded through Reclamation.

The Little Colorado River Multi-Objective Management (LCR-MOM) Program is made up of individuals, businesses, organizations, and government agencies and is in under the umbrella of the Little Colorado RC&D to provide interaction, coordination, and liaison among all stakeholders in the LCR Basin. These organizations work together to coordinate local counties, municipalities, and water and development districts, the Navajo Nation,

## ***7.0 Strategies and Actions***

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various Arizona State agencies, federal agencies (including Army Corps of Engineers, NPS, BLM, the Service, U.S. Forest Service), and the Northern Arizona Council of Governments. The Navajo Nation can play a major role since the majority of humpback chub critical habitat is within Navajo Nation lands; i.e., 5.5 miles of the lower 8 miles of the LCR.

These organizations should continue to work together to achieve the goals of protecting the humpback chub spawning population and habitat in the LCR, while proceeding with necessary water development in the LCR Basin. They should work toward conservation of the humpback chub, while avoiding conflicts among parties interested in and having responsibility for species protection and water development and management in the LCR Basin. All activities should be in compliance with all applicable laws, including, but not limited to, the ESA, NEPA, Indian Trust Responsibilities, Tribal Laws, State Water Laws, Adjudications, Interstate Compacts, and International Compacts governing the allocation of water.

Many stakeholders have parallel mandates and policies with respect to management of endangered species and related activities. However, agency or tribal objectives may differ and lead to conflicts in management. The purpose of this Plan is to inform the stakeholders in the basin of endangered species issues and to insure that potential conflicts are identified, understood, and resolved. A primary role of stakeholders should be to identify and implement opportunities to enhance protection for the humpback chub and critical habitat through cooperative efforts among these agencies and tribes.

The stakeholders should be instrumental in development and implementation of a public participation process in cooperation with the Council and the MOM Program. Development and implementation of a public participation process should be a priority. The annual meetings held by the Council is an example of the type of beneficial coordination that will help stakeholders throughout the basin understand issues and become current on new information.

### ***IV. Support Establishment of an Endangered Species Recovery Program.***

Given the current lack of clearly defined authorities, funding agreements, and

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## **7.0 Strategies and Actions**

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programs, the most logical course of action for implementation of a watershed plan for the LCR is for state and federal agencies to work together to establish an endangered species recovery program for the greater Grand Canyon area that would ultimately be tasked with implementation of the LCR management plan. As evidenced by experience in the Upper Colorado and San Juan basins, recovery programs have proven successful at facilitating and coordinating such management efforts with the support of various state, federal and local authorities as well as disparate stakeholder groups. Notable examples include the Green River Flow Recommendations, the Duchesne River Flow Recommendations, the Yampa River Management Plan, and the San Juan River Flow Recommendations. In the LCR Basin, similarly, no one agency appears to have authority or capability to implement the plan, so it is clear that a collaborative approach is the most viable option. Other similarities to existing recovery programs abound and a common theme is to conserve endangered species while proceeding with necessary development river basin. At this time, the most prudent option for implementing a watershed plan for the LCR is through a recovery program, basin-wide programmatic biological opinion, or other similar vehicle.

### **7.3 Actions**

The following is a list and brief description of management actions necessary to protect the humpback chub spawning population and its critical habitat in the LCR. Many of these actions are consistent with site-specific management actions identified in the 2002 Recovery Goals for Humpback Chub (U.S. Fish and Wildlife Service 2002).

#### ***1. Develop a Hazardous-Materials Spills Emergency Response Plan for the Lower LCR***

Tasks E-1.3 and E-1.4 of Management Action E-1 of the recovery goals call for identification and implementation of measures to minimize the risk of hazardous-materials spills from transport of materials along U.S. Highway 89 at and near the two Cameron bridges spanning the LCR. A Hazardous-Materials Spills Emergency Response Plan should be developed to minimize the risk of hazardous-materials spills that could have disastrous consequences on the humpback chub and designated critical habitat located less than 30 miles downstream of Cameron. This plan should be developed in cooperation and

## **7.0 Strategies and Actions**

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coordination with the U.S. Department of the Interior (Interior) agencies, Arizona Department of Transportation, EPA, Native American tribes, and local governments. Local resources available to respond to a spill event appear limited, and appropriate resources would have to be made available. An emergency response planning effort comparable to the “Colorado River Area Contingency Plan” (U.S. Environmental Protection Agency 1993) is recommended with responsibilities and funding worked out by the participating parties.

At the least, steps should be taken to retrofit containment features on the U.S. Highway 89 bridges near Cameron, as well as to make provisions to contain material spilled into the river channel. If the channel is dry, as is often the case in summer, fall, and winter, standard procedures should be established for removing and cleaning spilled material from the channel as quickly as possible. More stringent procedures would be needed if the river is flowing, as in spring and during monsoonal rainstorm events. Facilities, equipment, and personnel should be available to minimize the effect of a spill through proper containment and clean-up procedures.

### **2. Help to Provide Flow Regimes in the Lower LCR**

Tasks A-2.2 and A-2.3 of Management Action A-2 of the recovery goals call for identifying and providing flow regimes in the LCR that are necessary for all life stages of humpback chub to support a recovered Grand Canyon population. Maintaining ground water discharge to the Blue Springs complex is critical to maintaining the population of humpback chub in the LCR. The effects of ground water uses, especially from the C-aquifer, on discharge at the Blue Springs complex are not well understood and should be more thoroughly investigated. The relationship between ground water pumping, especially in the Flagstaff area, and potential reduction in discharge in the lower LCR needs to be better understood, in light of increasing pumping in that area for municipal water uses. This information is necessary in order to determine if specific pumping projects at specific locations are more likely to affect discharges from the C-aquifer. Possibly pumping in some parts of the aquifer, and not others, would reduce the risk of decreased discharge to important springs in GCNP, including Blue Springs, Havasu Springs, and numerous other spring sources.



## **7.0 Strategies and Actions**

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Although the LCR is ephemeral above the Blue Springs complex, surface flow that reaches the lower 13 miles of the LCR is important to the reproductive success, survival, and recruitment of the population. Most surface flow reaches the lower LCR as the result of spring snowmelt runoff or late summer monsoonal rainstorms. Options should be investigating for maintaining and protecting surface flows from upstream to designated critical habitat. Surface water is contained throughout the LCR Basin in over 2,700 small reservoirs, over which there is little control by federal or state agencies. Larger reservoirs, however, may have some flexibility for releases to benefit the humpback chub in the lower LCR. For example, annual transbasin exports to the Salt River drainage from Blue Ridge Reservoir and Show Low Lake are 9,600 and 3,600 acre-feet, respectively. These diversions compensate for water diverted from the Salt River Basin into the Gila River Basin for the Phelps Dodge Corporation (PDC) copper mine in Morenci. In the 1990s, these two projects accounted for over 80% of the 16,500 acre-feet of surface water diverted annually for mining and industrial purposes in the LCR Basin (Arizona Department of Water Resources 1994). Blue Ridge Dam and Reservoir was acquired by the Salt River Project in February 2005 as part of the Gila River Indian Water Rights Settlement approved by the Arizona Water Settlement Act and renamed Cragin Dam and Reservoir. The potential should be investigated for available water from these or other reservoirs in the LCR Basin to supplement existing surface flows that would reach the humpback chub population in the lower LCR.

### **3. *Establish a Hatchery Refugium for Humpback Chub from Grand Canyon***

This action is identified as a conservation measure in the 2008 Biological Opinion. Members of the GCDAMP have expressed the need to take humpback chub from the LCR to hold in protective custody and possibly to establish a captive breeding population (Humpback Chub Ad Hoc Committee 2003). The purpose for this captive population is to protect genetic material from the LCR and to keep captive fish in case the wild population is decimated by a catastrophic loss of individuals. This program should be done jointly and cooperatively by the Service, Reclamation, AGFD, NPS, and GCMRC. One important aspect of securing and/or preserving genetic integrity is to maintain individuals in a hatchery facility for culture and development of brood stock, as well as for providing live fish of various life stages for scientific research. The only humpback chub from Grand Canyon

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currently in a hatchery are small numbers used for research at the Willow Beach National Fish Hatchery, Arizona. Eggs procured from field-stripped humpback chub in the LCR in spring of 1992 were incubated and hatched at the Bubbling Pond State Fish Hatchery. The progeny were used for experimental purposes and none are left.

### ***4. Promote Expansion of the LCR Population of Humpback Chub***

The LCR population is limited from moving upstream of a natural barrier located above 9 miles above the confluence. Perennial flow from the Blue Springs complex begins about 13 miles above the confluence, leaving about 4 miles of unoccupied habitat—except for the area nearest Blue Springs which has a high carbon dioxide concentration that excludes fish (Carothers and Aitchison 1972). In August 2003, nearly 300 young humpback chub were translocated above a natural barrier (Chute Falls) in the LCR located about 9 miles above the confluence. This translocation was followed by another 300 fish in July 2004 and by another 567 fish in July 2005. Follow-up sampling indicates that survival and growth rates of the translocated fish were high. Limited reproduction and downstream movement of marked below Chute Falls was also documented (Stone and Sponholtz 2003, 2004). This translocation was supported and coordinated by Reclamation, NPS, and USGS and is identified as a conservation measure in the 2008 Biological Opinion.

This translocation of humpback chub expands the LCR population and provides an additional population buffer in case of a catastrophic population decline. It also helps investigators evaluate the feasibility of translocating humpback chub to other tributaries in Grand Canyon. Valdez et al. (2000) concluded that while translocating humpback chub from the LCR to other tributaries would not likely result in large self-sustaining populations, there is considerable value in translocated humpback chub acting as added insurance against extirpation of the species in the lower basin. This goal was also identified in a separate proposal by Grand Canyon Wildlands Council (2006). Tributary translocations also have the potential to establish refuges for humpback chub and to provide grow-out habitats for young that will disperse to, or be translocated to, the mainstem and augment the existing downstream aggregations (Valdez and Ryel 1995).

### 5. Develop and Implement a Nonnative Fish Control Strategy for the LCR

Tasks C-3.1 and C-3.2 of Management Action C-3 of the Humpback Chub Recovery Goals call for the development and implementation of control programs in the LCR to identify levels of control of rainbow trout, channel catfish, black bullhead, and common carp that will minimize negative interactions on humpback chub. Predation and competition by nonnative fishes has been identified as one of the primary causes for decline of native fishes of the Colorado River (Minckley 1991). Predation by brown trout, channel catfish, and rainbow trout has been documented on humpback chub and other native fishes in the Colorado River and in the LCR (Valdez and Ryel 1995; Marsh and Douglas 1997). Predation by these and other nonnative fishes may be severely depleting year classes of humpback chub and greatly reducing recruitment to the adult portion of the population (Coggins 2008). Nonnative fish control in the mainstem of Marble and Grand canyons and in their tributaries is identified as a conservation measure in the 2008 Biological Opinion.

The GCMRC is currently developing a Non-Native Fish Control Strategy for the mainstem Colorado River through Grand Canyon (Hilwig et al. 2007). The GCMRC has conducted experimental removal of nonnative fishes from reaches of the mainstem Colorado River, primarily rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) (Coggins et al. 2003). These efforts do not specifically address the lower 13 miles of the LCR, including critical habitat of humpback chub. Hence, there is a need to either integrate the lower LCR into these plans and strategies or develop an effective strategy for minimizing effects of nonnative fish on humpback chub in the lower LCR.

The Integrated Fisheries Management Plan for the Little Colorado River Watershed (Young et al. 2001) cultivates a pro-active stance toward native fishes by reducing potential conflicts between native fish management and nonnative sportfish management. This plan is important for reducing sources of nonnative fish originating upstream of humpback chub critical habitat. Attention needs to be given to the occurrence of nonnative fish species in the entire LCR drainage, not just the lower reaches and confluence area. Given the proliferation of warmwater nonnative fish both in the upper basin as well as the area immediately below Grand Falls (see Stone et al. 2007), it appears that expansion of nonnative fish distribution into critical habitat areas of the LCR and Colorado River is a formidable threat to continued

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existence of humpback chub and other native fish, perhaps on a scale comparable to that of water depletion. Distribution of nonnative fishes in the entire LCR basin (and attendant AGFD management plans) should be treated with the same level of detail as hazardous waste spills and water depletions.

### ***6. Establish a Reliable Flow Monitoring System for the Lower LCR and Blue Springs***

A reliable continuous-recording stream gage should be established and maintained in the lower LCR to record hourly flow, water temperature, conductivity, and pH. Stream flow and water quality records of the lower LCR, near the outflow to the Colorado River, are discontinuous because high flows often disable the station. The USGS gage on the Little Colorado River near Cameron (09402000) has been operating since 1947, and the gage above the mouth near Desert View (09402300) has been operating since May 1990. The latter gage was inoperable from 1993 to 2003 (see Figure 3, Section 3.3.1 of this document). A more reliable station needs to be established in order to procure accurate and reliable stream gage data for the LCR. Also, there is a need to establish a reliable discharge measurement system for the Blue Springs complex to monitor long-term trends in discharge rate and volume, and to determine if discharge from these springs is changing, possibly as a result of ground water pumping.

### ***7. Quantify the Relationship between Ground Water Pumping and Discharge at Blue Springs***

The LCR is the principal area where humpback chub spawn successfully in Grand Canyon, and the only perennial source of water to the spawning area is the Blue Springs complex. Habitat and flow requirements for the different life stages of this endangered species are generally unknown, but it is believed that depletion of flow to the Blue Springs complex would detrimentally impact the humpback chub. The Blue Springs complex is supplied by the C-aquifer, which is believed to be large (413 MAF) with a long residence time, but an unknown effect of ground water pumping. Although depletions in recharge to the Blue Springs complex may not be manifested for many years, the relationships of spring recharge, ground water pumping, and flow at the Blue Springs complex need to be better understood, considering the increased human use of water from the C-aquifer and the

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importance of this water supply to this endangered species.

An essential element of humpback chub habitat is the base flow from the Blue Springs complex. Any comprehensive LCR Basin development planning with a goal of protecting flow from the Blue Springs complex will depend on an ability to predict effects of development on the Coconino Aquifer. The current understanding of LCR Basin hydrology is not adequate for this purpose. Project-specific analysis to predict effects of proposed depletions of the C aquifer, particularly for projects on the San Francisco Peaks slope and west of Cameron, would help to prevent adverse affects to discharge of the Blue Springs complex.

The LCR adjudication process is a potential source of data and modeling for the C-aquifer. Possibly interests in the adjudication have developed models or other forms of analysis regarding ground water in the basin. If at the conclusion of the adjudication process these models were made available in the public domain, better predictions of the effect of development on the C-aquifer could be made.

Similarly, the relationship of surface flow especially that which reaches the critical habitat reach, to spawning success and suitable habitat for humpback chub is not well understood. High late winter floods (January-February) appear to be important for cleansing spawning areas, and spring floods (March-May) appear important for ascent by pre-spawning adults. Any further capture and depletion of these high flows in the upper reaches of the LCR Basin could detrimentally impact spawning, and egg and embryo survival.

### **8. *Determine Habitat and Instream Flow Needs of Humpback Chub in the Lower LCR***

The relationship between habitat of humpback chub in the LCR and flow has not been adequately described. Gorman (1994) described the habitat of the various life stages of humpback chub in the LCR, but did not quantitatively link habitat to flow. This is vital information to effectively identify possible responses by the humpback chub population to a wide range of potential threats. For example, understanding the role of spring floods in spawning and habitat maintenance is necessary for projecting the potential impact of surface

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water detention and diversion projects in the LCR Basin, and to understanding the frequency of strong and weak reproductive success. Assessing the ramifications of a change in base flow would require a model of instream flow and its relationship to humpback chub habitat. Such a model would be a key element in evaluating the potential ramifications of projects which would result in a change in base flow discharge from the Blue Springs complex, as well as in surface flow.

A reliable assessment of carrying capacity for humpback chub in the LCR should be an important component of the habitat to flow relationship. Resources that support the humpback chub in the LCR need to be evaluated in order to determine the maximum potential number of fish that the system can support. These resources include flow, water quality, habitat, food, and sympatric species. Multiple mark-recapture census in 2006 and 2007 estimated between 4,000 and 6,000 adults ( $>150$  mm TL) (U.S. Geological Survey 2006, 2007). Estimates in May 1992 estimated 4,602 adult humpback chub ( $>150$  mm TL) in the LCR (Douglas and Marsh 1996c). Previous “ballpark estimates” in May 1982 were 7,000-8,000 adults (Kaeding and Zimmerman 1983) and catch expansion estimates in May 1989 were 25,000 adults (Kubly 1990).

### **9. Continue to Monitor the Humpback Chub Population in the LCR**

Reclamation and other agencies should continue to coordinate with the GCMRC in monitoring the humpback chub population in the LCR. Recognizing changes in the demographics and/or total numbers of humpback chub in the LCR can provide warning of chronic or acute impacts. This information is fundamental for a comprehensive management program. A significant proportion of the adult humpback chub population in the LCR has been tagged, and the population has been monitored since 1977. The GCMRC has developed an age-structure, mark-recapture model to help estimate the numbers of adults in the population and their survival (Coggins et al. 2006a, 2006b). This monitoring program should be continued, but the amount of effort and handling of humpback chub should be evaluated to insure that handling and marking the fish annually is not harming the population.

### ***10. Monitor Genetic Diversity of Humpback Chub in Grand Canyon***

The LCR humpback chub population is isolated from the other five remaining populations of this species by Glen Canyon Dam. Under these conditions the genetic variability within the LCR population may be a concern. An evaluation of the genetic structure of the humpback chub and the roundtail chub in the Colorado River System, including Grand Canyon, has been conducted by Douglas and Douglas (2007). This information is an important component of any attempts to establish a second spawning population within Grand Canyon or reestablish populations elsewhere in the Colorado River Basin. Individuals from the LCR population, as well as the mainstem aggregations and any newly-established tributary populations should be monitored to determine if the genetic diversity of these populations is being sustained. Analyses by Keeler-Foster et al. (2008) suggest that within population variance accounts for 97% of genetic diversity, with only 3% between populations. A second analysis found that captive fish and translocated fish had fewer alleles indicating slightly lower levels of genetic diversity. However, both populations provide an excellent foundation for the development of additional stocks to reflect the current LCR population. A genetics management plan for humpback chub is currently being developed by the Dexter National Fish Hatchery and Technical Center.

### ***11. Determine Thermal and Chemical Tolerance Levels For Humpback Chub***

Studies are needed to define tolerance ranges and limits for various life stages of humpback chub to temperature, free carbon dioxide, and dissolved oxygen. Past laboratory studies indicate that this species is tolerant to high levels of TDS (>5,100 mg/L), which is considerably higher than maximum levels measured in the LCR (Bulkley et al. 1982). These tolerance levels need to be defined in order to determine if, in fact, juvenile and adult humpback chub could survive year-around in other tributaries. Also, temperature tolerances need to be better defined for young humpback chub descending from the LCR into the Colorado River in order to determine minimum size at which young survive the transition from about 20EC of the LCR to 10EC of the mainstem. These studies need to be combined with studies of larval drift to determine if there is substantial mortality of young during this transition. Ponding tributary inflows with high mainstem releases from Glen Canyon Dam would provide a large thermally-graded pool for enhanced survival of these young fish.

### ***12. Develop an Asian Tapeworm Control Program in the LCR***

Tasks C-1.1. and C-1.2 of the recovery goals identify the need to develop an Asian tapeworm control program in the LCR to identify the levels of control that will minimize the negative effects of parasitism on the humpback chub population. The Asian tapeworm was first reported in humpback chub from the LCR in 1990 (Clarkson et al. 1997; Brouder and Hoffnagle 1997). This parasite was found in gut contents of 6 of 168 (3.6%) mainstem adult humpback chub treated with a stomach pump, for an average of 6.7 tapeworms per infected fish (range, 1–28; Valdez and Ryel 1995). Clarkson et al. (1997) found Asian tapeworms in 28% of humpback chub examined from the LCR in 1990–1994. They also reported the parasite in speckled dace, common carp, fathead minnows, and plains killifish. Brouder and Hoffnagle (1997) also found Asian tapeworms in humpback chub (22.5%) from the LCR in 1994, as well as plains killifish (10.3%), speckled dace (3.8%), and fathead minnows (2.2%). They reported that nearly all (66.7–100%) of infected fish were captured near the LCR, although the parasite was found as far downstream as Kanab Creek, 132 km downstream of the LCR. Infection of humpback chub by the Asian tapeworm is a concern because of possible stress and death to the host and widespread infestation during periods of stress. This parasite is only able to complete its life cycle in the LCR where the temperature requirement of >20°C is met, but it is apparently able to survive in a fish host in cold mainstem temperatures.

### ***13. Update and Maintain the LCR Geographic Information System***

The Navajo Natural Heritage Program (1993) has initiated development of an LCR Database and an LCR Bibliography. The LCR Database is a Geographic Information System (GIS) consisting of several category layers. The major categories (and number of sub-categories in each) are biology (19), geology (11), hydrology (14), and environmental (2).

The LCR Bibliography consists of annotated bibliographies of reports and publications relevant to the LCR. There are two general formats for these annotated bibliographies: (1) an alphabetical, cross-referenced list by category and sub-category, and (2) a numbered alphabetical list of the whole database with a category index that references



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the citation by number. Enhancing, refining, and updating this database is important for understanding resource conditions throughout the LCR Basin, and for making wise management decisions.

A GIS is a valuable tool for resource monitoring. It provides spatial and temporal distributions of resources in an organized fashion that facilitates access and retrieval of information. A GIS also allows simultaneous assessment of several resources in order to ascertain interactions and/or possible conflicts in resource management. A model for developing a GIS for resource monitoring was developed by Werth et al. (1993).

### ***14. Maintain and Update a Library Database for Humpback Chub in the LCR***

The GCMRC has a Library Database that contains most of the literature relevant to the humpback chub and related resources in the Colorado River and its tributaries through Grand Canyon (<http://www.gcmrc.gov/webopac/main?siteid=GCMRC>). This database was initiated by GCES Phase II and has recently been maintained and supported largely by AGFD and GCMRC. Aside from reports and publications, the database consists of electronic data files containing information from fish studies conducted in the LCR and the mainstem Colorado River since the mid-1970s. An important component of this database is a complete list of tags applied to individual fish and the associated data (e.g., fish length, weight, habitat, etc.).

### ***15. Comprehensive Plan for the Management and Conservation of Humpback Chub in Grand Canyon.***

The Service has coordinated with AMP cooperators, a comprehensive plan for management and conservation of the humpback chub in Grand Canyon. This plan contains specific actions that are necessary for conservation of the species in the greater Grand Canyon area, including the LCR, including implementation of off-site refuges and rearing facilities as well as on-site translocations. Reclamation has committed to specific conservation measures in this biological opinion, but will also consider funding and implementing other actions not identified here to implement the plan. This action is identified as a conservation measure in the 2008 Biological Opinion.

### 7.4 Stakeholders and Interested Parties

The following are stakeholders and interested parties that are important to the implementation of this Plan. Most of these parties have management authorities and responsibilities within the LCR Basin. Each of these parties and their authorities are described in greater detail in Section 5.0 of this document.

#### 7.4.1 Federal Agencies

U.S. Department of the Interior.—The Department of the Interior has primary management responsibility and authority for land, water, and resources of the United States, and administers these through various agencies, including Reclamation, the Service, NPS, USGS, BIA, and BLM. The Secretary of the Interior has direct authority over the GCDAMP, which is a Federal Advisory Committee with direct responsibility to the Secretary.

U.S. Bureau of Reclamation.—Reclamation is the primary federal management agency in the Colorado River Basin. Reclamation has sponsored and funded much of the previous research on humpback chub in the lower LCR, and has a significant interest in management of endangered fishes in the Colorado River Basin.

U.S. Fish and Wildlife Service.—The Service has jurisdiction, management, and regulatory responsibilities over federally threatened and endangered species, and has played a significant role in research of humpback chub in the LCR.

National Park Service.—The NPS has jurisdiction over the lower 2.5 miles of the critical habitat reach, and administers all of the Colorado River corridor through GCNP.

U.S. Geological Survey.—The USGS is the leading research agency in the country and supports a large staff of physical and biological scientists that provide valuable input into addressing resource issues in the LCR Basin. The GCMRC is a program under the USGS.

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U.S. Bureau of Indian Affairs.—The BIA serves as a liaison for Native American groups throughout the region.

U.S. Bureau of Land Management.—The BLM has management responsibility and authority over much of the federal land in the LCR Basin.

U.S. Department of Agriculture.—The Department of Agriculture has responsibility and authority over crops and croplands in the LCR Basin, and acts as a liaison for agricultural interests, which are one of the primary users of water in the basin.

U.S. Forest Service.—The U.S. Forest Service is responsible for managing designated National Forest lands and multiple resource uses undertaken within these lands, including recreation, timber harvest, mining, and grazing.

### **7.4.2 State Agencies**

New Mexico Interstate Stream Commission.—The NMISC is empowered to investigate, protect, conserve, and develop the waters of the State of New Mexico, and to ensure adherence to interstate and international compacts.

New Mexico Department of Game and Fish.—The NMDGF manages all fish and wildlife within the State of New Mexico, except for tribal lands.

New Mexico Office of the State Engineer.—The State Engineer is charged with administering water resources for the State of New Mexico, and works closely with the NMISC.

New Mexico Department of Water Resources.—The Department of Water Resources is responsible for monitoring and maintaining water quantity and quality in the State of New Mexico.

Arizona Game and Fish Department.—The AGFD manages all fish and wildlife within the State of Arizona, except for tribal lands.

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Arizona Office of the State Engineer.—The State Engineer is charged with administering water resources for the State of Arizona.

Arizona Department of Water Resources.—The ADWR is responsible for protecting, conserving, and developing waters of the State of Arizona, and to ensuring adherence to interstate and international compacts.

### **7.4.3 Native American Tribes**

Navajo Nation.—Much of the LCR Basin and most of the designated critical habitat of the humpback chub are within lands of the Navajo Nation. The Navajo Nation has significant cultural and spiritual resources along the LCR.

Hopi Tribe.—Although the Hopi Tribe does not have legal jurisdiction within the critical habitat reach, the LCR gorge contains significant cultural resources that must be considered in management decisions affecting the LCR.

Zuni Tribe.—Although the Zuni Tribe does not have legal jurisdiction within the critical habitat reach, the LCR Basin contains significant cultural resources that must be considered in management decisions affecting the LCR.

### **7.4.4 Non-Governmental Organizations**

Little Colorado River Plateau Resource Conservation and Development Area.—The Little Colorado RC&D) is a non-profit corporation that brings together diverse stakeholders for the planning and development of natural resources in the LCR Basin with coordination by the Little Colorado River Watershed Coordinating Council. The Little Colorado River Multi-Objective Management (LCR-MOM) Program is made up of individuals, businesses, organizations, and government agencies and is in under the umbrella of the Little Colorado RC&D.

Environmental Groups.—Various environmental groups have interest in threatened

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and endangered species and in management of resources in the LCR Basin. The Nature Conservancy, Environmental Defense, Center for Biological Diversity, and the Grand Canyon Trust are groups that have various interests in the LCR Basin.

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